ASC 2010 ABSTRACTS

1EA-01

(INVITED) **TRANSITION-EDGE SENSOR BOLOMETER ARRAYS: APPLICATION, DESIGN, AND PERFORMANCE** ***A. T. LEE;*** UNIVERSITY OF CALIFORNIA. — I WILL REVIEW THE FIELD OF TRANSITION-EDGE SENSOR (TES) BOLOMETER ARRAYS. ASTRONOMICAL APPLICATIONS INCLUDE OBSERVATIONS OF THE COSMIC MICROWAVE BACKGROUND, STAR-FORMING GALAXIES, GALAXY CLUSTERS, AND DUSTY SOURCES IN OUR OWN GALAXY. THE FIRST GENERATION OF KILO-PIXEL TES BOLOMETER ARRAYS ARE PRODUCING SCIENCE NOW AND THE NEXT GENERATION IS BEING BUILT. THE COUPLING OF LIGHT FROM A TELESCOPE TO THE TESES IS AN ACTIVE AREA OF RESEARCH, WHERE THE GOAL IS TO BUILD THE MOST SENSITIVE FOCAL PLANES WITH THE LEAST SPATIAL AND POLARIZATION DISTORTION OF THE SKY SIGNAL. ALL KILOPIXEL TES BOLOMETER ARRAYS USE ONE OF SEVERAL FORMS OF READOUT MULTIPLEXING WHERE ONECOLD AMPLIFIER CAN READ OUT MANY BOLOMETERS. THE CURRENT STATUS AND FUTURE DIRECTIONS OF TES BOLOMETER ARRAY RESEARCH WILL BE DESCRIBED.

THE RESEARCH OF A.T. LEE IS SUPPORTED IN PART BY NSF GRANT AST-0618398, NASA GRANT NNG06GJ08G, AND DOE GRANT DE-AC02-05CH11231

1EA-02

SUPERCONDUCTING DETECTORS FOR CHARACTERIZATION OF THE COSMIC MICROWAVE BACKGROUND ***E. J. WOLLACK;*** NASA/GSFC. — THE MEASUREMENT OF THE POLARIZATION OF THE COSMIC MICROWAVE BACKGROUND (CMB) WITH HIGH SENSITIVITY WILL PROBE THE INFANT UNIVERSE, TESTING THE INFLATION PARADIGM AND EXPLORING PHYSICS ON ENERGY SCALES BEYOND THOSE ACCESSIBLE TO TERRESTRIAL PARTICLE ACCELERATORS. THIS MEASUREMENT WILL REQUIRE LARGE FOCAL PLANES OF BACKGROUND-LIMITED DETECTORS AND GOOD CONTROL OF SYSTEMATIC ERRORS. WE PRESENT OUR CURRENT PROGRESS ON PRODUCING SUCH ARRAYS. THE DETECTORS DESCRIBED COMBINE THE GOOD BEAM-FORMING PROPERTIES OF FEEDHORNS WITH THE SENSITIVITY PROVIDED BY TRANSITION-EDGE SENSORS. A HIGH DEGREE OF SYMMETRY IS ACCOMPLISHED VIA A NOVEL BROADBAND MAGIC-TEE HYBRID. BAND-DEFINING FILTERING IS DONE ON-CHIP.

1EA-03

A DUAL-POLARIZED MULTI-CHROIC ANTENNA-COUPLED TES-BOLOMETER WITH A COCHLEA-INSPIRED CHANNELIZER CIRCUIT ***R. O'BRIENT;*** UNIVERSITY OF CALIFORNIA AT BERKELEY. — WE HAVE FABRICATED A NOVEL MULTI-CHROIC ANTENNA-COUPLED TRANSITION EDGE SENSOR (TES)-BOLOMETER FOR COSMIC MICROWAVE BACKGROUND POLARIMETRY IN BALLOON-BOURN AND SATELLITE EXPERIMENTS. THE BOLOMETERS COUPLE TO A PLANAR DUAL-POLARIZED LOG-PERIODIC ANTENNA KNOWN AS A SINUOUS THROUGH A LOG-PERIODIC CHANNELIZER CIRCUIT WHOSE DESIGN IS INSPIRED BY THE MAMMALIAN-COCHLEA. EACH PIXEL HAS A SET OF 14 BOLOMETERS TO SIMULTANEOUSLY RECEIVE BOTH LINEAR POLARIZATIONS WITH 7 CONTIGUOUS SPECTRAL BANDS BETWEEN 70 AND 220GHZ. A CONTACTING SYNTHESIZED-ELLIPTICAL LENS MODIFIES THE ANTENNA'S GAIN.WE WILL SHOW CRYOGENIC OPTICAL TESTS OF A PROTOTYPE DEVICE THAT DEMONSTRATE HIGH TOTAL RECEIVER EFFICIENCY OF 30-40%, UNDER 2% CONTAMINATION FROM CROSS-POLARIZATION, AND THE SPECTRAL DISCRIMINATION OF EACH CHANNEL. WE WILL ALSO SHOW PATTERN MEASUREMENTS AND COMMENT ON EFFORTS TO REFINE THE ELLIPTICITY OF THE BEAMS.

ALL DEVICES WERE FABRICATED IN THE BERKELEY MICROLAB.

1EA-04

TOWARDS A LARGE-FORMAT FEEDHORN-COUPLED TES ARRAY FOR CMB POLARIMETRY ***H. M. CHO;*** NIST-BOULDER; FOR THE TRUCE COLLABORATION. — SUPERCONDUCTING SENSORS HAVE BEEN WIDELY COMPRISED IN COSMOLOGY TO DETECT THE TEMPERATURE ANISOTROPIES OF COSMIC MICROWAVE BACKGROUND (CMB) RADIATION. NEXT-GENERATION CMB EXPERIMENTS WILL SEARCH FOR THE SIGNATURE OF GRAVITY WAVES FROM INFLATION, BUT THEY WILL REQUIRE UNPRECEDENTED SENSITIVITIES IN ADDITION TO CAREFUL CONTROL OF SYSTEMATICS. EXISTING DETECTOR TECHNOLOGIES ALREADY OPERATE CLOSE TO THE BACKGROUND PHOTON NOISE, THUS IMPROVEMENTS IN SYSTEM SENSITIVITY MUST COME FROM LARGER FOCAL PLANE ARRAYS OF MILLIMETER-WAVE DETECTORS. OUR POLARIMETERS UTILIZE SUPERCONDUCTING CIRCUITS CONNECTING TO TRANSITION EDGE SENSORS (TES). THE ELEMENTS OF THE POLARIMETER CONSIST OF PLANAR ORTHOMODE TRANSDUCERS, COPLANAR WAVEGUIDES, BANDPASS FILTERS AND LOW PASS FILTERS, ALL MADE OUT OF NIOBIUM THIN FILM TECHNOLOGY. THE TES IS MADE OF A MOLYBDENUM-COPPER BILAYER THIN FILM. WE WILL PRESENT RESULTS FROM DETECTORS TO SHOW ACCURATE SPECTRAL BAND DEFINITION, DARK TES NOISE CONSISTENT WITH THE PROJECTED PHONON NOISE CONTRIBUTION AND END-TO-END OPTICAL EFFICIENCY OF 60%-70%. FURTHERMORE, WE REPORT ON PROGRESS TOWARDS A LARGE-FORMAT ARRAY EMPLOYING SEVERAL HUNDRED MONOLITHIC, MICROFABRICATED POLARIMETERS COUPLED TO SILICON MICROMACHINED PLATELET FEEDHORNS FOR 150 GHZ OPERATION FOR SPTPOL AND ACTPOL.

THE TRUCE COLLABORATION INCLUDS NIST-BOULDER, CU-BOULDER, GFSC, PRINCETON, U. OF CHICAGO AND U. OF MICHIGAN.

1EA-05

PROGRESS ON ANL/KICP TES BOLOMETERS FOR SPTPOL ***A. CRITES***[1], *L. BLEEM*[1], *J. CARLSTROM*[1], *C. CHANG*[1], *A. DATESMAN*[2], *R. DIVAN*[3], *W. EVERETT*[1], *J. MCMAHON*[4], *J. MEHL*[1], *S. MEYER*[1], *T. MONTROY*[5], *T. NATOLI*[6], *V. NOVOSAD*[2], *J. PEARSON*[2], *J. RUHL*[5], *J. SAYRE*[5], *G. WANG*[2], *V. YEFREMENKO*[2]; [1]KAVLI INSTITUTE FOR COSMOLOGICAL PHYSICS, UNIVERSITY OF CHICAGO, [2]MSD ARGONNE NATIONAL LABS, [3]CMN ARGONNE NATIONAL LABS, [4]UNIVERSITY OF MICHIGAN, [5]DEPARTMENT OF PHYSICS, CASE WESTERN RESERVE UNIVERSITY, [6]UNIVERSITY OF CHICAGO. — WE PRESENT PROGRESS ON ARGONNE/KICP TES BOLOMETERS FABRICATED AT ARGONNE NATIONAL LABS INCLUDING OPTICAL AND THERMAL PROPERTIES AND AN IMPROVED DESIGN FOR THE SECOND GENERATION OF DETECTORS. THESE DETECTORS WILL BE INSTALLED IN A RECEIVER THAT WILL MOUNT ON THE SOUTH POLE TELESCOPE AND WILL MEASURE THE POLARIZATION OF THE COSMIC MICROWAVE BACKGROUND RADIATION. THE SENSORS ARE BOLOMETERS CONSISTING OF A MO/AU TRANSITION EDGE SENSORS (TES) SUSPENDED ON SILICON NITRIDE WITH A GOLD BAR ABSORBER TO COUPLE RADIATION TO THE DEVICE. WE PRESENT OPTICAL MEASUREMENTS AND THERMAL CHARACTERIZATIONS OF PROTOTYPE DEVICES.

WORK AT THE UNIVERSITY OF CHICAGO IS SUPPORTED BY THE NSF THROUGH GRANT ANT- 0638937 AND THE NSF PHYSICS FRONTIER CENTER GRANT PHY-0114422 TO THE KICP AT THE UOFC AND SUPPORT FROM THE KAVLI FOUNDATION AND THE GORDON AND BETTY MOORE FOUNDATION.

1EA-06

ULTRASENSETIVE TES BOLOMETER FOR FIR SPACE BASED ASTRONOMY. ***D. MOROZOV***[1], *P. MAUSKOPF*[1], *P. ADE*[1], *M. BRUIJN*[2], *P. DE KORTE*[2], *H. HOEVERS*[2], *M. RIDDER*[2], *P. KHOSROPANAH*[2], *J. GAO*[3]; [1]CARDIFF UNIVERSITY, [2]NETHERLANDS INSTITUTE FOR SPACE RESEARCH (SRON), [3]DELFT UNIVERSITY. — WE PRESENT RESULTS OF DEVELOPING THE BACKGROUND LIMITED TRANSITION EDGE SENSOR (TES) BOLOMETER FOR THE WAVELENGTH BAND 30 − 60 MM. SUPERCONDUCTING THERMOMETER MADE OF TI/AU BILAYER AND TA RADIATION ABSORBER ARE SUSPENDED ON THIN SIXNY MEMBRANE LEGS. DEVICE IS VOLTAGE BIASED ON THE TRANSITION AND THE CURRENT TROUGH THE DEVICE IS MEASURED BY SQUD AMPLIFIER. THE THERMOMETER HAS TRANSITION TEMPERATURE TC = 100 MK AND THE DEVICE IS OPERATING AT 70 MK. DETECTOR IS COUPLED TO FIR RADIATION BY MEANS OF BACK CAVITY ON THE CHIP HOLDER AND HORN. RADIATION BAND IS DEFINED BY THE PAIR OF LOWPASS AND HIGHPASS MESH FILTERS. WE CHARACTERIZED OPTICAL PERFORMANCE OF DEVICE IN ABOVE WAVELENGTH BAND. HERE WE PRESENT MEASUREMENTS OF OPTICAL NOISE EQUIVALENT POWER (NEP), OPTICAL EFFICIENCY, DYNAMIC RANGE AND TIME CONSTANT. THE RESULTS SHOW THAT MEASURED TES DETECTORS ARE CLOSE TO MEET THE REQUIREMENT OF THE SHORT BAND OF SAFARI FTS IMAGING INSTRUMENT ON SPICA MISSION.

1EA-07

NBSI TES ARRAY AND READOUT: DEVELOPMENT AND CHARACTERISATION ***F. PAJOT***[1], *Y. ATIK*[1], *B. BELIER*[2], *L. BERGÉ*[3], *G. BORDIER*[4], *E. BRÉELLE*[4], *L. DUMOULIN*[3], *C. EVESQUE*[1], *F. GADOT*[2], *B. LERICHE*[1], *S. MARNIEROS*[3], *J. MARTINO*[4], *M. PIAT*[4], *D. PRELE*[4], *F. VOISIN*[4], *J. ZHONG*[5]; [1]IAS CNRS-UP11 ORSAY, [2]IEF CNRS-UP11 ORSAY, [3]CSNSM CNRS-UP11 ORSAY, [4]APC CNRS-UP7 PARIS, [5]IAS CNRS-UP11 ORSAY AND PMO NANJING, CHINA. — FUTURE GROUND AND SPACE ASTRONOMY EXPERIMENTS WILL REQUIRE LARGE ARRAYS OF SENSITIVE DETECTORS IN THE SUBMILLIMETER AND MILLIMETER RANGE. WE PRESENT HERE THE CHARACTERISATION AND LABORATORY PERFORMANCES OF A TES ARRAY. WE ARE USING NBSI SENSORS ON SIN MEMBRANES. THE READOUT ELECTRONICS IS BASED ON SQUIDS AND A SIGE ASIC. AN ANTENNA COUPLING DESIGN IS PRESENTED. SYSTEM PERFORMANCE ACHIEVED SO FAR IS ADAPTED FOR A GROUND BASED INSTRUMENT. THESE DETECTORS ARE INCLUDED IN THE DESIGN OF THE QUBIC B-MODE DETECTION EXPERIMENT FOR THE DOME C.

1EB-01

(INVITED) **MODULAR, MULTI-FUNCTION DIGITAL-RF RECEIVER SYSTEM** ***D. GUPTA****, D. KIRICHENKO, V. DOTSENKO, R. MILLER, J. DELMAS, R. WEBBER, S. GOVORKOV;* HYPRES. — SIGNIFICANT ADVANCES HAVE BEEN MADE IN DEVELOPING CRYOCOOLED SUPERCONDUCTOR DIGITAL RECEIVER SYSTEMS OF INCREASING FUNCTIONALITY, MODULARITY AND USER-FRIENDLINESS. FIRST, A PAIR OF LABORATORY PROTOTYPE SYSTEMS (ADR-003 AND ADR-004) WAS BUILT AND DEMONSTRATED WITH SINGLE-CHIP DIGITAL RECEIVERS FOR RF COMMUNICATION AND SIGNALS INTELLIGENCE APPLICATIONS, EACH COMPRISING A LOWPASS ANALOG-TO-DIGITAL CONVERTER (ADC) ATTACHED TO AN ON-CHIP DIGITAL CHANNELIZER AND CLOCKED AT 24.32 GHZ. THE MODULAR DESIGN METHODOLOGY ENSURES THAT WITHIN ITS INPUT-OUTPUT AND HEAT LOAD CAPACITY, THE SYSTEM COULD BE RECONFIGURED TO PERFORM A DIFFERENT FUNCTION BY CHANGING THE CHIP MODULE AND BY REPROGRAMMING THE FPGA. ADR-004 WAS RECONFIGURED WITH A 1.1-GHZ BANDPASS ADC, HIGH-TEMPERATURE SUPERCONDUCTOR (HTS) ANALOG FILTER AT 40 K TO PERFORM WORLD'S FIRST MULTI-NET LINK-16 DEMONSTRATION AT A U.S. NAVY FACILITY. AN IMPROVED VERSION (ADR-005), CONSISTING OF A 5×5 MM^2 7.5-GHZ BANDPASS ADC CHIP AND AN FPGA CHANNELIZER, SUCCESSFULLY REPEATED THE OVER-THE-AIR SATCOM DEMONSTRATION PERFORMED PREVIOUSLY USING A 1-CM^2 SINGLE-CHIP BANDPASS DIGITAL RECEIVER WITH AN ON-CHIP SUPERCONDUCTOR CHANNELIZER. THIS SYSTEM RAN ERROR-FREE FOR OVER 12 HOURS WITH AND WITHOUT A LOW-NOISE AMPLIFIER. TO OUR KNOWLEDGE, THIS IS THE FIRST TIME A SATCOM RECEIVER HAS BEEN OPERATED WITHOUT ANALOG AMPLIFICATION AND DOWN-CONVERSION.

THIS WORK WAS SUPPORTED IN PART BY THE OFFICE OF NAVAL RESEARCH

1EB-02

PRACTICAL OPERATION OF CRYOGEN-FREE PROGRAMMABLE JOSEPHSON VOLTAGE STANDARDS ***R. E. SCHWALL****, J. POWER, C. J. BURROUGHS, P. D. DRESSELHAUS, S. P. BENZ;* NIST. — CRYOGEN-FREE OPERATION IS RAPIDLY BECOMING THE PREFERRED IMPLEMENTATION OF PROGRAMMABLE JOSEPHSON VOLTAGE STANDARD (PJVS) SYSTEMS AS LIQUID HELIUM AVAILABILITY IS BECOMING MORE PROBLEMATIC. THERE ARE STRONG OPERATIONAL INCENTIVES FOR USING THE SMALLEST POSSIBLE CRYOCOOLER IN ORDER TO MINIMIZE ACOUSTIC NOISE, SYSTEM FOOTPRINT, AND POWER CONSUMPTION. THE CRYOCOOLER CAPACITY REQUIRED FOR RELIABLE OPERATION IS DEPENDENT ON A NUMBER OF FACTORS IN ADDITION TO THE POWER DISSIPATION OF THE PJVS CHIP. THESE INCLUDE THE CHOICE OF CHIP SUBSTRATE, THE JUNCTION FABRICATION PROCESS, THE THERMAL INTERFACES, WIRING PARASITIC HEAT LEAKS AND THE METHODS USED FOR STABILIZING THE COLDHEAD TEMPERATURE. WE HAVE DEMONSTRATED OPERATION OF A 5V PROGRAMMABLE JOSEPHSON VOLTAGE STANDARD ON A CRYOCOOLER AND USED ITS VARIOUS SUBARRAYS TO AS BOTH HEAT SOURCES AND TEMPERATURE SENSORS TO CHARACTERIZE THE THERMAL RESPONSE OF THE CONDUCTION CIRCUIT.WE REPORT HERE THE EVALUATION OF THE RELEVANT COOLING FACTORS USING A TIME-GATED MEASUREMENT TECHNIQUE WHICH ALLOWS PRECISE MEASUREMENT OF ON-CHIP ARRAY TEMPERATURE IN THE PRESENCE OF THE FLUCTUATING COLDHEAD TEMPERATURE CHARACTERISTIC OF A GIFFORD-MCMAHON CYCLE CRYOCOOLER. WE PRESENT RESULTS SUGGESTING THAT WITH APPROPRIATE SYSTEM DESIGN, OPERATION OF A PRACTICAL 10V PJVS ON A SMALL (NOMINALLY 100 MW CAPACITY AT 4.2K) CRYOCOOLER IS POSSIBLE.

1EB-03

A HTS SQUID RECEIVER SYSTEM FOR TRANSIENT ELECTRO-MAGNETIC MEASUREMENTS ***R. STOLZ***[1]*, A. CHWALA*[1]*, F. BAUER*[1]*, V. ZAKOSARENKO*[1]*, R. IJSSELSTEIJN*[1]*, U. HÜBNER*[1]*, M. STARKLOFF*[2]*, N. BONDARENKO*[2]*, M. MEYER*[2]*, H. MEYER*[1]*;* [1]IPHT JENA, [2]SUPRACON AG. — IN THE LAST DECADE IPHT HAS DEVELOPED A HIGHLY SENSITIVE GEOPHYSICAL MEASUREMENT SYSTEM FOR TRANSIENT ELECTRO-MAGNETICS (TEM). THESE SYSTEMS, BASED ON LTS SQUIDS, WERE SUCCESSFULLY APPLIED IN A MANY SURVEYS AROUND THE WORLD.FOR VERY REMOTE AREAS, WHERE LIQUID HELIUM SUPPLY IS LOGISTICALLY DIFFICULT, A COMPROMISE BETWEEN SENSITIVITY AND EASE OF USE COULD LAY IN USING HTS SQUIDS. THEREFORE, A NEW SYSTEM USING THREE ORTHOGONAL HTS SQUIDS HAS BEEN DEVELOPED. THE SQUIDS HAVE A RUGGED FLIP CHIP CONSTRUCTION WITH A 1CM X 1CM AREA. THEY HAVE A CRITICAL CURRENT OF ABOUT 15 TO 25 µA AND A MODULATION VOLTAGE SWING OF 40 TO 70 µV. THE NOISE IS IN THE RANGE OF 20 TO 50 FT/SQRT(HZ).THE SENSORS ARE READ OUT BY A FEEDBACK LOOP USING A HIGH SPEED AC-BIAS SCHEME WITH A TUNEABLE FREQUENCY IN THE RANGE OF 2 MHZ UP TO 10 MHZ TO REDUCE LOW FREQUENCY NOISE. THE 1/F NOISE CORNER IS ABOUT 30 HZ IN A MAGNETIC SHIELDING. THE SLEW RATE CAN ACHIEVE UP TO 3*10^6 PHI0/S.THE RESULTS OF THE FIRST FIELD TRIALS WITH THE NEW HTS TEM SYSTEM IN GERMANY WILL BE REPORTED.

1EB-04

OCEANMAG - A FULLY MOBILE MAGNETIC GRADIENT TENSOR MEASUREMENT SYSTEM ***S. T. KEENAN****, D. A. CLARK, P. J. CUSACK, J. A. YOUNG, C. P. FOLEY, K. E. LESLIE;* CSIRO MATERIALS SCIENCE AND ENGINEERING. — WE ARE DEVELOPING A MOBILE UNDERWATER SYSTEM FOR MEASURING THE MAGNETIC GRADIENT TENSOR BASED ON HIGH-T_C SQUIDS. THIS SYSTEM SERVES TO ENHANCE AND IMPROVE CONVENTIONAL MARINE MAGNETIC SURVEYS FOR APPLICATIONS SUCH AS SEABED MINERAL EXPLORATION AND UNEXPLODED ORDNANCE (UXO) DETECTION. FIVE INDEPENDENT COMPONENTS OF THE GRADIENT TENSOR ARE OBTAINED FROM THE OUTPUTS OF SIX PLANAR SQUID GRADIOMETERS MOUNTED ON A HEXAGONAL PYRAMID STRUCTURE. THE SQUID SENSORS ARE LONG BASELINE FLIP-CHIP GRADIOMETERS. THEY WERE DESIGNED TO PROVIDE A HIGH GRADIENT SENSITIVITY (~ 20 FT CM^{-1} $HZ^{-1/2}$ AT 10 HZ WHEN SHIELDED) AND INCREASED COMMON MODE REJECTION (INTRINSIC BALANCE OF ~10^3). EACH PLANE OF THE PYRAMID ALSO INCLUDES A SQUID MAGNETOMETER TO FURTHER IMPROVE THE BALANCE. TO CIRCUMVENT THE PROBLEM OF INCREASED NOISE ASSOCIATED WITH OPERATING IN THE EARTH'S FIELD WE ARE DEVELOPING A HIGHLY ACCURATE DUAL-STAGE FEEDBACK SYSTEM. THE FIRST STAGE USES ROOM TEMPERATURE ANISOTROPIC MAGNETORESISTIVE (AMR) REFERENCE SENSORS TO PROVIDE A LOW-FIELD ENVIRONMENT IN WHICH TO COOL THE SQUID SYSTEM AND THE SECOND STAGE USES SQUID MAGNETOMETERS. THE FEEDBACK FIELD IS PROVIDED USING A TRI-AXIAL SPHERICAL COIL ARRANGEMENT WHICH WILL PROVIDE A FIELD UNIFORMITY OF BETTER THAN 1:10^5 ACROSS THE SYSTEM. WE PRESENT RESULTS OF FULL GRADIENT TENSOR MEASUREMENTS, STATIC AND IN MOTION, ACHIEVED IN BOTH LABORATORY AND FIELD CONDITIONS.

THIS WORK WAS CARRIED OUT FOR THE CSIRO WEALTH FROM OCEANS NATIONAL RESEARCH FLAGSHIP. THE RESEARCH WAS SUPPORTED IN PART BY THE U.S. DEPARTMENT OF DEFENSE, THROUGH THE STRATEGIC ENVIRONMENTAL RESEARCH AND DEVELOPMENT PROGRAM (SERDP).

1EB-05

SYSTEM-LEVEL COMPARISON FOR ROOM TEMPERATURE AND CRYOGENICALLY COOLED RF RECEIVER FRONT-ENDS ***A. M. LEESE DE ESCOBAR***[1]*, T. GATHMAN*[1]*, D. GUPTA*[2]*;* [1]SPAWAR SYSTEMS CENTER PACIFIC, [2]HYPRES, INC.. — AN RF RECEIVER SYSTEM FRONT-END WAS MODELED IN ORDER TO QUANTIFY THE POTENTIAL BENEFIT OF UTILIZING CRYOGENIC COOLING TO OPTIMIZE SYSTEM PERFORMANCE. THE SYSTEM ARCHITECTURE WAS MODELED USING A 300K BASELINE AND THEN AGAIN AT 77K. THE SYSTEM CONTAINS NOTCH FILTERS, MULTIPLEXERS AND LOW NOISE AMPLIFIERS. WHERE BENEFICIAL, SUPERCONDUCTOR WAS ASSUMED INSTEAD OF METAL, ALLOWING A FIRST ORDER COMPARISON OF THE SYSTEM NOISE BENEFITS OF USING SUPERCONDUCTOR

INSTEAD OF COLD METAL IN CRITICAL SYSTEM COMPONENTS. FINITE Q VALUES WERE USED TO DIFFERENTIATE METAL AND SUPERCONDUCTOR RESONATORS. ALL LOSSES (METAL, COLD METAL, AND SUPERCONDUCTOR) WERE MODELED WITH RESPECT TO FREQUENCY. RESULTS ARE PRESENTED FOR AN ARCHITECTURE DESIGNED FOR THE V/UHF SPECTRAL REGION. ANALOG FRONT-END RESULTS ARE CONTRASTED AGAINST AN ASSUMED 4K ALL DIGITAL SYSTEM.

TACTICAL SIGINT TECHNOLOGY PROGRAM AND THE OFFICE OF NAVAL RESEARCH INTOP INP

1EB-06

AN OPTICAL INPUT MODULE WITH SUPERCONDUCTING SINGLE-FLUX-QUANTUM CIRCUIT OPERATING AT 1550 NM BAND ***H. TERAI****, S. SHINADA, Z. WANG, N. WADA;* NATIONAL INSTITUTE OF INFORMATION AND COMMUNICATIONS LABORATORY. — HIGH-SPEED OPERATION OF OVER 100-GHZ CLOCK FREQUENCY WITH EXTREMELY LOW POWER CONSUMPTION OF SUPERCONDUCTING SINGLE-FLUX-QUANTUM (SFQ) CIRCUITS ARE PROMISING FOR THE APPLICATION TO FUTURE ULTRAFAST PHOTONIC NETWORK. AN OPTICAL DATA STREAM OF OVER 40 GBIT/S COULD BE PROCESSED BY AN SFQ CIRCUIT WITHOUT DEMULTIPLEXING, WHICH CAN CONTRIBUTE TO THE REDUCTION OF TOTAL POWER CONSUMPTION IN THE PHOTONIC NETWORK. A KEY TECHNOLOGY TO APPLY THE SFQ CIRCUIT TO THE PHOTONIC NETWORK SYSTEM IS AN INTERFACE BETWEEN OPTICAL DEVICES AND SFQ CIRCUITS. WE DEVELOPED AN OPTICAL INPUT MODULE CONSISTING OF A BUILT-IN METAL-SEMICONDUCTOR-METAL PHOTODIODE (MSM-PD) WITH A CO-PLANAR WAVEGUIDE TRANSMISSION LINE. THIS MODULE WAS FABRICATED ON AN INP SUBSTRATE AND FLIP-CHIP BONDED WITH SFQ CIRCUIT ON A SI SUBSTRATE. THE FABRICATED MSM-PD SHOWED PHOTOSENSITIVITIES OF MORE THAN 0.2 A/W FOR THE WAVELENGTH RANGE 1480 NM TO 1530 NM EVEN AT 4.2 K. WE SUCCEEDED IN GENERATING SFQ PULSES USING AN OPTICAL INPUT POWER OF 0.75 MW, WHICH ARE MUCH LESS THAN THE THERMAL LOAD OF ABOUT 25 MW PER CABLE ON THE COOLING SYSTEM USING WIDEBAND COAXIAL CABLES.

THIS WORK WAS SUPPORTED IN PART BY THE NEW ENERGY AND INDUSTRIAL TECHNOLOGY DEVELOPMENT ORGANIZATION (NEDO) AS SUPERCONDUCTORS NETWORK DEVICE PROJECT.

1EB-07

CARBON NANOTUBE BASED POLYMER ADHESIVE FOR SUPERCONDUCTOR MULTI-CHIP MODULE PACKAGING ***R. S. E. JOHN***[1]*, C. S. THOMPSON*[1]*, V. V. DOTSENKO*[2]*, J. DELMAS*[2]*, D. GUPTA*[2]*, A. P. MALSHE*[1]*;* [1]UNIVERSITY OF ARKANSAS, [2]HYPRES INC.. — WE REPORT THE DEVELOPMENT OF A NANO-ENGINEERED CRYOGENIC ADHESIVE (NECA) CONSISTING OF AN EPOXY IMPREGNATED WITH SINGLE WALLED CARBON NANOTUBES (SWNT) FOR BONDING NIOBIUM-BASED SUPERCONDUCTOR MULTI CHIP MODULES (MCMS). THE THERMAL CONDUCTANCE OF THE NECA WAS MEASURED AS A FUNCTION OF SWNT LOADING. DEPENDING UPON THE LOADING CONCENTRATION, THE NECA OFFERS 300% - 900% ENHANCEMENT IN THERMAL CONDUCTION OVER THE BASE ADHESIVE WHILE MAINTAINING HIGH ELECTRICAL RESISTIVITY. ADDITIONALLY, WE REPORT THE THERMAL MODELING RESULTS FOR A NIOBIUM-BASED SUPERCONDUCTING SINGLE CHIP MODULE WITH THE INCORPORATION OF PURE EPOXY AND NECA. WHEN THE BASE EPOXY IS USED AS THE UNDERFILL MATERIAL, THE THERMAL MODEL PREDICTS > 100 MK TEMPERATURE GRADIENT BETWEEN THE FLIPPED CHIP WITH ACTIVE CIRCUITRY AND THE PASSIVE CARRIER SUBSTRATE, WHICH MIGHT DEGRADE THE CHIP'S PERFORMANCE AND THE OPERATING MARGINS. WITH THE USE OF NECA AS THE UNDERFILL, WE REPORT REDUCTION OF TEMPERATURE GRADIENTS TO A MORE ACCEPTABLE LEVEL OF ~50 MK. THESE RESULTS ARE EXPANDED TO FORESEEABLE MCM PACKAGE DESIGNS TO HIGHLIGHT THE MERIT OF NECA AS AN UNDERFILL MATERIAL FOR SUPERCONDUCTING ELECTRONIC PACKAGES.

THE AUTHORS WOULD LIKE TO THANK ROBERT WEBBER, STEVE KAPLAN FOR TECHNICAL DISCUSSIONS AND MOURAD BENAMARA FOR ASSISTANCE WITH TEM IMAGING OF CARBON NANOTUBES AND EPOXY IMPREGNATED WITH CARBON NANOTUBES.

1EC-01

(INVITED) **LONG COHERENCE TIME IN A SUPERCONDUCTING PERSISTENT-CURRENT QUBIT** ***J. BYLANDER***[1]*, S. GUSTAVSSON*[1]*, F. YOSHIHARA*[2]*, K. HARRABI*[2]*, Y. NAKAMURA*[3]*, J. TSAI*[3]*, W. D. OLIVER*[4]*;* [1]MIT, [2]THE INSTITUTE OF PHYSICAL AND CHEMICAL RESEARCH (RIKEN), JAPAN, [3]RIKEN AND NANO ELECTRONICS RESEARCH LABORATORIES, NEC CORP., JAPAN, [4]MIT AND MIT LINCOLN LABORATORY. — WE REPORT RECORD RELAXATION TIMES T1 IN EXCESS OF 10 US IN AN ALUMINUM PERSISTENT-CURRENT QUBIT (FLUX QUBIT), READ OUT BY A HYSTERETIC DC SQUID. WHEN OPERATING THE QUBIT AT THE OPTIMAL POINT IN FLUX BIAS, SPIN-ECHO REFOCUSING GIVES AN ENERGY-RELAXATION LIMITED COHERENCE TIME T2 = 2T1. THE FREE-INDUCTION DECAY TIME CONSTANT T2* REACHES 2.5 US. WE CONFIRM THE GAUSSIAN PHASE DECAY INDICATIVE OF NEARLY 1/F FLUX NOISE AS WELL AS THE NOISE AMPLITUDE REPORTED IN REF. [1]. CONTRARY TO DEPHASING, THE ENERGY RELAXATION RATE HAS WEAK BIAS DEPENDENCE. FINDING THE MICROSCOPIC MECHANISM FOR T1 RELAXATION REMAINS ONE OF THE MOST IMPORTANT TOPICS IN THIS FIELD.WE ALSO CHARACTERIZED A QUBIT WITH VARIABLE TUNNEL COUPLING 0.8-4.8 GHZ, WHICH IS REALIZED BY REPLACING ONE OF THE JOSEPHSON JUNCTIONS IN THE QUBIT WITH A SQUID LOOP. THEN, THE INDEPENDENT ADJUSTMENT OF THE QUBIT ENERGY-LEVEL SEPARATION AND THE TUNNEL COUPLING ALLOWS FOR BOTH ZZ AND XZ QUBIT-QUBIT COUPLING ARCHITECTURES [2]. AT VARYING OPERATING POINTS, T1 RANGED FROM 1 TO 2 US, AND THE SPIN-ECHO REFOCUSED T2 DECAY WAS 700 NS.[1] F. YOSHIHARA, K. HARRABI, A.O. NISKANEN, Y. NAKAMURA, AND J. S. TSAI, PHYS. REV. LETT. 97, 167001 (2006).[2] F. G. PAAUW, A. FEDOROV, C. J. P. M HARMANS, AND J. E. MOOIJ, PHYS. REV. LETT. 102, 090501 (2009).

1EC-02

DESIGN IMPROVEMENTS FOR SUPERCONDUCTING QUBITS ***M. STEFFEN****, D. DIVINCENZO, S. KUMAR, M. KETCHEN, G. KEEFE, M. ROTHWELL, J. ROZEN;* IBM. — RAPID UNDERSTANDING OF DECOHERENCE PROCESSES, BOTH ENERGY AND PHASE RELAXATION, FOR SUPERCONDUCTING QUBITS LED TO NOVEL DESIGN MODIFICATIONS WITH WHICH VARIOUS QUBIT PERFORMANCE METRICS WERE IMPROVED DRAMATICALLY. ONE EXAMPLE OF A SUCCESSFULLY REDESIGNED QUBIT IS THE TRANSMON QUBIT. HERE WE SHOW THAT THERE ARE OTHER MODIFICATIONS THAT CAN MADE BESTOWING QUBITS WITH PROPERTIES WHICH WE BELIEVE ARE ADVANTAGEOUS FOR MULTI-QUBIT APPLICATIONS. SPECIFICALLY WE HIGHLIGHT A MODIFIED FLUX QUBIT WHICH IS LESS SENSITIVE TO SOME OF THE KNOWN DECOHERENCE SOURCES.

1EC-03

DIRECT OBSERVATION OF COHERENT POPULATION TRAPPING IN A SUPERCONDUCTING ARTIFICIAL ATOM ***W. R. KELLY****[1], Z. DUTTON[1], J. SCHLAFER[1], B. MOOKERJI[1], T. A. OHKI[1], J. S. KLINE[2], D. P. PAPPAS[2];* [1]RAYTHEON BBN TECHNOLOGIES, [2]NIST BOULDER. — THE PHENOMENON OF COHERENT POPULATION TRAPPING (CPT) OF AN ATOM (OR SOLID STATE ``ARTIFICIAL ATOM''), AND THE ASSOCIATED EFFECT OF ELECTROMAGNETICALLY INDUCED TRANSPARENCY (EIT), ARE CLEAR DEMONSTRATIONS OF QUANTUM INTERFERENCE DUE TO COHERENCE IN MULTI-LEVEL QUANTUM SYSTEMS. WE REPORT OBSERVATION OF CPT IN A SUPERCONDUCTING PHASE QUBIT BY SIMULTANEOUSLY DRIVING TWO COHERENT TRANSITIONS IN A $\LAMBDA$-TYPE CONFIGURATION, UTILIZING THE THREE LOWEST LYING LEVELS OF A LOCAL MINIMUM OF A PHASE QUBIT. WE OBSERVE $60(\PM 7)\%$ SUPPRESSION OF EXCITED STATE POPULATION UNDER CONDITIONS OF CPT RESONANCE. WE PRESENT DATA AND MATCHING THEORETICAL SIMULATIONS SHOWING THE DEVELOPMENT OF CPT IN TIME. FINALLY, WE USED THE OBSERVED TIME DEPENDENCE OF THE EXCITED STATE POPULATION TO CHARACTERIZE QUANTUM DEPHASING TIMES OF THE SYSTEM.

WE ACKNOWLEDGE GENEROUS INTERNAL SUPPORT FROM BBN TECHNOLOGIES TO CARRY OUT THIS WORK. WE THANK JON HABIF FOR THE SUGGESTION TO TRY THIS EXPERIMENT. THE FABRICATION OF THE DEVICE WAS FUNDED BY THE US GOVERNMENT AND IARPA.

1EC-04

QUANTUM NOISE BROADENED CAPTURE INTO AUTORESONANCE ***K. MURCH****, R. VIJAY, I. SIDDIQI;* QNL, UC BERKELEY. — A NONLINEAR JOSEPHSON JUNCTION OSCILLATOR DRIVEN NEAR RESONANCE CAN EXHIBIT BISTABILITY, FORMING THE BASIS FOR SENSITIVE, DIGITAL QUANTUM STATE READOUT. WE CONSIDER THE CASE OF A HIGH-Q RESONATOR EMBEDDED WITH A JOSEPHSON JUNCTION EXCITED WITH A CHIRPED FREQUENCY SIGNAL. FOR SUFFICIENT DRIVE AMPLITUDE, THE RESONATOR PHASE LOCKS WITH THE DRIVE SIGNAL AND ENTERS THE HIGH AMPLITUDE OSCILLATION STATE, A PHENOMENON KNOWN AS AUTORESONANCE. THE PROBABILITY OF CAPTURE IN A GIVEN CHIRPED PULSE DEPENDS ON THE INITIAL PHASE DIFFERENCE BETWEEN THE DRIVE SIGNAL AND OF THE FLUCTUATION INDUCED OSCILLATIONS OF THE RESONATOR. WE FIND THAT THE WIDTH OF THIS THRESHOLD IS IN AGREEMENT WITH RECENT THEORETICAL PREDICTIONS AND SCALES AS THE SQUARE ROOT OF THE TEMPERATURE AND CHIRP RATE. FOR A 6 GHZ RESONATOR, THE WIDTH SATURATES BELOW 150MK DUE TO THE ZERO-POINT FLUCTUATIONS OF THE RESONATOR.

1EC-05

MANUFACTURABLE PHASE QUBITS ***R. M. LEWIS****, J. E. BAUMGARDNER, A. A. PESETSKI, D. L. MILLER, E. FOLK, A. HERR, J. J. TALVACCHIO;* NORTHROP GRUMMAN. — WE REPORT ON DEVELOPMENT OF A MANUFACTURABLE SUPERCONDUCTING PHASE-QUBIT WITH LONG COHERENCE TIME. OUR QUBITS FEATURE AL/ALOX/AL TRILAYER JUNCTIONS AND ARE FABRICATED ON A STANDARD 6-INCH SI MANUFACTURING LINE AT NORTHROP GRUMMAN ELECTRONIC SYSTEMS. YIELD AND UNIFORMITY OF JC ARE ASSESSED ACROSS THE ENTIRE WAFER. INITIAL FABRICATION RUNS, ON VARYING SUBSTRATES, YIELDED DEVICES WITH T_1 TIMES UP TO 160 NS, RABI DECAY TIMES OF BETWEEN 80 AND 120 NS, AND RAMSEY FRINGE DECAYS (T_2) BETWEEN 40 AND 70 NS. SPECTROSCOPY OF THE |0> TO |1> TRANSITION SHOWS A DENSITY OF TWO-LEVEL-SYSTEMS CONSISTENT WITH REPORTS BY OTHER GROUPS. WE WILL ALSO DISCUSS FORTHCOMING RESULTS ON NEW QUBITS WITH SHUNTING CAPACITORS.

WE THANK RAY SIMMONDS AND HIS GROUP AT NIST-BOULDER FOR TECHNICAL ASSISTANCE.

1EC-06

ANOMALOUS SWITCHING CURVES IN A SQUID PHASE QUBIT ***H. KWON****[1], A. PRZYBYSZ[1], B. COOPER[1], H. PAIK[2], K. OSBORN[2], B. PALMER[2], R. BUDOYO[1], J. ANDERSON[1], C. LOBB[1], F. WELLSTOOD[1];* [1]UNIVERSITY OF MARYLAND, COLLEGE PARK, [2]LPS. — WE HAVE OBSERVED ANOMALOUS SWITCHING CURVES (S-CURVES) IN A DC SQUID PHASE QUBIT WHICH IN TURN LEAD TO ANOMALIES IN MEASUREMENTS OF RABI OSCILLATIONS, RELAXATION AND FIDELITY. THE DEVICE HAS TWO AL/ALOX/AL JOSEPHSON JUNCTIONS IN A 1 NH LOOP TO FORM A SQUID; ONE JUNCTION ACTS AS A PHASE QUBIT AND THE OTHER THAT ACTS AS A DETECTOR JUNCTION. THE QUBIT JUNCTION HAS A SIZE OF ABOUT 2 MM^2 WITH A CRITICAL CURRENT OF 0.1 MA AND HAS AN ADDED LOW-LOSS SIN SHUNTING CAPACITOR. THE 1 MA DETECTOR JUNCTION IS ISOLATED FROM THE BIAS LEADS BY AN ON-CHIP INDUCTOR-CAPACITOR (LC) NETWORK WITH AN 100 MHZ CUT-OFF. WE MEASURE THE STATE OF THE SYSTEM AT 20 MK BY SENDING A SHORT CURRENT PULSE TO THE DEVICE AND MONITORING WHETHER IT SWITCHES TO THE VOLTAGE STATE. WHEN MICROWAVES ARE USED TO PUMP TO THE 0 OR 1 STATE, THE RESULTING S-CURVES LOOK AS EXPECTED. HOWEVER, UNLIKE PREVIOUS RESULTS ON CONVENTIONAL PHASE QUBITS, WHEN

THE DEVICE IS PUMPED TO A SUPERPOSITION STATE, THE RESULTING S-CURVE IS NOT A WEIGHTED SUM OF THE 0 AND 1 S-CURVES. INSTEAD, THE S-CURVE APPEARS TO SHIFT TO LOWER PULSE CURRENT WITH INCREASING AMPLITUDE TO BE IN THE 1 STATE. WE WILL EXAMINE POSSIBLE EXPLANATIONS FOR THIS BEHAVIOR AND IMPLICATIONS FOR MEASUREMENT OF QUANTUM SUPERPOSITION STATES IN THIS SYSTEM.

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1EC-07

MEASUREMENTS OF A COOPER-PAIR BOX COUPLED TO A QUASI-LUMPED ELEMENT RESONATOR ***Z. KIM***[1]*, B. SURI*[1]*, V. ZARETSKEY*[1]*, S. NOVIKOV*[1]*, K. D. OSBORN*[2]*, F. C. WELLSTOOD*[3]*, B. S. PALMER*[2]*;* [1]DEPARTMENT OF PHYSICS, UNIVERISTY OF MARYLAND, [2]LABORATORY FOR PHYSICAL SCIENCES, [3]JQI, CNAM, DEPARTMENT OF PHYSICS, UNIVERISTY OF MARYLAND. — WE HAVE COUPLED A "QUASI-LUMPED ELEMENT" MICROWAVE RESONATOR WITH A RESONANT FREQUENCY OF 5.44 GHZ MADE OF SUPERCONDUCTING AL ON SAPPHIRE, TO AN AL/ALOX/AL COOPER-PAIR BOX (CPB) QUBIT. THE RESONATOR IS IN TURN WEAKLY COUPLED TO A TRANSMISSION LINE AND HAS A LOADED Q OF 30,000. WHEN THE QUBIT IS FAR DETUNED FROM THE RESONATOR, COMPARED WITH THE COUPLING STRENGTH, WE MEASURE THE STATE OF OUR CPB QUBIT BY MONITORING THE PHASE AND AMPLITUDE OF TRANSMITTED POWER APPLIED AT THE 5.44 GHZ RESONANCE [1, 2]. BY USING A SECOND MICROWAVE TONE RESONANT WITH THE CPB QUBIT, WE CAN EXCITE THE CPB FROM THE GROUND STATE AND EXTRACT THE CHARGING ENERGY AND JOSEPHSON ENERGY AS WELL AS THE COUPLING STRENGTH BETWEEN THE RESONATOR AND QUBIT. T_1 OF OUR TWO DEVICES WAS FOUND TO BE GREATER THAN A FEW MICROSECONDS AT 20 MK, CORRESPONDING TO A SPECTRAL DENSITY OF CHARGE NOISE $S_Q \sim 10^{-17}\ E^2$/HZ. SINGLE- AND TWO-TONE SPECTROSCOPY OF THIS SYSTEM WILL BE PRESENTED AS WELL AS MEASUREMENTS OF T_1 AND T_2^*.[1] ALEXANDRE BLAIS *ET AL*., PHYS. REV. A **69**, 062320 (2004).[2] A. WALLRAFF *ET AL*., PHYS. REV.L **95**, 060501 (2005).

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1EPA-01

EVOLUTION OF ELECTRICAL AND ELECTRODYNAMIC PROPERTIES OF $YBA_2CU_3O_{7-X}$ BICRYSTAL JOSEPHSON JUNCTIONS WITH OXYGEN LOADING ***I. I. GUNDAREVA***[1]*, O. Y. VOLKOV*[1]*, Y. Y. DIVIN*[2]*, V. N. GUBANKOV*[1]*, V. V. PAVLOVSKIY*[1]*;* [1]KOTEL'NIKOV INSTITUTE OF RADIO ENGINEERING AND ELECTRONICS OF RAS, MOSCOW, 125009, RUSSIA, [2]FORSCHUNGSZENTRUM JÜLICH, D-52425 JÜLICH, GERMANY. — IT WAS SHOWN RECENTLY, THAT [100]-TILT $YBA_2CU_3O_{7-X}$ BICRYSTAL JOSEPHSON JUNCTIONS (JJ) ARE VERY CLOSE TO THE RSJ MODEL WHEN ANNEALED IN OXYGEN [1]. HERE, WE PRESENT THE RESULTS OF MEASUREMENTS OF *IV*-CURVES AND DYNAMIC RESISTANCES $R_D(V)$ OF [001]-TILT BICRYSTAL JOSEPHSON JUNCTIONS AT VARIOUS LEVELS OF OXYGEN LOADING. OXYGEN CONTENT WAS MODIFIED BY ANNEALING IN OZONE ATMOSPHERE, IN VACUUM OR IN AIR. THE DEVIATIONS OF $I(V)$ AND $R_D(V)$ DEPENDENCIES FROM THOSE, PREDICTED BY RSJC MODEL, SUCH AS *IV*-CURVE NONLINEARITY AT HIGH VOLTAGES AND FINE FEATURES IN *IV*-CURVES WERE OBSERVED. EVOLUTION OF JUNCTION CHARACTERISTICS TO RSJC-LIKE ONES WAS DEMONSTRATED WITH OXYGEN LOADING OF GRAIN BOUNDARIES. ELECTRODYNAMIC PROPERTIES OF JJ WERE ANALYZED USING LOG-PERIODIC TERAHERTZ ANTENNAS, INTEGRATED WITH THE JUNCTIONS. FINE STRUCTURES, RELATED TO ANTENNA RESONANCES, WERE OBSERVED ON JJ CHARACTERISTICS AND WERE MODIFIED WITH OXYGEN CONTENT. THEIR MODIFICATIONS WERE EXPLAINED BY VARIATION OF COUPLING OF ANTENNA WITH JJ AND ELECTROMAGNETIC LOSSES IN GRAIN BOUNDARY AND SUPERCONDUCTING FILM.1. M. V. LYATTI, U. POPPE, Y. Y. DIVIN. IEEE TRANS. APPL. SUPERCOND. (2007) VOL. 17, N.2, PP. 314-317.

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1EPA-02

DESIGN OF A HTS RF-SQUID BASED ON BIEPITAXIAL JOSEPHSON JUNCTION TECHNOLOGY ***L. LONGOBARDI***[1]*, D. STORNAIUOLO*[2]*, G. PAPARI*[3]*, F. TAFURI*[1]*;* [1]SECONDA' UNIVERSITA' DEGLI STUDI DI NAPOLI AND CNR-SPIN, [2]CNR-SPIN, NAPOLI, [3]NEST, CNR-INFM AND SCUOLA NORMALE SUPERIORE DI PISA. — RECENTLY, THE OBSERVATION OF MACROSCOPIC QUANTUM EFFECTS IN HIGH CRITICALTEMPERATURE SUPERCONDUCTOR (HTS) JOSEPHSON JUNCTIONS (JJS) PAVED THE WAY TO THE POSSIBLE USE OF HTS IN QUANTUM HYBRID CIRCUITS. DISSIPATION IN HTS JJS HAS BEEN PROVEN TO BE BELOW EXPECTATIONS, EVEN IN JUNCTION CONFIGURATIONS DESIGNED TO FULLY EXPLOIT THE FUNCTIONALITY OF A D-WAVE ORDER PARAMETER SYMMETRY, WHERE LOW ENERGY QUASI-PARTICLES CAN BE MORE HARMFUL FOR COHERENCE.ALTHOUGH REPRODUCIBILITY AND YIELD HAVE TO BE IMPROVED TO REACH THE REQUIRED STANDARDS, YBACUO BIEPITAXIAL GRAIN BOUNDARY JUNCTIONS ARE VERY FLEXIBLE FOR CIRCUIT DESIGN AND CAN BE EASILY INTEGRATED INTO MORE COMPLEX CIRCUITS AND POSSIBLY IN HYBRID SYSTEMS.WE REPORT ON THE DESIGN OF YBACUO RF-SQUIDS BASED ON THE PROPERTIES OF SUB-MICRON BIEPITAXIAL JUNCTIONS WITH VARIABLE INTERFACE WITH RESPECT TO THE ORDER PARAMETERS OF THE TWO ELECTRODES. THE STUDY OF THE DOUBLE WELL POTENTIAL OF SUCH SYSTEM MAY OFFER FURTHER INSIGHTS FOR A DEEPER UNDERSTANDING OF THE DYNAMICS OF A HTS JOSEPHSON DEVICE. THE RF-SQUID HAS BEEN DESIGNED TO HAVE INDEPENDENT CONTROLS FOR THE BARRIER HEIGHT BETWEEN THE WELLS AND FOR THE RELATIVE POSITIONS OF THE ENERGY LEVELS IN DIFFERENT FLUXOID WELLS. THE FLUX STATE OF THE RF-SQUID IS READOUT BY AN INDUCTIVELY COUPLED DC SQUID MAGNETOMETER.

1EPA-03

STEP-EDGE JOSEPHSON JUNCTIONS WITH MULTILAYERED HIGH TEMPERATURE SUPERCONDUCTING THIN FILM ***O. V. SHCHERBAKOVA***[1]*, A. V. PAN*[1]*, S. FEDOSEEV*[1]*, J. DU*[2]*, S. K. H. LAM*[2]*, C. P. FOLEY*[1]*;* [1]ISEM, UNIVERSITY OF WOLLONGONG, [2]CSIRO MATERIALS SCIENCE AND ENGINEERING. — APPLICATION OF JOSEPHSON EFFECT IN SENSORS, ELECTRONIC AND METROLOGICAL DEVICES WORKING AT TEMPERATURE OF 77 K REQUIRES FABRICATION OF EFFICIENT AND REPRODUCIBLE HIGH TEMPERATURE SUPERCONDUCTING (HTS) JOSEPHSON JUNCTIONS (JJ). GENERALLY, IMPORTANT ASPECTS FOR APPLICATION OF JJS ARE NON-HYSTERETIC *I-V* CHARACTERISTICS, REPRODUCIBLE JUNCTIONS PARAMETERS (CRITICAL CURRENT, I_C, AND NORMAL RESISTANCE, R_N), AND A HIGH I_CR_N PRODUCT. THESE ISSUES ARE WELL ESTABLISHED IN JJS BASED ON LOW TEMPERATURE SUPERCONDUCTING MATERIALS, BUT BECOME OF A PARTICULAR CONCERN IN HTS JOSEPHSON JUNCTIONS. IT IS MAINLY DUE TO THE SMALL COHERENCE LENGTH AND THE COMPLEXITY OF STRUCTURAL CHARACTERISTICS PECULIAR TO HTS MATERIALS. IN ORDER TO ENHANCE THE PERFORMANCE OF HTS JUNCTIONS, WE INTRODUCE MULTILAYERED APPROACH TO YBCO-BASED STEP-EDGE GRAIN BOUNDARY JOSEPHSON JUNCTION MANUFACTURE. THIN YBCO AND MULTILAYERED YBCO/NDBCO/YBCO FILMS OF A SIMILAR THICKNESS (~190 NM) WERE GROWN BY A PULSED-LASER DEPOSITION TECHNIQUE ON MGO (100) SUBSTRATES WITH ARTIFICIALLY CREATED STEP EDGE. LARGE DISCREPANCIES OF I_C AND R_N VALUES WERE FOUND BETWEEN THESE TWO TYPES OF JUNCTION. DETAILED RESULTS OF THEIR STRUCTURAL AND ELECTRICAL PROPERTIES WILL BE REPORTED.

THIS WORK IS FINANCIALLY SUPPORTED BY THE AUSTRALIAN RESEARCH COUNCIL.

1EPA-05

ANNEALING TEMPERATURE EFFECTS ON YBCO/$LAALO_3$ AND YBCO/CEO_2/AL_2O_3 FOR MICROWAVE APPLICATIONS BY TFA-MOD ***Q. LI***[1]*, D. SHI*[1]*, X. ZHU*[2]*, L. WANG*[1]*, S. DOU*[1]*;* [1]INSTITUTE FOR SUPERCONDUCTING AND ELECTRONIC MATERIALS, UNIVERSITY OF WOLLONGONG, [2]KEY LABORATORY OF MATERIALS PHYSICS, INSTITUTE OF SOLID STATE PHYSICS, CHINESE ACADEMY OF SCIENCES. — YBCO SUPERCONDUCTING FILMS CAN BE USED AS MICROWAVE APPLICATIONS DUE TO THEIR LOW SURFACE RESISTANCE. BOTH $LAALO_3$ AND AL_2O_3 SUBSTRATES CAN BE CONSIDERED AS APPLICABLE ALTERNATIVES. IN THIS WORK, IN ORDER TO OPTIMIZE THE ANNEALING TEMPERATURE EFFECTS ON THE MICROSTRUCTURE AND PROPERTIES WERE INVESTIGATED FOR YBCO/$LAALO_3$ AND YBCO/CEO_2/R-CUT AL_2O_3 FILMS BY TFA-MOD. THE RESULTS SHOW THAT THE ANNEALING TEMPERATURE WINDOW IS BROADER FOR YBCO FILMS ON $LAALO_3$ SUBSTRATES; WHILE, THE WINDOW IS RELATIVE NARROW FOR YBCO FILMS ON CEO_2/AL_2O_3 SUBSTRATES. THE REASONS WERE ALSO DISCUSSED. THE RESULTS WILL PROVIDE USEFUL INFORMATION ABOUT PROCESSING EFFECTS ON YBCO FILMS USING TFA-MOD FOR MICROWAVE APPLICATIONS.

WE GRATEFULLY ACKNOWLEDGE THE FINANCIAL SUPPORT FROM THE AUSTRALIAN RESEARCH COUNCIL (ARC) THROUGH THE ARC LINKAGE PROJECT (LP0669456).

1EPA-06

NANOSTRUCTURING OF YBCO JOSEPHSON JUNCTIONS BY PHASE SEPARATION ***D. GUSTAFSSON****, B. IANDOLO, T. BAUCH, F. LOMBARDI;* CHALMERS UNIVERSITY OF TECHNOLOGY. — WE REPORT ON A NEW METHOD TO FABRICATE NANOSCALE BIEPITAXIAL YBA2CU3O7-D (YBCO) JOSEPHSON JUNCTIONS WITH WIDTHS DOWN TO 100 NM OR LESS WHILE AT THE SAME TIME AVOIDING THE DAMAGE DUE TO CONVENTIONAL PATTERNING PROCEDURE (E-LITHOGRAPHY IN COMBINATION WITH ION BEAM ETCHING). THE JUNCTIONS ARE FABRICATED BY DEPOSITING A YBCO FILM ON A MGO (110) SUBSTRATE PARTIALLY COVERED BY A THIN STO (110) SEED LAYER. THE YBCO GROWS (001) ORIENTED ON THE MGO AND (103) ORIENTED ON THE STO. FOR SPECIFIC DEPOSITION CONDITIONS THE MERGING REGION BETWEEN THE TWO FILMS WILL CONSIST OF A COMBINATION OF NANOSCALE (100-300 NM WIDE) GRAIN BOUNDARY CONNECTIONS SEPARATED BY MICROMETERS WIDE INSULATING Y2BACUO5 PHASE (GREEN PHASE). THE NANOJUNCTIONS ARE ISOLATED BY USING A FOCUS ION BEAM (FIB); SINCE THEY ARE EMBEDDED IN GREEN PHASE MATRIX, THEIR LATERAL SIDES WILL NOT BE TOUCHED BY FIB ETCHING. BY THIS PROCEDURE WE HAVE FABRICATED NANOJUNCTIONS AND NANOSQUIDS WITH ALMOST IDEAL MAGNETIC FIELD DEPENDENCE OF THE MAXIMUM JOSEPHSON CURRENT AND SPECIFIC RESISTANCE MORE THAN 1 ORDER OF MAGNITUDE LOWER COMPARED TO THE VALUES USUALLY OBTAINED BY STANDARD PATTERNING TECHNIQUE. THESE FACTS CLEARLY SHOW THAT, WE ARE GETTING CLOSER TO PROBE THE INTRINSIC PROPERTIES OF THE GRAIN BOUNDARY WHICH HAS STRONG IMPLICATIONS BOTH FOR BASIC PHYSIC STUDIES AND FOR THE REALIZATION OF HTS BASED NANODEVICES.

1EPA-07

TRANSPORT PROPERTIES OF YBCO NANOWIRES ***S. NAWAZ****, T. BAUCH, F. LOMBARDI;* CHALMERS UNIVERSITY OF TECHNOLOGY. — THE PHENOMENON OF SUPERCONDUCTIVITY IS SUPPRESSED IN LOW DIMENSIONAL SUPERCONDUCTING STRUCTURES (NANOSCALE) DUE TO THERMAL AND QUANTUM PHASE SLIP EVENTS. TO EXPLORE THIS LOW DIMENSIONAL REGIME IN DETAIL, A LOT OF WORK HAS BEEN CARRIED OUT IN LOW TEMPERATURE SUPERCONDUCTING NANOWIRES. EXPERIMENTS HOWEVER ARE STILL NOT CONCLUSIVE. TO STUDY THERMAL AND QUANTUM PHASE SLIP PROCESSES IN HIGH TEMPERATURE SUPERCONDUCTORS (HTS) IT IS IMPORTANT TO ESTABLISH RELIABLE FABRICATION TECHNIQUES TO OBTAIN REPRODUCIBLE NANOWIRES. BECAUSE OF THE ABSENCE OF LIFT OFF PROCEDURES AND THE EXTREMELY SMALL COHERENCE LENGTH OF HTS THIS IS A VERY CHALLENGING TASK. IN THIS WORK WE HAVE FABRICATED YBCO NANOWIRES ON MGO SUBSTRATES BY E-BEAM LITHOGRAPHY, AR- ETCHING AND AN AMORPHOUS CARBON AS ETCHING MASK. IN THIS WAY WE WERE ABLE TO FABRICATE YBCO NANOWIRES WITH

DIFFERENT LENGTHS AND WIDTH DOWN TO70 NM. WIRES WITH DIFFERENT DIMENSIONS AND LENGTHS HAD VALUES OF THE CRITICAL CURRENT DENSITY VARYING OF SEVERAL ORDERS OF MAGNITUDE. HERE WE PRESENT THE ELECTRICAL CHARACTERIZATION OF OUR NANOWIRES DOWN TO 300 MK. FROM THE MICROWAVE RESPONSE AS A FUNCTION OF THE POWER WE CLEARLY OBSERVE DIFFERENT BEHAVIOR FOR THE WIRE WITH THE SAME WIDTH AND DIFFERENT LENGTHS. JOSEPHSON JUNCTION LIKE BEHAVIOR IS OBSERVED AT THE LOWEST CRITICAL CURRENT DENSITY

WE ACKNOWLEDGE OUR THANKS TO DMITRY S.GOLUBEV FOR VERY USEFUL DISCUSSIONS ON PHASE SLIP PROCESSES AND PROVIDING RELATED LITERATURE.

1EPA-08

NUMERICAL CALCULATION STUDY ON THE CURRENT DISTRIBUTION OF YBCO NANOBRIDGES AND ITS APPLICATION TO THE CONTROL OF THE CHARACTERISTICS OF ASYMMETRIC BRIDGES ***M. INOUE****, K. KAJINO, K. FUJITA, K. HAYAKAWA, A. FUJIMAKI;* NAGOYA UNIVERSITY. — CURRENT DISTRIBUTION OF YBCO NANOBRIDGES WAS INVESTIGATED BY THE NUMERICAL CALCULATION METHOD AND THE RESULTS WERE APPLIED TO ASYMMETRIC BRIDGES. HIGH-TEMPERATURE-SUPERCONDUCTOR (HTS) NANOBRIDGES ARE IMPORTANT IN REALIZING NOVEL DEVICES. IN ORDER TO STUDY PROPERTIES OF NARROW BRIDGES AND THE BEHAVIOR OF MAGNETIC FLUX IN THE NANOBRIDGES, WE CARRIED OUT NUMERICAL CALCULATION OF THE CURRENT DISTRIBUTION IN THE BRIDGE, WHICH IS IMPORTANT FOR INVESTIGATING THE BEHAVIOR OF THE FLUX QUANTUM. THE CURRENT DISTRIBUTION CHANGES NOT ONLY BY THE BRIDGE WIDTH BUT ALSO BY THE BRIDGE SHAPE. WE CALCULATED THE CURRENT DISTRIBUTION BY THE FINITE ELEMENT METHOD FOR SEPARATING THE EFFECT OF THE BRIDGE WIDTH AND THAT OF THE BRIDGE SHAPE, WHICH IS DIFFICULT BY THE ANALYTICAL METHOD, AND OBTAINED THE WIDTH DEPENDENCE OF THE CURRENT DISTRIBUTION FOR NECK-SHAPED BRIDGES NARROWER THAN 150 NM. WHEN WE APPLY THIS METHOD TO ASYMMETRIC BRIDGES, WE CAN EXPECT ASYMMETRIC CURRENT-VOLTAGE CHARACTERISTICS CAUSED BY THE RATCHET-LIKE VORTEX BEHAVIOR ORIGINATING IN THE ASYMMETRIC CURRENT DISTRIBUTION. WE DEMONSTRATED SUCH EFFECT BY MAKING BRIDGES USING YBCO FILMS.

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1EPA-09

RATCHET EFFECT OF VORTEX MOTION IN ASYMMETRICAL NANOBRIDGES WITH A MAGNETIC FIELD ***K. KAJINO****, K. FUJITA, K. HAYAKAWA, M. INOUE, A. FUJIMAKI;* NAGOYA UNIVERSITY. — WE REPORT YBA2CU3O7-X (YBCO) NANOBRIDGES WITH AN ASYMMETRICAL STRUCTURE BASED ON THE RATCHET EFFECT OF VORTEX MOTION, AIMING TO THE APPLICATION FOR SUPERCONDUCTING RECTIFIERS IN SINGLE-FLUX-QUANTUM CIRCUITS. THE BIAS CURRENT DISTRIBUTION IN WIDTH DIRECTION OF NANOBRIDGES VARIES WITH THE BRIDGE SHAPE. FOCUSING ON THIS, WE PREPARED ASYMMETRICAL NANOBRIDGES (ANBS). ANBS WILL SHOW ASYMMETRICAL CHARACTERISTICS IN AN EXTERNAL MAGNETIC FIELD, BECAUSE THE DIRECTIONS OF VORTEX MOTION ARE RESTRICTED AS THE RATCHET EFFECT. 4 PARALLEL, 200 NM-WIDE YBCO-ANBS WERE PREPARED BY ELECTRON BEAM LITHOGRAPHY. THEY SHOWED ASYMMETRIC CURRENT-VOLTAGE CHARACTERISTICS AND PERIODIC VOLTAGE MODULATION WITH AN EXTERNAL MAGNETIC FIELD. WE ALSO OBSERVED THE INCREASE IN THE CRITICAL CURRENTS FOR ONE MAGNETIC FIELD DIRECTION AND THE DECREASE FOR THE OPPOSITE DIRECTION, WHICH REFLECTS THE EFFECT OF THE ASYMMETRICAL SHAPE. THE CRITICAL CURRENTS VARIED BY 5-10 PERCENT AT 2.5 MT, AND LINEARLY DEPENDED ON THE MAGNETIC FIELD IN A RANGE OF 0-2.5 MT. WE WILL DISCUSS THE WIDTH AND LOOP SIZE DEPENDENCES OF THE MAGNETIC FIELD SENSITIVITY TO ENHANCE THE ASYMMETRIC CHARACTERISTICS.

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1EPB-01

DIFFUSION STOP-LAYERS FOR SUPERCONDUCTOR INTEGRATED CIRCUITS AND QUBITS WITH NB-BASED JOSEPHSON JUNCTIONS ***S. K. TOLPYGO****, D. AMPARO, R. T. HUNT, J. A. VIVALDA, D. YOHANNES;* HYPRES, INC.. — IT HAS BEEN FOUND RECENTLY THAT NB-BASED (E.G., NB/AL/ALOX/NB) JOSEPHSON JUNCTIONS (JJS) BEING INTEGRATED INTO MULTILAYERED DIGITAL CIRCUITS FREQUENTLY DEMONSTRATE UNUSUAL DEPENDENCES OF THEIR TUNNELING CHARACTERISTICS ON THE JUNCTION'S ENVIRONMENT, ON THE TYPE AND SIZE OF METAL LAYERS MAKING CONTACT TO NIOBIUM BASE AND COUNTER ELECTRODES OF THE JUNCTION, AND ALSO ON AGING. THESE CIRCUIT PATTERN-DEPENDENT DEVIATIONS OF CRITICAL CURRENTS OF JJS FROM THE EXPECTED VALUES ARE HIGHLY UNDESIRABLE IN COMPLEX DIGITAL CIRCUITS BECAUSE THEY REDUCE CIRCUIT YIELD, PERFORMANCE, AND RESTRICT THE INTEGRATION SCALE. THE DESCRIBED VARIABILITY OF JOSEPHSON JUNCTIONS IN NB-BASED INTEGRATED CIRCUITS CAN BE EXPLAINED AS RESULTING FROM HYDROGEN POISONING OF NB LAYERS DURING PROCESSING WITH SUBSEQUENT CHANGES IN THE IMPURITY (HYDROGEN) CONCENTRATION IN JUNCTION ELECTRODES DUE TO DIFFUSION OF DISSOLVED IMPURITIES BETWEEN DIFFERENT CIRCUIT ELEMENTS AND LAYERS THROUGH CONTACTS AND VIAS.WE HAVE DEVELOPED AND WILL PRESENT A NEW TECHNOLOGY FOR SUPERCONDUCTOR INTEGRATED CIRCUITS THAT EMPLOYS DIFFUSION STOP-LAYERS PROTECTING JOSEPHSON JUNCTIONS FROM INTERLAYER MIGRATION OF IMPURITIES AND THUS MINIMIZES THE PATTERN-DEPENDENT EFFECTS AND VARIABILITY OF TUNNELING CHARACTERISTICS OF NB/AL/ALOX/NB JUNCTIONS IN INTEGRATED CIRCUITS.

SUPPORTED IN PART BY ONR GRANT N000140910079

1EPB-02

INVESTIGATION OF THE ROLE OF H IN FABRICATION-PROCESS-INDUCED VARIATIONS OF NB/AL/ALOX/NB JOSEPHSON JUNCTIONS ***D. AMPARO***[1]*, S. K. TOLPYGO*[2]*;* [1]STONY BROOK UNIVERSITY, [2]HYPRES, INC.. — THE CORRECT OPERATION AND HIGH PERFORMANCE OF COMPLEX SUPERCONDUCTING INTEGRATED CIRCUITS SIGNIFICANTLY DEPEND ON FABRICATION-PROCESS-INDUCED VARIATIONS OF THE JOSEPHSON JUNCTION CRITICAL CURRENT. VARIATIONS IN NB/AL/ALOX/NB JUNCTIONS WERE INVESTIGATED AND SHOWN TO BE DEPENDENT ON HOW THE JUNCTION ELECTRODES ARE CONNECTED TO OTHER LAYERS IN THE INTEGRATED CIRCUIT, ESPECIALLY THE GROUND PLANE AND TI/PD/AU CONTACT PAD. THE OBSERVED ENHANCEMENT OF JUNCTION CRITICAL CURRENT AND GAP VOLTAGE OVER TIME FOR JUNCTIONS WITH CERTAIN WIRING CONNECTIONS SUGGESTS THAT THE PHENOMENON IS RELATED TO THE DIFFUSION OVER TIME OF IMPURITIES BETWEEN THE JUNCTION ELECTRODE AND THE TI/PD/AU PAD. SPECTROGRAPH DATA COLLECTED FROM MONITORING THE H EMISSION LINE INTENSITY IN THE PLASMA DURING ETCHING WAS RELATED TO THE AMOUNT OF H IN THE DEPOSITED NB RELEASED DURING ETCHING. CONSIDERING THE STRONG AFFINITY OF BOTH NB AND TI TO H, A MODEL WHERE H IS THE MAIN IMPURITY ELEMENT INVOLVED IN THE DIFFUSION-RELATED PHENOMENON IS PRESENTED. FURTHER DATA ON THE CHANGES TO THE RESISTANCE OF VARIOUS CONFIGURATIONS OF NB WIRE AT DIFFERENT STEPS IN THE FABRICATION PROCESS ARE PRESENTED AND ANALYZED TO QUANTIFY THE AMOUNT OF H AND IDENTIFY THE MOST SIGNIFICANT SOURCE OF CONTAMINATION DURING FABRICATION.

1EPB-03

DEVELOPMENT OF NB-BASED NON-HYSTERETIC JOSEPHSON JUNCTION FABRICATION PROCESS USING METAL-SILICIDE BARRIER ***Y. CHONG****, J. S. CHOI, W. SONG, Y. H. LEE, S. I. PARK;* KOREA RESEARCH INSTITUTE OF STANDARDS AND SCIENCE. — WE REPORT OUR DEVELOPMENT OF NB-BASED NON-HYSTERETIC JOSEPHSON JUNCTION FABRICATION PROCESS FOR QUANTUM VOLTAGE APPLICATIONS. WE HAVE MAINTAINED NB-ALUMINUM OXIDE TUNNEL JUNCTION PROCESS FOR SQUID AND VOLTAGE STANDARD APPLICATIONS. BY MODIFYING THE EXISTING PROCESS, WE DEVELOP A PROCESS FOR NON-HYSTERETIC JOSEPHSON JUNCTION CIRCUITS USING METAL-SILICIDE AS METALLIC BARRIER MATERIAL. WE USE SPUTTER DEPOSITION OF NB AND $MOSI_2$, PECVD DEPOSITION OF SILICON OXIDE AS INSULATOR MATERIAL, AND ICP-RIE FOR METAL AND OXIDE ETCH. METAL FILMS FOR PADS AND RESISTORS ARE PATTERNED BY LIFT-OFF PROCESS. WE REPORT OUR PROCESS OPTIMIZATION RESULT AND CHARACTERIZATION OF DEVICES.

1EPB-06

THE EFFECT OF MAGNETIC NANOPARTICLES ON INDUCTANCES TOWARD SFQ DEVICE APPLICATION ***H. AKAIKE****, K. SHIGEHARA, S. YANO, T. OKUMURA, A. FUJIMAKI;* NAGOYA UNIVERSITY. — USE OF MAGNETIC MATERIALS HAS A POTENTIAL FOR IMPROVING SINGLE FLUX QUANTUM (SFQ) DEVICES INCLUDING SFQ CIRCUITS BECAUSE HIGH SELF- OR MUTUAL- INDUCTANCE OBTAINED BY USING MAGNETIC MATERIALS WOULD REDUCE THE DEVICE SIZE OR INCREASE THE SENSITIVITY OF THE DEVICES. WE HAVE FOCUSED ON MAGNETIC NANOPARTICLES AS A MAGNETIC MATERIAL, AND EVALUATED THE EFFECT OF THE NANOPARTICLES ON INDUCTANCES USING SQUIDS. IN THE EVALUATION, WE PREPARED PHOTORESISTS WITH FE_3O_4 NANOPARTICLES AND FORMED THE PHOTORESIST PATTERNS ON THE SQUIDS. THIS METHOD ENABLED US TO CHANGE THE MAGNETIC PROPERTIES OF THE PHOTORESISTS BY NANOPARTICLE'S SIZES AND THEIR CONCENTRATIONS IN THE PHOTORESISTS AND TO PLACE THE NANOPARTICLES AT ANY POSITION ON THE SURFACE OF THE DEVICES EASILY. THE INDUCTANCES OF THE SQUIDS DID NOT CHANGE WITHOUT APPLIED DC MAGNETIC FIELDS FOR NANOPARTICLE'S SIZES UP TO 15 NM. ON THE OTHER HAND, WHEN DC MAGNETIC FIELDS WERE APPLIED, THE INDUCTANCES WERE SLIGHTLY INCREASED. WE WILL MEASURE THE INDUCTANCES OF VARIOUS TYPES OF SQUIDS WITH THE PHOTORESIST PATTERNS OF DIFFERENT PROPERTIES. DETAILS OF THE EXPERIMENTAL RESULTS WILL BE PRESENTED.

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1EPB-07

CURRENT NOISE INVESTIGATIONS IN JOSEPHSON DEVICES BY SWITCHING CURRENT MEASUREMENTS *C. GRANATA, A. VETTOLIERE, R. RUSSO, M. RUSSO,* ***B. RUGGIERO****;* ISTITUTO DI CIBERNETICA. — RECENTLY THERE IS A RENEWED INTEREST IN THE STUDY OF CRITICAL CURRENT NOISE IN JOSEPHSON DEVICES DUE TO REDUCTION OF THE DECOHERENCE INDUCED BY THE CRITICAL CURRENT FLUCTUATIONS IN THE QUBITS BASED ON THESE DEVICES. WE PRESENT AN EXPERIMENTAL INVESTIGATION OF WHITE AND FLICKER NOISE IN HIGH QUALITY UNDERDAMPED JOSEPHSON JUNCTIONS AND SQUIDS BY A TECHNIQUE BASED ON THE SWITCHING CURRENT MEASUREMENTS. IN SUCH A WAY IT IS POSSIBLE TO OBTAIN A DIGITAL SAMPLING OF THE CRITICAL CURRENT AS A FUNCTION OF THE TIME I_C (T) AND THE CORRESPONDING FLUCTUATION $\Delta I_C = I_C$ (T) - $\langle I_C(T) \rangle$ WITH A SAMPLING FREQUENCY GIVEN BY THE RAMP FREQUENCY. COMPUTING THE FAST FOURIER TRANSFORM MODULE IT IS POSSIBLE TO EVALUATE THE POWER DENSITY SPECTRUM OF THE CRITICAL CURRENT FLUCTUATION $S_{\Delta IC}$ (F). WE HAVE PERFORMED MEASUREMENTS OF JOSEPHSON JUNCTIONS HAVING AN AREA RANGING FROM (4X4) MM^2 FROM (40X40) MM^2 AND SQUID WITH DIFFERENT LOOP INDUCTANCE IN THE RANGE OF TEMPERATURE FROM 4.2 K TO 1.2 K. THE EXPERIMENTAL RESULTS SHOW A LINEAR BEHAVIOR OF THE WHITE NOISE FROM BOTH THE AREA OF THE JUNCTION AND THE TEMPERATURE INDICATING THAT IT IS ESSENTIALLY DUE TO THE NYQUIST NOISE OF THE NORMAL

RESISTANCE OF THE JOSEPHSON JUNCTIONS. THE LOW FREQUENCY NOISE EXHIBITS A 1/F BEHAVIOUR; FURTHER INVESTIGATIONS TO UNDERSTAND THE DOMINANT MECHANISM OF THIS NOISE ARE IN PROGRESS.

THIS WORK WAS PARTIALLY SUPPORTED BY ITALIAN MIUR UNDER THE PROJECT "SVILUPPO DI COMPONENTISTICA SUPERCONDUTTRICE AVANZATA E SUA APPLICAZIONE A STRUMENTAZIONE BIOMEDICA" (L 488/92, CLUSTER 14 - COMPONENTISTICA AVANZATA).

1EPB-08

MEASUREMENT OF EPITAXIAL NBN/ALN/NBN TUNNEL JUNCTIONS WITH A LOW CRITICAL CURRENT DENSITY AT LOW TEMPERATURE ***W. QIU**, Z. WANG;* KOBE ADVANCED ICT RESEARCH CENTER, NATIONAL INSTITUTE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY. — SUPERCONDUCTING QUBIT CIRCUIT REQUIRES HIGH QUALITY LOW CRITICAL CURRENT DENSITY JOSEPHSON TUNNEL JUNCTIONS. WE HAVE DEVELOPED HIGH QUALITY EPITAXIAL NBN/ALN/NBN TUNNEL JUNCTIONS WITH CRITICAL CURRENT DENSITY JC RANGED FROM AS LOW AS FEW A/CM^2 TO FEW TENS OF KA/CM^2. IN THIS WORK, WE MEASURED CURRENT-VOLTAGE CHARACTERISTICS FOR JUNCTIONS WITH A JC~32 A/CM^2 IN THE TEMPERATURE RANGE FROM 11 MK TO ABOVE 4.2 K. ALL JUNCTIONS SHOWED IN GOOD QUALITY AND HIGH GAP VOLTAGE (> 5.5 MV). WE FOUND THE JUNCTIONS SUB-GAP LEAKAGE CURRENT WERE TEMPERATURE DEPENDENT ABOVE 2.5 K AND SATURATED AT TEMPERATURE BELOW 2.5 K, ABOUT 60 PA AT 2 MV. THE VOLTAGE NOISE SPECTRAL DENSITIES HAVE BEEN MEASURED AT BASE TEMPERATURE AS THE JUNCTIONS BIASED ABOVE THE GAP VOLTAGE. THE SPECTRAL DENSITIES SHOWED CLEARLY 1/F BEHAVIOR AT LOW FREQUENCY AND WERE INVERSELY PROPORTIONAL TO JUNCTION'S LINEAR DIMENSION.*THIS WORK IS SUPPORTED IN PART BY NSF GRANT NO. (DMR-0325551)

SUPERCONDUCTING QUBIT, JOSEPHOSN JUNCTION, LOW FREQUENCY NOISE

1EPB-09

FABRICATION OF HIGH-QUALITY NBN/ALN/NBN TUNNEL JUNCTIONS WITH A WIDE RANGE OF CURRENT DENSITY ***Z. WANG**, W. QIU, K. MAKISE, H. TERAI;* NATIONAL INSTITUTE OF INFORMATION AND COMMUNICATION TECHNOLOGY. — WE REPORT ON THE FABRICATION AND PROPERTIES OF HIGH-QUALITY NBN/ALN/NBN TUNNEL JUNCTIONS WITH A WIDE RANGE OF CURRENT DENSITY J_C FOR VARIOUS APPLICATIONS SUCH AS QUANTUM DEVICES, THZ-BAND DETECTORS AND SO ON. THE JUNCTIONS WERE FABRICATED BY REACTIVE DC-MAGNETRON SPUTTERING DEPOSITION OF NBN/ALN/NBN TRILAYERS, I-LINE STEPPER LITHOGRAPHY, LIFT-OFF AND RIE TECHNIQUE. THE JUNCTION AREA WAS VARIED IN 0.25-250 UM^2. IN A WIDE RANGE OF J_C FROM A FEW OF A/CM^2 TO SEVERAL TENS OF KA/CM^2, THE JUNCTIONS SHOWED EXCELLENT JOSEPHSON TUNNELING PROPERTIES WITH A LARGE GAP VOLTAGE OF 5.6 MV AND A LARGE I_CR_N PRODUCT OF 3.5 MV. THE QUALITY FACTOR R_{SG}/R_N OF THE JUNCTIONS, WHERE THE R_{SG} IS THE SUBGAP RESISTANCE MEASURED AT 4 MV, IS ABOUT 50 FOR THE JUNCTIONS WITH A J_C OF 3 A/CM^2, AND ABOVE 10 FOR THE JUNCTIONS WITH A J_C OF 25 KA/CM^2, RESPECTIVELY. THE INTERFACE PROPERTIES OF THE JUNCTIONS WERE INVESTIGATED BY CROSS SECTIONAL OBSERVATION OF THE NBN/ALN/NBN INTERFACE USING A TRANSMISSION ELECTRON MICROSCOPE (TEM). THE JUNCTIONS SHOWED A VERY SMOOTH AND CLEAR ELECTRODE-BARRIER INTERFACE. BOTH OF BASE AND COUNTER NBN ELECTRODES HAD A SINGLE-CRYSTAL STRUCTURE WITHOUT DEPENDENCE ON THE ALN BARRIER THICKNESS.

1EPB-10**CHARACTERIZATION OF NBTIN THIN FILMS DEPOSITED ON VARIOUS SUBSTRATES** ***K. MAKISE**[1], M. TAKEDA[2], H. TERAI[1], Z. WANG[1];* [1]KOBE ADVANCED ICT RESEARCH CENTER, NICT, [2]GRADUATE SCHOOL OF SCIENCE AND TECHNOLOGY, SHIZUOKA UNIVERSITY. — NIOBIUM-TITANIUM NITRIDE (NBTIN) IS VERY ATTRACTIVE FOR SUPERCONDUCTING ELECTRONICS BECAUSE OF ITS LARGE SUPERCONDUCTING ENERGY GAP AND EASY DEPOSITING ON VARIOUS SUBSTRATES. SINCE QUALITY OF NBTIN THIN FILMS STRONGLY DEPEND ON A SPUTTERING CONDITION SUCH AS GAS PRESSURE, IT IS IMPORTANT TO OPTIMIZE DEPOSITING CONDITION FOR FABRICATION OF HIGH-QUALITY NBTIN THIN FILMS. IN ORDER TO FIND THE OPTIMUM CONDITION FOR FABRICATION OF HIGH-QUALITY NBTIN THIN FILMS, WE INVESTIGATED THE RELATIONSHIP BETWEEN SUPERCONDUCTING PROPERTIES AND CRYSTAL STRUCTURE FOR THE NBTIN THIN FILMS DEPOSITED ON VARIOUS SUBSTRATES UNDER DIFFERENT DEPOSITING CONDITIONS. THE NBTIN THIN FILMS WERE PREPARED BY REACTIVE DC MAGNETRON SPUTTERING ON MGO, AL_2O_3 AND FUSED QUARTZ SUBSTRATES . WE SYSTEMATICALLY INVESTIGATED THE TEMPERATURE DEPENDENCE OF RESISTANCE, CHEMICAL COMPOSITION, SURFACE ROUGHNESS AND XRD ANALYSIS, AND DESCRIBE THE SUPERCONDUCTING PROPERTIES, COMPOSITION AND CRYSTAL STRUCTURES.

1EPC-01

FABRICATION AND CHARACTERISTICS OF ULTRA-WIDEBAND BANDPASS YBCO FILTER WITH IMPENDENCE STUBS ***L. M. WANG**[1], C. T. WU[2], W. C. LIN[2], M. L. CHANG[2];* [1]GRADUATE INSTITUTE OF APPLIED PHYSICS, NATIONAL TAIWAN UNIVERSITY, [2]DEPARTMENT OF ELECTRICAL ENGINEERING, DA-YEH UNIVERSITY. — COMPACT ULTRA-WIDEBAND (UWB) BANDPASS FILTER (BPF) IS PRESENTED FOR APPLICATIONS ON SHORT-RANGE AND HIGH-SPEED WIRELESS COMMUNICATION. SUPERCONDUCTING $YBA_2CU_3O_Y$ (YBCO) STEPPED IMPEDANCE RESONATORS AND COUPLED-LINE SECTIONS AS INVERTER CIRCUITS ARE DESIGNED TO FORM THE BASIC FILTER STRUCTURE. IN THE FILTER DESIGN, CONNECTED HIGH-LOW STEPPED IMPEDANCE MICROSTRIP LINES CONSTRUCT THE RESONATORS, AND OPEN-STUB LINES ARE UTILIZED TO ADD RETURN-LOSS POLES IN THE PASS-BAND AND CREATE TRANSMISSION ZEROS IN THE LOWER/UPPER STOP-BAND REGION. THE SIMULATION RESULTS SHOW THE PASSBAND FROM 3.35 GHZ TO 7.65 GHZ HAS A 3-DB FRACTIONAL

BANDWIDTH OF 78 PERCENT, COMPUTED INSERTION LOSSES BETTER THAN 0.1 DB AND RETURN LOSSES GREATER THAN 15 DB. REJECTION LEVELS IN THE UPPER/LOWER STOP-BANDS ARE BETTER THAN 20 DB.FOR FABRICATION, HIGH-T_C SUPERCONDUCTING (HTS) YBCO FILMS WERE DEPOSITED ON DOUBLE-SIDE-POLISHED 0.5-MM-THICK $LAALO_3$ (100) SUBSTRATES BY A SPUTTERING SYSTEM. THE REALIZED HTS UWB BPF SHOWS WIDE PASSBAND WITHIN 3.4 -8.7 GHZ WITH A MAXIMUM INSERTION LOSS OF 1.0 DB. THE MEASURED RESULTS SHOW A GOOD HTS UWB BPF PERFORMANCE. MOREOVER, THE TEMPERATURE-DEPENDENT FREQUENCY RESPONSES AND THE INSERTION LOSS CAN BE DESCRIBED BY THE MODIFIED TWO-FLUID MODEL BASED FORMULAS, INDICATING THAT THE FREQUENCY SHIFT IN HTS BPF IS DOMINATED BY THE TEMPERATURE DEPENDENCE OF THE MAGNETIC PENETRATION DEPTH.

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1EPC-02

PICO PULSE PROPAGATION ANALYSIS OF HTS STRIP LINE USING TIME-DEPENDENT GINZBURG-LANDAU EQUATION ***S. YOSHIMORI;*** TAKUSHOKU UNIVERSITY. — SINCE THE PHOTON ENERGY OF THE ELECTROMAGNETIC WAVES IN THE MILLIMETER WAVE AND THE THZ REGIONS IS NOT SMALL ENOUGH COMPARED WITH THE SUPERCONDUCTING ENERGY GAP OF THE HTS AT 77K, WE ANALYZED THE PICO PULSE PROPAGATION PROPERTIES OF THE HTS STRIP LINES IN THE MILLIMETER WAVE AND THE THZ REGIONS USING THE TWO DIMENSIONAL TIME-DEPENDENT-GINZBURG-LANDAU EQUATION.WE FOUND FOLLOWING RESULTS.(1)FOR EXAMPLE, AT 100GHZ, THE ATTENUATION OF THE HTS STRIP LINE MADE OF C-AXIS ORIENTED THIN FILM WAS ABOUT 1000DB/μM AT 50K DUE TO THE ANISOTROPIC CRYSTAL STRUCTURE OF $YBA_2CU_3O_7$. ON THE OTHER HAND, THE ATTENUATION OF THE HTS STRIP LINE MADE OF A-AXIS ORIENTED THIN FILM WAS ONLY 10DB/M AT 50K.(2)THE ATTENUATION OF THE HTS STRIP LINE MADE OF C-AXIS ORIENTED THIN FILM WAS DEPENDENT ON THE PROPAGATION POWER. ON THE OTHER HAND, THE ATTENUATION OF THE HTS STRIP LINE MADE A-AXIS ORIENTED THIN FILM WAS NOT DEPENDENT ON THE PROPAGATION POWER.(3) A PICO PULSE CAN PROPAGATE WITHIN SEVERAL NANOMETERS IN THE CASE OF HTS STRIP LINE MADE OF C-AXIS ORIENTED THIN FILM. ON THE OTHER HAND, THE PICO PULSE CAN PROPAGATE LONGER THAN 10CM IN THE CASE OF HTS STRIP LINE MADE OF A-AXIS ORIENTED THIN FILM.

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1EPC-03

DC AND MICROWAVE CHARACTERIZATION OF YBCO WEAK LINKS ***T. G. MCCONKEY,*** *H. A. ATIKIAN, H. A. MAJEDI;* UNIVERSITY OF WATERLOO, INSTITUTE FOR QUANTUM COMPUTING. — THE CO-EXISTENCE OF MACROSCOPIC QUANTUM TUNNELING SIMILAR TO JOSEPHSON EFFECT AND NONLINEAR ELECTRODYNAMIC CHARACTERISTICS OF HTS WEAK LINKS MAKE THEM ATTRACTIVE TO DESIGN NOVEL PASSIVE AND ACTIVE MICROWAVE CIRCUITS. BASIC PLANAR MICROWAVE STRUCTURES, SUCH AS A COPLANAR MICROWAVE TRANSMISSION LINE CAN BE USED AS A HOST OF SINGLE AND ARRAYS OF WEAK LINKS.BEFORE SUCH APPLICATIONS COULD BE FEASIBLY ACCOMPLISHED, A GREATER UNDERSTANDING OF THE WEAK LINK DEVICE IS NECESSARY, BY A COMPLETE MICROWAVE AND DC CHARACTERIZATION. THE WEAK LINKS TO BE ANALYZED ARE COMPOSED OF THIN FILM YBCO FABRICATED ON A LAAIO SUBSTRATE WITH AU FILM ADDED FOR IMPROVED CONTACT TO MEASUREMENT DEVICES. THE CHARACTERIZATION IS ACCOMPLISHED WITH THE USE OF A CUSTOM MADE TWO PROBE MICROWAVE CRYOSTAT PROBE STATION, ALLOWING THE WEAK LINK TO BE COOLED TO BELOW ITS CRITICAL TEMPERATURE WHILE MAKING BOTH DC AND SCATTERING-PARAMETER MEASUREMENTS.INITIAL STEPS TO THE CHARACTERIZATION WILL BE DC I-V MEASUREMENTS OF SINGLE AND ARRAYS OF WEAK LINKS OF VARYING DIMENSIONS TO DETERMINE THE RELATION BETWEEN THE GEOMETRY OF THE DEVICE AND THE NONLINEAR I-V REGIONS. MICROWAVE CHARACTERIZATION WILL BE ACCOMPLISHED BY S-PARAMETER MEASUREMENT OF UP TO 50GHZ BY MAKING USE OF A COPLANAR LINE AS A BASE REFERENCE. THIS SHOULD LEAD TO THE FORMULATION OF A MATHEMATICAL MODEL THAT CAN ACCURATELY PREDICT THE NONLINEAR RESPONSES OF THE YBCO WEAK LINK.

FABRICATION MADE POSSIBLE IN COOPERATION WITH THEVA AND STAR CRYOELECTRONICS.

1EPC-04

RELATING THE NONLINEAR SURFACE IMPEDANCE TO THE LOCAL NONLINEAR SUPERFLUID DENSITY IN HIGH TEMPERATURE SUPERCONDUCTORS ***E. ROCAS***[1]*, C. COLLADO*[1]*, A. PADILLA*[2]*, J. C. BOOTH*[1]*;* [1]NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY, [2]UNIVERSITAT POLITECNICA DE CATALUNYA. — THE SURFACE IMPEDANCE IS THE MOST COMMON PARAMETER USED TO CHARACTERIZE THE ELECTROMAGNETIC (EM) PROPERTIES OF SUPERCONDUCTORS, AS IT CAN BE EASILY RELATED TO THE RESONANCE FREQUENCY AND QUALITY FACTOR OF A MICROWAVE RESONATOR. FOR THIS REASON, THE SURFACE IMPEDANCE IS COMMONLY USED IN QUANTIFYING AND MODELING THE NONLINEAR EM RESPONSE OF SUPERCONDUCTORS. SUCH APPROACHES ARE BASED PRIMARILY ON PHENOMENOLOGICAL EXPRESSIONS FOR THE DEPENDENCE OF THE SURFACE IMPEDANCE ON THE RF MAGNETIC FIELD, WHICH ARE NOT DIRECTLY RELATED TO THE MATERIAL PARAMETERS REQUIRED FOR A LOCAL DESCRIPTION OF THE NONLINEARITIES, SUCH US THE CRITICAL CURRENT DENSITY AND THE QUASI-PARTICLE FACTOR B(T). IN THIS WORK, THE NONLINEAR SURFACE IMPEDANCE IS DERIVED FROM A LOCAL DESCRIPTION OF THE NONLINEAR SUPERFLUID DENSITY DEPENDENCE ON THE CONDENSATE VELOCITY. WE USE A RIGOROUS APPROACH BASED ON THE TIME-DOMAIN NONLINEAR LONDON EQUATIONS AND THE

TWO-FLUID MODEL IS FOLLOWED, AND A NEW EXPRESSION FOR THE NONLINEAR SURFACE IMPEDANCE IS OBTAINED. RESULTS OF THIS NEW FORMULATION SHOW VERY GOOD AGREEMENT WITH NONLINEAR SIMULATIONS OF A PLANE WAVE PROPAGATING ACROSS A VACUUM-SUPERCONDUCTOR BOUNDARY.

CARLOS COLLADO THANKS GENERALITAT DE CATALUNYA FOR GRANT BE2-00196

1EPC-05

ANALYSIS AND DESIGN OF NEGATIVE RESISTANCE JOSEPHSON PARAMETRIC AMPLIFIERS ***H. R. MOHEBBI***[1]*, A. H. MAJEDI*[2]*;* [1]UNIVERSITY OF WATERLOO, INSTITUTE FOR QUANTUM COMPUTING,, [2]UNIVERSITY OF WATERLOO, INSTITUTE FOR QUANTUM COMPUTING. — THE THEORY OF PARAMETRIC AMPLIFICATION IN CIRCUITS WITH JOSEPHSON JUNCTIONS (JJ) IS DISCUSSED IN A GENERAL AND SYSTEMATIC APPROACH. A NOVEL CIRCUIT TOPOLOGY IS PRESENTED TO MODEL THE INTERACTION OF THE SIGNAL AND PUMP SIGNALS IN A JJ-BASED PARAMETRIC DEVICE. THE PHYSICAL IMPLEMENTATION OF THIS CIRCUIT ON A PLANAR MICROWAVE TECHNOLOGY IS PRESENTED. MOREOVER, FOURIER ANALYSIS FOR THE NONLINEAR INDUCTANCE ASSOCIATED WITH THE JJ IS CARRIED OUT AND AMPLITUDES OF THE HARMONICS ARE COMPARED TO EACH OTHER. CLOSED-FORM EXPRESSIONS ARE DERIVED FOR GAIN CHARACTERISTICS, BANDWIDTH DETERMINATION AND NOISE PROPERTIES OF THE PROPOSED PARAMETRIC POWER AMPLIFIER. THE RESULTS OF THE DESIGN PROCESS ARE SHOWN FOR AL AND NB JUNCTIONS SEPARATELY.

1EPC-06

DEVELOPMENT OF TWIN SLOT DIPOLE ANTENNA INTEGRATED YBCO GRAIN BOUNDARY JOSEPHSON JUNCTION DETECTORS FOR 0.2 TO 1 THZ ***N. TAKAHASHI****, H. YAMADA, A. SAITO, S. OHSHIMA, K. NAKAJIMA;* YAMAGATA UNIVERSITY. — TWIN SLOT DIPOLE ANTENNA (TWIN-SDA) INTEGRATED YBCO GAIN BOUNDARY JOSEPHSON JUNCTION DETECTORS HAVE BEEN DEVELOPED FOR THE FREQUENCY RANGE OF 0.2 TO 1THZ. WE DEMONSTRATE A FEASIBLE TWIN-SDA FOR YBCO DETECTORS IN VIEW OF THE SIMPLE COPLANAR STRUCTURE. NUMERICAL SIMULATIONS REVEAL THAT THE FULL WAVE OPERATION OF TWIN-SDA EXHIBITS LOW RADIATION RESISTANCE AND REMAINED INDUCTIVE COMPONENT. A COPLANAR WAVE GUIDE HAS BEEN USED TO CANCEL THE REACTANCE AND INTEGRATE TWO SDA ONTO A YBCO GRAIN BOUNDARY JOSEPHSON JUNCTION. IT IS EXPECTED THAT THE COPLANAR WAVE GUIDE FED TWIN-SDA IMPROVES IMPEDANCE MATCHING LOSSES THAT DOMINATE THE RF COUPLING COEFFICIENT OF DETECTORS. IT IS SHOWN THAT THE CHARACTERISTIC FREQUENCY OF YBCO JOSEPHSON JUNCTIONS CAN BE OPTIMIZED BY CHANGING OPERATION TEMPERATURE FOR THE FREQUENCY RANGE 0.2 AND 1.2 THZ ACCORDING TO THE FULL WAVE OPERATION OF TWIN-SDA. FOR 0.2THZ, THE OPTIMIZED OPERATION IS DEMONSTRATED AT 77K. DETECTOR PERFORMANCE EXTENDED UP TO 0.94THZ ARE ALSO DEMONSTRATED.

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1EPD-01

TES SERIES ARRAY BOLOMETER FOR 4.2K APPLICATION *J. BEYER,* ***D. DRUNG****;* PHYSIKALISCH-TECHNISCHE BUNDESANSTALT. — WE ARE DEVELOPING A TRANSITION EDGE SENSOR SERIES ARRAY (TES-SA). THE GOAL IS TO ENABLE THE READOUT OF A TES-BASED BOLOMETER OPERATED AT 4.2K BY MEANS OF A SEMICONDUCTOR-BASED AMPLIFIER, I.E., TO SIMPLIFY THE TES READOUT BY AVOIDING A SQUID CURRENT SENSOR. THIS WAY, THE TES READOUT IS COMPARABLE TO THE READOUT OF CONVENTIONAL SEMICONDUCTOR THERMISTOR BOLOMETERS AS USED, FOR INSTANCE, AT 4.2K IN COMMERCIAL FAR-INFRARED FOURIER TRANSFORM SPECTROMETERS. AT THE SAME TIME, STRONG NEGATIVE ELECTROTHERMAL FEEDBACK OF THE VOLTAGE-BIASED TES-SA CAN BE EXPLOITED FOR IMPROVED LINEARITY OR SENSITIVITY. THE TES-SA IS A SERIES ARRAY OF A LARGE NUMBER, HUNDREDS TO THOUSANDS, OF IDENTICAL TESS THAT ARE CONNECTED IN SERIES BY LOW-INDUCTANCE SUPERCONDUCTING WIRING. THIS IS DONE TO INCREASE THE TOTAL IMPEDANCE WHILE PRESERVING THE OVERALL SHAPE OF THE SUPERCONDUCTING TRANSITION. WE ANALYZE NOISE AND DYNAMIC PERFORMANCE OF A TES-SA BOLOMETER BASED ON NIOBIUM/ALUMINUM BILAYER AND SHOW THAT READOUT WITH A ROOM TEMPERATURE TRANSIMPEDANCE AMPLIFIER IS FEASIBLE. THIS AMPLIFIER IS BASED ON AN ULTRA-LOW NOISE CHOPPER AMPLIFIER WITH A NOISE TEMPERATURE BETWEEN 1 AND 20 KELVIN DEPENDING ON THE REQUIRED BANDWIDTH.

1EPD-02

ALMN TRANSITION EDGE SENSORS FOR CMB POLARIMETERS ***D. R. SCHMIDT***[1]*, H. CHO*[1]*, H. HUBMAYR*[1]*, P. LOWELL*[1]*, M. NIEMACK*[1]*, G. O'NEIL*[1]*, J. ULLOM*[1]*, K. YOON*[1]*, K. IRWIN*[1]*, B. HOLZAPFEL*[2]*, M. LUEKER*[2]*, E. GEORGE*[2]*, E. SHIROKOFF*[2]*;* [1]NIST, [2]PHYSICS DEPARTMENT, UNIVERSITY OF CALIFORNIA AT BERKELEY. — SUPERCONDUCTING TRANSITION EDGE SENSORS (TESS) REQUIRE SUPERCONDUCTING FILMS WITH TRANSITION TEMPERATURES (T_CS) AND PROPERTIES THAT CAN BE TAILORED TO THE PARTICULAR REQUIREMENTS OF INDIVIDUAL APPLICATIONS. WE HAVE BEEN DEVELOPING ALMN FILMS WITH TUNABLE T_C. THE ADDITION OF MN TO AL SUPPRESSES TC, BUT DOES NOT SIGNIFICANTLY BROADEN THE SUPERCONDUCTING DENSITY OF STATES OF THE AL. WE CAN PRODUCE FILMS WITH T_CS FROM BELOW 50 MK TO 1.4 K THROUGH ADJUSTMENT OF THE MN CONCENTRATION IN AL. WE HAVE USED THIS MATERIAL EXTENSIVELY IN SUPPORT OF OUR ELECTRONIC-REFRIGERATION PROGRAM. SINCE THIS IS A BULK EFFECT, THE T_C IS NOT DEPENDENT ON PRECISE CONTROL OF FILM THICKNESS AS IN THE STANDARD BI-LAYER APPROACH FOR TESS. WE HAVE PREVIOUSLY USED ALMN TO FABRICATE TES SENSORS FOR X-RAY MICRO-CALORIMETERS

TARGETED FOR READOUT OUT WITH TIME DIVISION SQUID MULTIPLEXING SCHEMES. IN THIS WORK, WE EXPLORE THE PROPERTIES OF ALMN FILMS IN A REGIME WELL SUITED FOR TESS WHICH ARE READOUT WITH LOW FREQUENCY DIVISION MULTIPLEXING. WE HAVE ALSO FABRICATED PROTOTYPE CMB POLARIMETERS WITH ALMN FOR THE SOUTH POLE TELESCOPE AND WILL SHOW INITIAL MEASUREMENTS OF THESE SENSORS.

1EPD-03

CHARACTERIZATION OF SI_XN_Y ABSORBERS AND THERMAL SUPPORT BEAMS FOR ULTRA-SENSITIVE FAR-INFRARED (IR)/SUB-MM TRANSITION EDGE SENSORS ***A. D. BEYER***[1]*, M. E. KENYON*[2]*, P. M. ECHTERNACH*[2]*, B. -. EOM*[3]*, J. BUENO*[2]*, P. K. DAY*[2]*, J. J. BOCK*[1]*, C. M. BRADFORD*[1]*;* [1]CALIFORNIA INSTITUTE OF TECHNOLOGY/JET PROPULSION LABORATORY, [2]JET PROPULSION LABORATORY, [3]CALIFORNIA INSTITUTE OF TECHNOLOGY. — WE PRESENT HEAT CAPACITY C AND THERMAL CONDUCTIVITY G MEASUREMENTS OF SI_XN_Y ABSORBERS AND SUPPORT BEAMS FOR USE IN TRANSITION EDGE SENSORS (TESS) EMPLOYING SUPERCONDUCTING BILAYER THERMISTORS WITH TARGET T_C=65MK. IN ORDER TO MEET THE REQUIREMENTS OF SPACE-BORNE FAR-IR/SUB-MM SPECTROMETERS, SUCH AS THE BLISS AND SAFARI INSTRUMENTS FOR SPICA, COMPOSITE TESS MUST EXHIBIT ULTRA-SENSITIVE NOISE EQUIVALENT POWER NEP<10^{-19}W/HZ^{1/2} AND OPERATE WITH FAST EFFECTIVE RESPONSE TIME T_EFF<150MS. WE MEASURED C AND G FOR SOLID MEMBRANE AND WIRE-MESH SI_XN_Y ABSORBERS SUSPENDED BY SI_XN_Y SUPPORT BEAMS MANUFACTURED USING DIFFERENT FABRICATION PROCESSES. DIFFERENT GEOMETRIES OF SUPPORT BEAMS AND PROCESSES PRODUCED SI_XN_Y SUPPORT BEAMS WITH G RANGING FROM 10FW/K TO 100FW/K AT 50MK WITH LITTLE VARIATION AMONG PROCESSES. FROM THE PREDICTION NEP=\SQRT{4K_BT_C^2G}, WE EXPECT NEP<10^{-19}W/HZ^{1/2}. FOR THE ABSORBERS, C WAS AS LOW AS 5FJ/K AT 50MK BUT INCREASED BY A FACTOR OF UP TO 20 FOR DIFFERENT PROCESSES. DUE TO THE FACT THAT VOLTAGE-BIASED TESS MAY EXHIBIT T_EFF AS MUCH AS 100 TIMES SMALLER THAN THE THERMAL RESPONSE TIME T_0=C/G IN NEGATIVE ELECTROTHERMAL FEEDBACK OPERATION, WE EXPECT T_EFF <150MS IN COMPOSITE TESS.

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1EPD-05

THERMAL MODELING OF TES DEVICES USED IN FEEDHORN COUPLED MILLIMETER WAVE POLARIMETERS ***J. HUBMAYR***[1]*, J. W. APPEL*[2]*, J. E. AUSTERMANN*[3]*, J. A. BEALL*[1]*, D. BECKER*[1]*, B. A. BENSON*[4]*, L. E. BLEEM*[4]*, C. L. CHANG*[4]*, J. E. CARLSTROM*[4]*, H. M. CHO*[1]*, A. T. CRITES*[4]*, T. ESSINGER-HILEMAN*[2]*, W. EVERETT*[4]*, N. W. HALVERSON*[3]*, J. W. HENNING*[3]*, G. C. HILTON*[1]*, K. D. IRWIN*[1]*, J. MCMAHON*[5]*, J. MEHL*[4]*, S. S. MEYER*[4]*, S. MOSELEY*[6]*, M. D. NIEMACK*[1]*, L. P. PARKER*[2]*, S. T. STAGGS*[2]*, K. YOON*[1]*;* [1]NIST QUANTUM DEVICES GROUP, [2]PRINCETON UNIVERSITY, [3]CENTER FOR ASTROPHYSICS AND SPACE ASTRONOMY, DEPARTMENT OF ASTROPHYSICAL AND PLANETARY SCIENCES AND DEPARTMENT OF PHYSICS, UNIVERSITY OF COLORADO, BOULDER, [4]KALVI INSTITUTE FOR COSMOLOGICAL PHYSICS, UNIVERSITY OF CHICAGO, [5]DEPARTMENT OF PHYSICS, UNIVERSITY OF MICHIGAN, [6]NASA GODDARAD SPACE FLIGHT CENTER. — WE DISCUSS THE ELECTRO-THERMAL MODELING OF TRANSITION EDGE SENSOR(TES) DETECTORS UNDER DEVELOPMENT FOR THE COSMIC MICROWAVE BACKGROUNDPOLARIZATION EXPERIMENT SPTPOL. THE POLARIMETERS OPERATE AT 150 GHZ,ARE FEEDHORN COUPLED TO THE SKY AND CONSIST OF PLANAR ORTHOMODETRANSDUCERS THAT TRANSMIT POWER FROM ORTHOGONAL POLARIZATIONS ONTO TWOINDEPENDENT TES BOLOMETERS. THE TES ARE AC BIASED AT MHZ FREQUENCIESAND READ OUT WITH SQUID-BASED FREQUENCY DOMAIN MULTIPLEXING. WEDEMONSTRATE A MULTI-BLOCK THERMAL MODEL USED TO PREDICT THE STABILITYAND NOISE PERFORMANCE OF THE BOLOMETERS.

1EPD-06

ENERGY RESOLUTION OF TERAHERZ SINGLE-PHOTON-SENSITIVE BOLOMETRIC DETECTORS ***D. F. SANTAVICCA***[1]*, B. REULET*[2]*, B. S. KARASIK*[3]*, S. V. PEREVERZEV*[3]*, D. OLAYA*[4]*, M. E. GERSHENSON*[4]*, F. W. CARTER*[1]*, L. FRUNZIO*[1]*, D. E. PROBER*[1]*;* [1]YALE UNIVERSITY, [2]UNIVERSITE PARIS-SUD, [3]JET PROPULSION LAB, [4]RUTGERS UNIVERSITY. — WE REPORT MEASUREMENTS OF THE ENERGY RESOLUTION OF ULTRA-SENSITIVE BOLOMETRIC DETECTORS. THE DEVICE IS A SUPERCONDUCTING TITANIUM NANOBRIDGE WITH NIOBIUM CONTACTS. A FAST MICROWAVE PULSE IS USED TO SIMULATE A SINGLE HIGHER-FREQUENCY PHOTON, WHERE THE ABSORBED ENERGY OF THE PULSE IS EQUAL TO THE PHOTON ENERGY. THIS TECHNIQUE ALLOWS PRECISE CALIBRATION OF THE INPUT COUPLING AND AVOIDS PROBLEMS WITH UNWANTED BACKGROUND PHOTONS. PRESENT DEVICES HAVE AN INTRINSIC FULL-WIDTH AT HALF-MAXIMUM ENERGY RESOLUTION OF APPROXIMATELY 23 TERAHERTZ (0.1 EV), NEAR THE PREDICTED VALUE DUE TO INTRINSIC THERMAL FLUCTUATION NOISE. DEVICES WITH A SMALLER NANOBRIDGE VOLUME AND A REDUCED CRITICAL TEMPERATURE ARE PREDICTED TO ACHIEVE AN ENERGY RESOLUTION OF BELOW 1 TERAHERTZ. WE ALSO DISCUSS A TECHNIQUE FOR FREQUENCY-DIVISION MULTIPLEXING AN ARRAY OF THESE DETECTORS WITH MICROWAVE REFLECTOMETRY.

THIS WORK IS SUPPORTED IN PART BY NSF, NASA, AND YALE UNIVERSITY.

1EX-01

(INVITED) **BASIC PRINCIPLES AND DESIGN CONSIDERATIONS FOR TRANSITION-EDGE SENSOR (TES) CALORIMETERS** ***J. ULLOM****;* NIST. — CALORIMETERS INCORPORATING TRANSITION-EDGE SENSOR (TES) THERMOMETERS ARE AN ATTRACTIVE TECHNOLOGY FOR LOW-NOISE MEASUREMENTS OF STIMULI RANGING FROM EV-SCALE NEAR-INFRARED PHOTONS TO MEV-SCALE PARTICLES. A COMMON MOTIVATION FOR THE USE OF TES CALORIMETERS IS THE SIMULTANEOUS NEED FOR SPECTRAL RESOLUTION AND EFFICIENCY AT LEVELS THAT CANNOT BE ACHIEVED WITH

MORE CONVENTIONAL TECHNOLOGIES. IN THIS PRESENTATION, WE REVIEW THE BASIC PRINCIPLES OF TES SENSORS. IN ADDITION, WE REVIEW DESIGN CONSIDERATIONS RELEVANT TO APPLICATIONS, EMPHASIZING HOW SENSOR PARAMETERS SUCH AS SPEED, SIZE, EFFICIENCY, AND RESOLUTION ARE OPTIMIZED. FINALLY, WE BRIEFLY REVIEW RECENT PROGRESS APPLYING TES CALORIMETERS TO A VARIETY OF MEASUREMENTS INCLUDING X-RAY SPECTROSCOPY, DARK MATTER DETECTION, AND NUCLEAR MATERIALS ANALYSIS.

1EX-02

SUPERCONDUCTING TRANSITION-EDGE SENSOR MICROCALORIMETERS FOR ULTRA-HIGH RESOLUTION ALPHA-PARTICLE SPECTROMETRY ***M. P. CROCE***[1]*, M. K. BACRANIA*[1]*, A. S. HOOVER*[1]*, M. W. RABIN*[1]*, N. J. HOTELING*[1]*, E. M. BOND*[1]*, W. A. MOODY*[1]*, S. P. LAMONT*[1]*, D. E. DRY*[1]*, J. N. ULLOM*[2]*, D. A. BENNETT*[2]*, R. D. HORANSKY*[2]*, V. KOTSUBO*[2]*, R. CANTOR*[3]*;* [1]LOS ALAMOS NATIONAL LABORATORY, [2]NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY, [3]STAR CRYOELECTRONICS. — ALPHA-PARTICLE SPECTROMETRY IS A POWERFUL ANALYTICAL TOOL FOR NUCLEAR FORENSICS AND ENVIRONMENTAL MONITORING. SUPERCONDUCTING TRANSITION-EDGE SENSOR MICROCALORIMETERS HAVE BEEN SHOWN TO YIELD UNSURPASSED ENERGY RESOLUTION FOR ALPHA SPECTROMETRY. WITH NEARLY AN ORDER OF MAGNITUDE BETTER ENERGY RESOLUTION (1.06 KEV FWHM AT 5.3 MEV) THAN THE CURRENT STATE-OF-THE-ART SILICON DETECTORS (8-10 KEV AT 5.3 MEV), IT IS POSSIBLE TO MEASURE SAMPLES CONTAINING MULTIPLE RADIOISOTOPES THAT WOULD REQUIRE EXPENSIVE AND TIME-CONSUMING RADIOCHEMICAL SEPARATION PRIOR TO MEASUREMENT WITH A SILICON DETECTOR. MICROCALORIMETER DETECTORS USE A SUPERCONDUCTING TRANSITION-EDGE SENSOR AS AN EXTREMELY SENSITIVE THERMOMETER TO MEASURE THE HEAT DEPOSITED IN AN ABSORBING ELEMENT BY INDIVIDUAL ALPHA PARTICLES. THE DETECTORS ARE OPERATED AT ~100 MK INSIDE A CRYOSTAT WITH AN ADIABATIC DEMAGNETIZATION REFRIGERATOR. ELECTRODEPOSITED SAMPLES ARE PLACED INSIDE THE CRYOSTAT FOR MEASUREMENT. SIGNALS ARE AMPLIFIED BY A SQUID ARRAY AND DIGITIZED FOR ANALYSIS. THIS PRESENTATION WILL DISCUSS MICROCALORIMETER DETECTOR PERFORMANCE, OPERATION, SIGNAL ANALYSIS, AND APPLICATIONS OF THE TECHNOLOGY, AND RECENT RESULTS WILL BE SHOWN.

1EX-03

LARGE ARRAYS AND LARGE ABSORBERS: A 256 PIXEL GAMMA-RAY SPECTROMETER BASED ON TES MICROCALORIMETERS ***D. A. BENNETT***[1]*, W. B. DORIESE*[1]*, G. C. HILTON*[1]*, A. S. HOOVER*[2]*, R. D. HORANSKY*[1]*, N. HOTELING*[2]*, K. D. IRWIN*[1]*, P. J. KARPIUS*[2]*, V. KUTSUBO*[1]*, M. W. RABIN*[2]*, C. D. REINTSEMA*[1]*, D. SWETZ*[1]*, L. R. VALE*[1]*, D. T. VO*[2]*, J. N. ULLOM*[1]*;* [1]NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY, [2]LOS ALAMOS NATIONAL LABORATORY. — WE HAVE DEVELOPED A MICROCALORIMETER-BASED GAMMA-RAY SPECTROMETER WITH MORE THAN 160 ACTIVE PIXELS. THIS COLLECTING AREA COMBINED WITH THE SUPERIOR ENERGY RESOLUTION OF MICROCALORIMETERS MAKES POSSIBLE MEASUREMENTS SUCH AS THE NONDESTRUCTIVE ASSAY OF NUCLEAR MATERIALS. WE PRESENT SPECTRA CONTAINING MILLIONS OF COUNTS FROM A MIXED ISOTOPE PLUTONIUM SOURCE AND MAKE A HEAD-TO-HEAD COMPARISON OF ISOTOPIC ACCURACY WITH SIMILAR MEASUREMENTS OBTAINED FROM A HIGH-PURITY GERMANIUM SENSOR. OUR MICROCALORIMETERS CONSIST OF A BULK TIN ABSORBER ATTACHED TO A TRANSITION-EDGE SENSOR (TES) AND HAVE DEMONSTRATED SINGLE-PIXEL ENERGY RESOLUTIONS OF 22 EV AT 103 KEV, A FACTOR OF 20 BETTER THAN GERMANIUM DETECTORS. THE LARGE HEAT CAPACITY OF THE ATTACHED ABSORBER NECESSITATES THE USE OF A TWO-BODY MODEL IN THE DESIGN AND CHARACTERIZATION OF THESE DEVICES. THESE INHERENTLY TWO-BODY DEVICES HAVE DIFFERENT STABILITY CRITERIA FROM WHAT IS PREDICTED BY TRADITIONAL ONE-BODY TES MODELS. IN ORDER TO UNDERSTAND THESE CRITERIA AND TO PREDICT PULSE SHAPES IMPORTANT TO OPTIMIZING MULTIPLEXED READOUT, WE HAVE DEVELOPED AN ANALYTICAL SOLUTION FOR THE TIME-DOMAIN RESPONSE THAT INCLUDES THE ATTACHED ABSORBER AND THE FINITE INDUCTANCE OF THE TES CIRCUIT BIAS. THIS MODEL WAS USED TO SELECT AN OPTIMAL INDUCTANCE THAT REDUCES SENSOR RESPONSE TIMES WHILE INCREASING THE NUMBER OF MULTIPLEXED SENSORS TO 32 PER COLUMN.

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1EX-04

DEVELOPMENT OF LEAD ABSORBER COUPLED TRANSITION EDGE SENSOR DETECTORS FOR POSITRON ANNIHILATION SPECTROSCOPY ***R. M. T. DAMAYANTHI****, N. IYOMOTO, M. OHNO, H. TAKAHASHI;* UNIVERSITY OF TOKYO. — COMMERCIALLY AVAILABLE HPGE DETECTORS FOR POSITRON ANNIHILATION SPECTROSCOPY (PAS) AT 511 KEV ARE LIMITED TO ~1 KEV ENERGY RESOLUTION AND NOT SUFFICIENT FOR FINE MEASUREMENTS. TRANSITION EDGE SENSOR (TES) GAMMA-RAY DETECTORS HAVE BEEN REPORTED WITH MORE THAN AN ORDER OF IMPROVEMENT IN ENERGY RESOLUTION THAN HPGE DETECTORS AT ~100 KEV. THEREFORE, WE HAVE STARTED TO DEVELOP DETECTORS FOR PAS ANALYSIS, CONSISTING OF AN IR-TES THERMOMETER WITH AN EPOXY COUPLED LEAD ABSORBER.OUR FIRST DETECTOR REPORTED AN ENERGY RESOLUTION OF 4.7 KEV FWHM AT 662 KEV AND A DOUBLE-EXPONENTIAL-DECAYED SIGNAL RESPONSE WITH A LONG DECAY TAIL OF ~135 MS. TO REDUCE THE DECAY TIME WE DESIGNED A NEW DETECTOR WITH BETTER THERMAL CONDUCTANCE BETWEEN THE TES AND THE HEAT SINK (G_TES). AS A RESULT, THE DECAY TIME WAS IMPROVED BY A FACTOR OF FIVE. HOWEVER, THE ENERGY RESOLUTION WAS DEGRADED TO 9.2 KEV FWHM AT 662 KEV. WE ARE ANALYZING THE NOISE IN DETAIL TO UNDERSTAND ITS ORIGINS.TO IMPROVE THE ENERGY RESOLUTION AND THE RESPONSE TIME, WE HAVE FABRICATED NEW DETECTORS FOR DIFFERENT G_TES VALUES, USING A SMALL ABSORBER SIZE

(0.5 MM CUBIC PB ABSORBERS) TO REDUCE HEAT CAPACITY. WE USED A FLIP CHIP BONDER TO ATTACH THE PB ABSORBER ON TO THE TES OF THE NEW DETECTORS. THIS ALLOWED US TO BETTER CONTROL THE AMOUNT OF EPOXY USED AND PERHAPS ALSO REDUCES THE STRESS ON THE TES. WE PLAN TO PRESENT THE LATEST RESULTS OF OUR TES GAMMA-RAY DETECTORS IN THE WORKSHOP.

THIS WORK IS SUPPORTED IN PART BY JAPAN SOCIETY FOR THE PROMOTION OF SCIENCE AND TECHNOLOGY (JSPS).

1EX-05

THE TRANSITION-EDGE-SENSOR ARRAY FOR THE MICRO-X SOUNDING ROCKET ***M. E. ECKART***[1]*, J. S. ADAMS*[1]*, C. N. BAILEY*[1]*, S. R. BANDLER*[2]*, J. A. CHERVENAK*[1]*, A. J. EWIN*[1]*, F. M. FINKBEINER*[1]*, R. L. KELLEY*[1]*, C. A. KILBOURNE*[1]*, F. S. PORTER*[1]*, J. E. SADLEIR*[1]*, S. J. SMITH*[1]*, E. FIGUEROA-FELICIANO*[3]*, P. WIKUS*[3]*, A. THE MICRO-X COLLABORATION*[4]*;* [1]NASA/GSFC, [2]NASA/GSFC AND UNIVERSITY OF MARYLAND, COLLEGE PARK, [3]MASSACHUSETTS INSTITUTE OF TECHNOLOGY, [4]VARIOUS. — THE MICRO-X SOUNDING ROCKET PROGRAM WILL FLY A 128-ELEMENT ARRAY OF TRANSITION-EDGE-SENSOR MICROCALORIMETERS TO ENABLE HIGH-RESOLUTION X-RAY IMAGING SPECTROSCOPY OF THE PUPPIS-A SUPERNOVA REMNANT. TO MATCH THE ANGULAR RESOLUTION OF THE OPTICS WHILE MAXIMIZING THE FIELD-OF-VIEW AND RETAINING A HIGH ENERGY RESOLUTION (2-4 EV AT 1 KEV), WE HAVE DESIGNED THE PIXELS USING 600 X 600 SQ. MICRON AU/BI ABSORBERS, WHICH OVERHANG 140 X 140 SQ. MICRON MO/AU SENSORS. THE DATA-RATE CAPABILITIES OF THE ROCKET TELEMETRY SYSTEM REQUIRE THE PULSE DECAY TO BE SLOWED TO ~2 MS TO ALLOW A SIGNIFICANT PORTION OF THE DATA TO BE TELEMETERED DURING FLIGHT. HERE WE REPORT EXPERIMENTAL RESULTS FROM THE FLIGHT ARRAY, INCLUDING MEASUREMENTS OF ENERGY RESOLUTION, CROSSTALK, AND UNIFORMITY. IN ADDITION, WE PRESENT STUDIES OF TEST DEVICES THAT HAVE A VARIETY OF ABSORBER CONTACT GEOMETRIES, AS WELL AS A VARIETY OF MEMBRANE-PERFORATION SCHEMES THAT ARE DESIGNED TO SLOW THE PULSE DECAYS.

1EX-06

DEVELOPMENT OF TRANSITION-EDGE-SENSOR MICROCALORIMETERS FOR SOLAR PHYSICS ***S. R. BANDLER***[1]*, C. N. BAILEY*[2]*, J. A. CHERVENAK*[2]*, M. E. ECKART*[2]*, F. M. FINKBEINER*[3]*, F. S. PORTER*[2]*, C. A. KILBOURNE*[2]*, R. E. KELLEY*[2]*, J. E. SADLEIR*[4]*, S. J. SMITH*[1]*;* [1]UNIVERSITY OF MARYLAND & NASA/GSFC, [2]NASA/GSFC, [3]RSIS & NASA/GSFC, [4]UNIVERSITY OF ILLINOIS & NASA/GSFC. — WE HAVE BEEN DEVELOPING TRANSITION-EDGE-SENSOR (TES) BASED X-RAY MICROCALORIMETER ARRAYS FOR FUTURE SOLAR PHYSICS MISSIONS. THE MICROCALORIMETERS NEED TO ACCOMMODATE HIGH COUNT RATES (> 300 CPS) WHILE MAINTAINING HIGH ENERGY RESOLUTION (< 4 EV FWHM) IN THE X-RAY ENERGY BAND OF 0.2-10 KEV. SMALL PIXEL SIZES (LESS THAN 70 MICRONS) ARE DESIRABLE TO PROVIDE HIGH ANGULAR RESOLUTION. WE HAVE ACHIEVED AN ENERGY RESOLUTION OF 2.1 EV FWHM AT 6 KEV IN A PIXEL WITH A 34 MICRON GOLD ABSORBER, AND A RESOLUTION OF 2.3 EV FWHM AT 6 KEV IN A PIXEL WITH A 57 MICRON GOLD ABSORBER. THIS PERFORMANCE HAS BEEN ACHIEVED IN PIXELS THAT ARE FABRICATED DIRECTLY ONTO SOLID SUBSTRATES, AND HAVE A HIGH ENOUGH THERMAL CONDUCTANCE TO ACCOMMODATE HIGH COUNT RATES. THESE DEVICES OPERATE IN A MODE THAT IS QUITE DIFFERENT FROM TRADITIONAL TESS. THE TRANSITION TEMPERATURE TC IS EXTREMELY CURRENT DEPENDENT, MORE SO THAN TRADITIONAL TES DESIGNS, BECAUSE THE SIZE IS SO SMALL; ALSO THE HEAT CAPACITY IS SMALL. DURING AN X-RAY EVENT, SINCE THE TES IS VOLTAGE BIASED, THE CURRENT (I) CHANGES SIGNIFICANTLY, AND CONSEQUENTLY, SO DOES TC. THUS, INSTEAD OF THE RESISTANCE (R) CHANGING ACCORDING TO THE SLOPE OF THE TES R-T CHARACTERISTIC, THE RESISTANCE MOVES ON AN R-I-T SURFACE IN A WAY THAT STILL GIVES A VERY LINEAR RESPONSE. WE WILL DESCRIBE THE PERFORMANCE AND CHARACTERISTICS OF THESE DETECTORS, AND ALSO THE EXPECTED PERFORMANCE AT HIGH COUNT RATES.

THIS WORK WAS FUNDED UNDER UNDER NASA'S ROSES PROGRAM FOR SOLAR AND HELIOSPHERIC PHYSICS RESEARCH.

1EX-07

TRANSITION-EDGE-SENSOR X-RAY SPECTROSCOPY FOR ELECTRONIC-STRUCTURE MEASUREMENT IN PHOTOVOLTAIC SYSTEMS ***W. B. DORIESE***[1]*, G. C. HILTON*[1]*, K. D. IRWIN*[1]*, D. R. SCHMIDT*[1]*, D. S. SWETZ*[1]*, J. N. ULLOM*[1]*, D. A. FISCHER*[2]*, V. SUNDSTROM*[3]*, J. UHLIG*[3]*, I. MAASILTA*[4]*, M. PALOSAARI*[4]*, K. KINNUNEN*[5]*;* [1]NIST - BOULDER LABS, [2]NIST - GAITHERSBURG, [3]KEMICENTRUM LUND UNIVERSITY, [4]UNIVERSITY OF JYVASKYLA, [5]KEMICENTRUM LUND UNIVERSITY AND UNIVERSITY OF JYVASKYLA. — WE ARE DEVELOPING TWO TES MICROCALORIMETER-ARRAY-BASED INSTRUMENTS TO MEASURE ELECTRONIC STRUCTURE IN THIRD-GENERATION PHOTOVOLTAICS, COMPLEX, NANOSTRUCTURED MATERIALS SYSTEMS IN WHICH THE FUNCTIONS OF LIGHT ABSORPTION, CHARGE TRANSFER, AND REDUCTION ARE PERFORMED BY DIFFERENT COMPONENTS, AND WHERE MUCH OF THE INTERESTING CHEMISTRY OCCURS AT BURIED INTERFACE LAYERS. THE FIRST INSTRUMENT, TO BE DEPLOYED AT THE NIST U7A BEAMLINE AT THE NATIONAL SYNCHROTRON LIGHT SOURCE AND OPTIMIZED TO OBSERVE C K-ALPHA FLUORESCENCE FROM ORGANIC PHOTOVOLTAICS AT 280 EV WITH ~1 EV (FWHM) ENERGY RESOLUTION, WILL ALLOW DIRECT BANDGAP MEASUREMENTS. THE SECOND INSTRUMENT, WITH SENSITIVITY UP TO 8 KEV AND <4 EV RESOLUTION, WILL BE DEPLOYED AT NOVEL TABLETOP PHOTON SOURCES IN LUND AND JYVASKYLA THAT GENERATE AN OPTICAL PULSE TO INITIATE PHOTOCHEMISTRY IN THE TARGET AND A SECOND, BROADBAND X-RAY PULSE AFTER A TUNABLE, SUBPICOSECOND DELAY TO INTERROGATE THE TARGET'S ELECTRONIC STRUCTURE. IN THIS PAPER, WE DISCUSS THE DESIGN DETAILS OF THE PAIR OF 256-PIXEL INSTRUMENTS; THEIR SHARED, NOVEL 3-DIMENSIONAL DETECTOR SNOUT AND 8-COLUMN BY 32-ROW TIME-DIVISION MULTIPLEXER ARCHITECTURE; OPTIMIZING TES ARRAYS FOR

HIGH COUNT RATES; AND INITIAL EXPERIMENTAL RESULTS FROM THE DEPLOYED INSTRUMENTS.

1EY-01

SUBMICRON SELF-SHUNTED NBN-TAN-NBTIN PLANARIZED JUNCTIONS *J. C. VILLEGIER[1], S. BOUAT[1], M. AURINO[1], M. HEITZMAN[2], D. RENAUD[2];* [1]CEA-GRENOBLE INAC, [2]CEA-GRENOBLE LETI. — NBTIN-TAN-NBN, SNS JOSEPHSON JUNCTIONS WITH TYPICALLY 7NM THICK TAN BARRIERS TUNED THROUGH NITROGEN CONTENT AT METAL-INSULATOR TRANSITION, HAVE BEEN ELABORATED IN THE STACK OF RSFQ CIRCUITS PATTERNED ON 8 INCH SILICON WAFERS. NBN BASE ELECTRODE, TAN AND NBTIN COUNTER-ELECTRODE ARE REACTIVELY SPUTTERED BY DC-MAGNETRON AT 300°C UNDER PARAMETER MATCHED TO CONTROL BOTH THE FILMS TEXTURES, LOW ROUGHNESS, UNIFORMITY ON LARGE AREA (30X30 CM^2) AND SUITABLE SUPERCONDUCTING PROPERTIES TO ACHIEVE CONTROLLABLE AND UNIFORM CURRENT DENSITIES AROUND 30 KA/CM^2 AT 9K. A DEEP UV STEPPER COMBINED WITH SF6 GAS RIE ARE USED TO ACHIEVE LOW SPREAD LITHOGRAPHY IN JUNCTION DIAMETERS 716 NM (3Σ ~ 40 NM) DOWN TO 465 NM (3Σ ~ 84 NM) ACROSS 8 INCH. A THICK PE-CVD SILICA LAYER IS APPLIED BEFORE CMP PLANARIZATION PROCESS. AS WE VARIED THE TAN BARRIER DEPOSITION CONDITIONS AND ANNEALING INSIDE THE BATCH OF WAFERS, THE JUNCTIONS EXHIBIT CURRENT DENSITIES IN THE RANGE 5 TO 50 KA/CM^2 AND RNIC PRODUCTS UP TO 2 MV AT 9K. WE WILL PRESENT OBTAINED SPREAD ON JOSEPHSON CURRENT, SQUID AND SFQ GATES CHARACTERISTICS AND THE STRONG POTENTIAL FOR MAKING NBN RSFQ CIRCUITS OPERATING IN A RELAXED CRYOGENIC ENVIRONMENT AT 9K.

WORK SUPPORTED BY ANR06 TCOM-023 HYPERSCAN

1EY-02

(INVITED) **FLEXIBLE MGB2 RIBBON CABLE INTERCONNECTS FOR DC AND RF APPLICATIONS** ***C. YUNG****, B. MOECKLY;* STI. — CRYOGENIC WIRING EXHIBITING LOW THERMAL CONDUCTIVITY AS WELL AS LOW SIGNAL LOSS IS OF KEY INTEREST TO THE LOW-TEMPERATURE DIGITAL SUPERCONDUCTING ELECTRONICS COMMUNITY. SIGNAL ROUTING FROM ROOM TEMPERATURE TO VARIOUS REFRIGERATIVE STAGES REQUIRES A HIGH-DENSITY INTERCONNECT THAT CAN SCALE TO LARGE NUMBERS WITHOUT ADVERSELY AFFECTING THE HEAT LOAD INTO THE CRYOSTAT. OTHER POSSIBLE APPLICATIONS OF THESE RIBBON CABLES INCLUDE INTERCONNECTS IN LARGE PIXEL ARRAY DETECTORS. FLAT RIBBON CABLES ARE IDEAL FOR THESE PURPOSES DUE TO THEIR LOW VOLUME-TO-SURFACE AREA RATIO IF A SUITABLE SUBSTRATE IS CHOSEN. WE ARE INVESTIGATING THE USE OF MgB_2 ON A NUMBER OF FLEXIBLE FLAT SUBSTRATES AS A VIABLE ALTERNATIVE TO NIOBIUM TRACES ON POLYIMIDE. USING THE TECHNIQUE OF REACTIVE EVAPORATION TO DEPOSIT THIN FILMS OF MgB_2 AT SUBSTRATE TEMPERATURES OF 400 TO 600 °C, WE ARE ABLE TO PRODUCE 1CM X 10 CM TAPES OF HIGH QUALITY MgB_2 (T_C ~ 38-39K) ON A VARIETY OF SUBSTRATES WHICH CAN SUBSEQUENTLY BE PATTERNED INTO HIGH-DENSITY DC SIGNALS TRACES OR COPLANAR WAVEGUIDES FOR RF SIGNAL PROPAGATION. FLEXIBLE YTTRIA-STABILIZED-ZIRCONIA AND POLYIMIDE SUBSTRATES CURRENTLY OFFER THE MOST PROMISING RESULTS AS LOW HEAT LEAK FLEXIBLE LEADS WHICH CAN WITHSTAND THE HIGH DEPOSITION TEMPERATURES FOR MgB_2 DEPOSITION. WE WILL DISCUSS THE BENEFITS AND COMPARE THE MEASURED ELECTRICAL PROPERTIES OF MgB_2 ON THE TWO FLEXIBLE SUBSTRATES.

1EY-03

SNIS BINARY ARRAYS OPERATION ON HIGH-ORDER SHAPIRO STEPS ***V. LACQUANITI[1], A. SOSSO[1], N. DE LEO[1], M. FRETTO[1], J. KOHLMANN[2], F. MUELLER[2];*** [1]INRIM, [2]PTB. — CIRCUITS OF BINARY ARRAYS IN PROGRAMMABLE AND AC JOSEPHSON VOLTAGE STANDARD (PJAV) MAKE USE OF THE -1, 0, 1 STEPS WITH NON-HYSTERETIC JUNCTIONS IRRADIATED WITH A MICROWAVE SIGNAL. PJAVS OPERATING AT 1 V AND 10 V HAVE BEEN REALIZED, WITH THE NUMBER OF JUNCTIONS RANGING FROM 8000 UP TO 300.000, DEPENDING ON THE JUNCTIONS CHARACTERISTIC VOLTAGE VC .HERE WE SHOW THAT WIDE SHAPIRO STEPS CORRESPONDING TO THE SECOND, THIRD AND EVEN FOURTH HARMONIC OF THE SIGNAL ARE GENERATED WHEN IRRADIATING BINARY DIVIDED ARRAYS OF NB/AL-ALOX/NB SNIS JOSEPHSON JUNCTIONS WITH 70-75 GHZ MICROWAVES. THE ARRAYS FABRICATED IN A JOINT COOPERATION BETWEEN INRIM AND PTB SHOWED VC OF 0.5-0.7 MV AT 4.2 K.VOLTAGES UP TO 3.7 AND 4.9 V HAVE BEEN OBTAINED ON 8192 JUNCTIONS ARRAYS, 200 μA WIDE. THIS AMPLITUDE DUE TO A STEP REDUCTION IN A SINGLE SEGMENT OF THE ARRAY, IS AUGMENTED TO TYPICALLY 1 MA FOR 1024, 2048 AND 4096 SUB-ARRAYS.FURTHER POSSIBILITIES DERIVE FROM THE COMBINED USE OF THE FIRST AND SECOND OR THE SECOND AND THIRD STEP, SINCE THE RANGE OF CHARACTERISTIC VOLTAGES OF THE JUNCTIONS IS SUITED FOR OPTIMAL OPERATION IN EITHER CASE. THUS, SNIS JUNCTIONS ALLOW TO BUILD CIRCUITS WHERE THE MAXIMUM VOLTAGE OUTPUT CAN BE ACHIEVED BY USING A SMALLER NUMBER OF JUNCTIONS COMPARED TO OTHER TECHNOLOGIES.

IMERA JOSY PROJECT

1EY-04

(INVITED) **A SELF-SHUNTED JUNCTION TECHNOLOGY FOR SINGLE-FLUX-QUANTUM DIGITAL CIRCUITS** ***D. OLAYA[1], P. D. DRESSELHAUS[1], S. P. BENZ[1], A. HERR[2], Q. P. HERR[2], A. G. IOANNIDIS[2], D. L. MILLER[2], A. W. KLEINSASSER[3];*** [1]NIST, [2]NORTHROP GRUMMAN CORP., [3]JET PROPULSION LABORATORY. — SINGLE-FLUX-QUANTUM CIRCUITS HAVE BEEN DEMONSTRATED WITH SELF-SHUNTED $NB/NB_XSI_{1-X}/NB$ JUNCTIONS WITH A CRITICAL CURRENT DENSITY (J_C) OF 5.5 KA/CM^2. SHIFT REGISTERS OPERATED WITH ±30 % BIAS MARGINS, CONFIRMING JUNCTION REPRODUCIBILITY AND UNIFORMITY. STATIC DIGITAL DIVIDERS OPERATED UP TO 165 GHZ FOR A SINGLE VALUE OF BIAS CURRENT. THE SPEED OF THESE CIRCUITS IS COMPARABLE TO SIMILAR ONES USING ALO_X JUNCTIONS, WHICH IS CURRENTLY THE DOMINANT TECHNOLOGY FOR SUPERCONDUCTING ELECTRONICS (SCE). SEVERAL PROPERTIES OF THESE JUNCTIONS MAKE THEM ATTRACTIVE FOR THEIR USE IN SCE. $NB/NB_XSI_{1-X}/NB$

JUNCTIONS CAN BE SELF-SHUNTED ALLOWING INCREASED CIRCUIT DENSITY (BY A FACTOR OF TWO IN THE CASE OF THE SHIFT REGISTERS). THE THICKNESS OF NB_XSI_{1-X} BARRIERS IS ON THE ORDER OF 10 NM, COMPARED TO ~1 NM FOR ALO_X BARRIERS, WHICH COULD LEAD TO BETTER JUNCTION UNIFORMITY AND, CONSEQUENTLY, HIGHER CIRCUIT YIELD. THIS IS ESPECIALLY IMPORTANT AT HIGHER VALUES OF J_C, WHERE POINT DEFECTS DOMINATE THE TRANSPORT IN THIN ALO_X BARRIERS. THE SIMPLE CO-SPUTTERING DEPOSITION OF NB_XSI_{1-X} AND THE SAME DRY ETCHING PROCESS FOR ELECTRODES AND BARRIERS ALLOW THE FABRICATION OF MULTIPLE STACKED JUNCTIONS, WHICH CAN ALSO CONTRIBUTE TO AN INCREASE IN CIRCUIT DENSITY.

1EY-05

COMPARISON IN ELECTRICAL CHARACTERISTICS OF NBN JUNCTIONS WITH ALNX BARRIERS FORMED BY DIFFERENT PLASMA NITRIDATION METHODS ***H. AKAIKE****, N. NAITO, Y. NAGAI, C. MARUYAMA, A. FUJIMAKI;* NAGOYA UNIVERSITY. — WE HAVE FABRICATED NBN/ALN/NBN SIS JUNCTIONS USING TWO KINDS OF PLASMA-NITRIDED ALN BARRIER FORMATION METHODS, AND COMPARED THE ELECTRICAL CHARACTERISTICS OF THEM. ONE METHOD WAS A RADICAL-NITRIDATION METHOD WHERE N_2 RADICALS IN AN RF N_2 PLASMA CONTRIBUTE TO ALN BARRIER FORMATION. THE OTHER WAS A CONVENTIONAL PLASMA-NITRIDATION METHOD WHERE N_2 IONS AS WELL AS N_2 RADICALS DO TO THE BARRIER FORMATION. BOTH ALN BARRIERS WERE FORMED BY NITRIDATION OF THE SURFACE OF AN AL LAYER DEPOSITED ON THE BASE NBN LAYER. FOR BOTH JUNCTIONS, WE OBSERVED THE SIMILAR TENDENCY IN DEPENDENCE OF JUNCTION GAP VOLTAGE, V_G, ON AL FILM THICKNESS, AND OBTAINED THE V_G AS HIGH AS AROUND 4 MV WHEN AL FILM THICKNESS WAS 1 NM. ON THE OTHER HAND, CRITICAL CURRENT DENSITY, J_C, AND THE QUALITY FACTOR, R_{SG}/R_N, DEPENDED ON THE FORMATION METHOD. THE JUNCTIONS WITH THE RADICAL-NITIRIDATION METHOD SHOWED J_C UP TO 7 KA/CM^2, AND R_{SG}/R_N AS HIGH AS 26 FOR 1 KA/CM^2 JUNCTIONS, WHEREAS THE OTHER JUNCTIONS DID J_C RANGING FROM 5 TO 32 KA/CM^2, AND R_{SG}/R_N AS HIGH AS 9. IN ADDITION, THE FORMER JUNCTION SHOWED BETTER CRITICAL CURRENT UNIFORMITY THAN THE LATTER JUNCTION. THESE RESULTS INDICATED THAT THE ALN BARRIER FORMED BY THE RADICAL-NITRIDATION METHOD WAS MORE HOMOGENEOUS THAN THE OTHER BARRIER.

THIS WORK WAS IN PART SUPPORTED BY A GRANT-IN-AID FOR SCIENCE RESEARCH IN A PRIORITY AREA "SINGLE-FLUX-QUANTUM LOCALIZED ELECTROMAGNETIC WAVE INTEGRATED CIRCUITS" FROM THE MINISTRY OF EDUCATION, SPORTS, CULTURE, SCIENCE, AND TECHNOLOGY, JAPAN.

1EY-06

MGB_2/MGO/MGB_2 JOSEPHSON JUNCTIONS FOR HIGH-SPEED CIRCUIT ***K. CHEN****[1], C. ZHUANG[1], Q. LI[2], X. X. XI[1];* [1]TEMPLE UNIVERSITY, [2]THE PENNSYLVANIA STATE UNIVERSITY. — MGB_2/MGO/MGB_2 SANDWICH-TYPE JOSEPHSON JUNCTIONS HAVE BEEN FABRICATED USING MGB_2 FILMS GROWN BY HYBRID PHYSICAL-CHEMICAL VAPOR DEPOSITION (HPCVD) AND MGO BARRIER AND INSULATING LAYERS MADE BY RF MAGNETRON SPUTTERING. THE JUNCTIONS EXHIBIT NON-VANISHING J_C UP TO 40 K, THE T_C OF MGB_2. JOSEPHSON EFFECTS WERE OBSERVED BY FRAUNHOFER-LIKE PATTERN IN MAGNETIC FIELD MODULATION OF I_C AND SHAPIRO STEPS IN *I-V* CURVES UNDER THE MICROWAVE RADIATION. THE *I-V* CURVES OF THE JUNCTION ARE HYSTERETIC AT TEMPERATURES BELOW 25 K AND ARE RSJ-LIKE ABOVE 25 K, DUE TO THE INTERNAL SHUNT FROM THE MULTIPLE ANDREEV REFLECTION. THE I_CR_N PRODUCT OF THE UNSHUNTED JUNCTION IS UP TO 3 MV AND J_C IS UP TO 275 KA/CM^2 AT 4 K. THE J_C SPREAD (1Σ) OF 10 JUNCTIONS ON ONE CHIP IS BETTER THAN 10% AND MGB_2 INTERCONNECTION HAS ALSO BEEN ACHIEVED WITHOUT SIGNIFICANTLY CHANGING JUNCTION PROPERTIES. HIGH-SPEED SUPERCONDUCTING DIGITAL CIRCUITS MADE OF THESE JUNCTIONS ARE EXPECTED TO WORK AT FREQUENCY UP TO 1 THZ OR AT TEMPERATURE OVER 20 K.

THIS WORK IS PARTIALLY SUPPORTED BY ONR AND DOE

1EZ-01

(INVITED) **EXPERIMENTAL INVESTIGATION OF AN EIGHT QUBIT SUPERCONDUCTING OPTIMIZATION PROCESSOR** ***R. HARRIS****, M. W. JOHNSON, T. LANTING, A. J. BERKLEY, J. JOHANSSON, P. BUNYK, E. TOLKACHEVA, E. LADIZINSKY;* D-WAVE SYSTEMS. — A CHIP COMPRISED OF EIGHT RF-SQUID FLUX QUBITS, SIXTEEN IN-SITU TUNABLE INTER-QUBIT INDUCTIVE COUPLERS, AN XY-ADDRESSABLE READOUT SYSTEM AND CONTROLLED VIA AN ADDRESSABLE ON-CHIP PROGRAMMABLE MAGNETIC MEMORY ARRAY HAS BEEN DESIGNED, FABRICATED AND TESTED. THE ARCHITECTURE OF THE CHIP AND THE INFRASTRUCTURE USED TO CONTROL IT WERE EXPLICITLY CHOSEN TO FACILITATE THE IMPLEMENTATION OF AN ADIABATIC QUANTUM OPTIMIZATION ALGORITHM. THE PERFORMANCE OF THIS PROTOTYPE INFORMATION PROCESSOR HAS BEEN CHARACTERIZED BY MEASURING THE SUCCESS OF THE HARDWARE IN SOLVING LARGE SETS OF RANDOM ISING SPIN GLASS PROBLEMS AS A FUNCTION OF PROCESSOR TEMPERATURE. THE EXPERIMENTAL DATA HIGHLIGHT MANY OF THE KEY PRACTICAL CHALLENGES THAT WE HAVE OVERCOME AND THOSE THAT LIE AHEAD IN ORDER TO REALIZE A FUNCTIONAL LARGE SCALE ADIABATIC QUANTUM COMPUTER.

WE ACKNOWLEDGE SIYUAN HAN, A. KLEINSASSER AND G. KERBER FOR VALUABLE INSIGHT AND FEEDBACK.

1EZ-02

ROLE OF GEOMETRY ON THE COLOR OF FLUX NOISE IN DC SQUIDS ***F. WELLSTOOD****[1], C. URBINA[2], J. CLARKE[3];* [1]UNIVERSITY OF MARYLAND, [2]CEA SACLAY, [3]UNIVERSITY OF CALIFORNIA, BERKELEY. — WE EXAMINE THE BEHAVIOR OF LOW FREQUENCY FLUX NOISE MEASURED IN TEN NB-NBOX-PBIN DC SQUIDS IN THE TEMPERATURE RANGE FROM 1 K TO 20 MK. AS WAS PREVIOUSLY REPORTED, THE FLUX NOISE POWER

SPECTRUM $S_\Phi(F)$ TYPICALLY SCALES WITH FREQUENCY AS A/F^A. REMARKABLY, THE NOISE AMPLITUDE A INCREASES AS THE TEMPERATURE IS DECREASED BELOW ABOUT 0.7 K AND SATURATES TO A VALUE AROUND $(5M\Phi_O)^2$/HZ BELOW ABOUT 0.2 K. HERE WE REPORT ON THE SYSTEMATIC DEPENDENCE OF BOTH A AND THE SLOPE A OF THE POWER SPECTRUM ON THE SIZE AND LINEWIDTH OF THE SQUID LOOPS. IN PARTICULAR, WE FIND THAT THE SLOPE A REACHES VALUES AS LOW AS 0.6 IN THE SMALLEST DEVICES (~ 20 MM) AT THE LOWEST TEMPERATURES, WHILE A IS IN THE RANGE OF 0.9-1 FOR FOUR OF OUR LARGEST DEVICES (~ 1 MM). CLOSE EXAMINATION OF THE DATA ALSO REVEALS A ROUGH SCALING OF THE NOISE SPECTRUM WITH THE SQUID LOOP INDUCTANCE AND POSSIBLE LORENTZIAN FEATURES IN SOME OF THE SPECTRA IN THE 0.5 K TO 1 K RANGE.

THIS WORK WAS SUPPORTED BY DOE BES, THE CENTER FOR NANOPHYSICS AND ADVANCED MATERIALS, THE LABORATORY FOR PHYSICAL SCIENCES, AND THE JOINT QUANTUM INSTITUTE.

1EZ-03

QUANTUM ERROR CORRECTION FEEDBACK USING RECIPROCAL QUANTUM LOGIC ***Q. P. HERR**, A. Y. HERR, J. E. BAUMGARDNER II, A. A. PESETSKI;* NORTHROP GRUMMAN CORPORATION. — ANY SOLID STATE QUBIT IMPLEMENTATION WILL REQUIRE A MK ENVIRONMENT PROVIDED BY A DILUTION REFRIGERATOR AND WILL REQUIRE AUXILIARY CLASSICAL LOGIC IN ORDER TO FEED BACK ERROR CORRECTION. CO-LOCATING THE CLASSICAL LOGIC IN THE MK ENVIRONMENT MINIMIZES INTERCONNECT OVERHEAD AND LATENCY, BUT PLACES SEVERE CONSTRAINTS ON POWER DISSIPATION. WE REPORT DESIGN AND TEST OF A CIRCUIT IMPLEMENTING STANDARD TWO-OF-THREE MAJORITY ERROR CORRECTION LOGIC BASED ON INDIRECT MEASUREMENT OF QUBIT STATE. THE CIRCUIT IS BASED ON RECIPROCAL QUANTUM LOGIC USING 20 UA JUNCTIONS FABRICATED IN THE HYPRES 30A/CM^2 PROCESS. AT A CLOCK RATE OF 100 MHZ AND A DUTY CYCLE 0.1% EXPECTED FOR THE APPLICATION, THE CIRCUIT DISSIPATED ONLY 200 FW NEGLECTING THE OUTPUT AMPLIFIERS.

1EZ-04

OPERATION OF PD-SOI STRUCTURES AT CRYOGENIC TEMPERATURES ***I. V. VERNIK**[1], T. OHKI[1], M. B. KETCHEN[2], M. BHUSHAN[3];* [1]RAYTHEON BBN TECHNOLOGIES, [2]IBM RESEARCH, [3]IBM STG DIVISION. — HIGH PERFORMANCE CRYO-CMOS IS OF POTENTIAL INTEREST FOR MERGED JOSEPHSON-CMOS APPLICATIONS AS WELL AS FOR CONTROL CIRCUITRY FOR CONVENTIONAL AND QUANTUM SUPERCONDUCTING ELECTRONICS. WE REPORT ON THE SUCCESSFUL OPERATION OF PARTIALLY DEPLETED SILICON ON INSULATOR (PD-SOI) DIGITAL TEST STRUCTURES AT TEMPERATURES DOWN TO 2.8 K. THIS 45 NM CMOS TECHNOLOGY NODE HARDWARE WAS FABRICATED ON 300 MM WAFERS THAT WERE PART OF A DEVELOPMENT LOT NOT OPTIMIZED FOR LOW TEMPERATURE OPERATION. THESE STRUCTURES COMPRISE A SET OF RING OSCILLATORS, AN OUTPUT MULTIPLEXER AND A DIVIDE BY 1024 CIRCUIT FOLLOWED BY AN OFF-CHIP DRIVER. IN GOING FROM 300 K TO CRYOGENIC TEMPERATURES STATIC POWER DISSIPATION DECREASES BY AN ORDER OF MAGNITUDE WHILE CIRCUIT DELAYS IMPROVE BY ABOUT 20 %. TO GET FURTHER INSIGHT WE HAVE ALSO MEASURED AT CRYOGENIC TEMPERATURE SINGLE MOSFETS AND SMALL ARRAYS OF MOSFETS FABRICATED ALONGSIDE THE RING OSCILLATORS. EXPERIMENTAL RESULTS AND POTENTIAL APPLICATION OF CRYOGENIC PD-SOI ARE DISCUSSED.

1EZ-05

A SCALABLE CONTROL SYSTEM FOR A SUPERCONDUCTING ADIABATIC QUANTUM OPTIMIZATION PROCESSOR ***P. BUNYK**, M. W. JOHNSON, A. J. BERKLEY, R. HARRIS, J. JOHANSSON, T. LANTING, E. TOLKACHEVA, I. PERMINOV, E. CHAPPLE, B. WILSON, J. HILTON, E. LADIZINSKY, G. ROSE;* D-WAVE SYSTEMS INC.. — OPERATION OF D-WAVE'S PROTOTYPE ADIABATIC QUANTUM OPTIMIZATION PROCESSORREQUIRES ABILITY TO APPLY A MULTITUDE OF TIME-INDEPENDENT AND A LIMITEDNUMBER OF TIME-DEPENDENT FLUX BIASES TO CONTROL SEVERAL TYPES OF SUPERCONDUCTINGDEVICES IN AN INTEGRATED CIRCUIT. THESE FLUX BIASES ARE USED BOTH TO SPECIFYTHE OPTIMIZATION PROBLEM THAT IS TO BE SOLVED AND, EQUALLY IMPORTANT, TO COMPENSATEFOR FABRICATION VARIATIONS AND PHYSICAL NON-LINEARITIES OF THE DEVICES. OUR CURRENTPROCESSORS REQUIRE SIX SUCH SIGNALS PER QUBIT AND ONE PER INTER-QUBIT COUPLER. TO BUILD A LARGEENOUGH PROCESSOR TO BE CONSIDERED COMPETITIVE (I.E., SOLVING NON-TRIVIAL PROBLEMSTHAT ARE CONSIDERED INTRACTABLE FOR CONVENTIONAL DIGITAL COMPUTERS), THE CIRCUIT MUST MAKEEFFICIENT USE OF A LIMITED NUMBER OF CONTROL LINES GOING BETWEEN ROOM TEMPERATURE AND THEPROCESSOR'S LOW TEMPERATURE (~ 20 MK) PACKAGING. OUR SOLUTION TO THIS REAL-WORLD PROCESSORDESIGN PROBLEM INVOLVES THE USE OF ON-CHIP DIGITALLY PROGRAMMABLE FLUX SOURCES (FLUX DACS)THAT ARE ADDRESSED USING ONLY A SMALL NUMBER OF BIAS LINES VIA RSFQ BINARY DEMULTIPLEXERS.WE PRESENT DATA VERIFYING THE SUCCESSFUL OPERATION OF SUCH A CONTROL SYSTEM ON PROCESSORSCONTAINING UP TO 128 QUBITS AND 352 INTER-QUBIT COUPLERS.

1EZ-06

MICROSTRIP SQUID AMPLIFIERS FOR QUBIT READOUT AT GIGAHERTZ FREQUENCIES AND MILLIKELVIN TEMPERATURES ***J. E. JOHNSON**[1], E. M. HOSKINSON[2], D. KINION[3], C. MACKLIN[2], J. B. HANSEN[4], I. SIDDIQI[2], J. CLARKE[1];* [1]UC BERKELEY, [2]QNL, UC BERKELEY, [3]LAWRENCE LIVERMORE NATIONAL LABORATORY, [4]TECHNICAL UNIVERSITY OF DENMARK. — THE NOISE PERFORMANCE OF CRYOGENIC SEMICONDUCTOR HEMT AMPLIFIERS PRESENTLY LIMITS THE SENSITIVITY OF DISPERSIVE QUBIT READOUT TECHNIQUES. TO IMPROVE THE OVERALL SIGNAL TO NOISE RATIO OF OUR FLUX QUBIT READOUT, WE HAVE FABRICATED AND CHARACTERIZED LOW NOISE MICROSTRIP SQUID AMPLIFIERS (MSAS) OPERATING IN THE 1.2 TO 1.6 GHZ FREQUENCY BAND. THE MSA CONSISTS OF A MICROSTRIP INPUT COIL, OPEN AT ONE END, INDUCTIVELY COUPLED TO A SQUID WASHER WHICH ALSO SERVES AS THE

MICROSTRIP GROUND PLANE. THE RESISTIVELY-SHUNTED SQUID IS OPERATED IN THE VOLTAGE STATE IN AN OPEN LOOP CONFIGURATION. THE INPUT IS CRITICALLY COUPLED TO A 50-Ω SOURCE VIA A CAPACITOR TO OPTIMIZE THE GAIN AND BANDWIDTH. AT 25 MK WE HAVE OBSERVED STABLE FORWARD GAIN UP TO 14 DB ON RESONANCE AT 1.39 GHZ WITH BANDWIDTHS OF TYPICALLY 20 MHZ AND NOISE TEMPERATURES OF ABOUT 300 MK (CAVES ADDED NOISE NUMBER OF ABOUT 4.0). THIS NOISE TEMPERATURE IS AN ORDER OF MAGNITUDE LOWER THAN THAT OF A TYPICAL HEMT. HIGHER FREQUENCY OPERATION WILL BE DISCUSSED.

THIS WORK WAS FUNDED IN PART BY THE U.S. GOVERNMENT AND BY BBN TECHNOLOGIES.

1EZ-07

DISPERSIVE READOUT OF A FLUX QUBIT USING A MICROSTRIP SQUID AMPLIFIER ***E. M. HOSKINSON***[1]*, J. E. JOHNSON*[2]*, C. MACKLIN*[3]*, J. CLARKE*[2]*, I. SIDDIQI*[3]*;* [1]QNL AND DEPT. OF PHYSICS, UC BERKELEY, [2]DEPT. OF PHYSICS, UC BERKELEY, [3]QNL, DEPT. OF PHYSICS, UC BERKELEY. — DISPERSIVE TECHNIQUES FOR THE READOUT OF SUPERCONDUCTING QUBITS OFFER THE POSSIBILITY OF HIGH REPETITION-RATE QUANTUM NON-DEMOLITION MEASUREMENT BY AVOIDING DISSIPATION CLOSE TO THE QUBIT. OUR DISPERSIVE READOUT SCHEME CONSISTS OF A THREE JUNCTION ALUMINUM FLUX QUBIT FABRICATED INSIDE THE LOOP OF A DC SQUID. THE SQUID, WHICH ACTS AS A FLUX DEPENDENT NONLINEAR INDUCTOR, IS SHUNTED BY A CAPACITOR. THE CAPACITOR AND SQUID FORM A 1-2 GHZ QUBIT STATE DEPENDENT RESONATOR. TO MEASURE THE STATE OF THE QUBIT, WE EXCITE THE RESONATOR WITH CAPACITIVELY COUPLED MICROWAVES AND MONITOR THE PHASE OF THE REFLECTED SIGNAL. THE PERFORMANCE OF THIS SCHEME IS LIMITED BY THE NOISE TEMPERATURE OF THE AMPLIFIER USED TO DETECT THE REFLECTED SIGNAL. TO IMPROVE PERFORMANCE, WE USE A MICROSTRIP SQUID AMPLIFIER (MSA) WITH A NOISE TEMPERATURE OF A FEW HUNDRED MILLIKELVIN. THIS NOISE TEMPERATURE IS AN ORDER OF MAGNITUDE LOWER THAN THAT OF THE HEMT (HIGH ELECTRON MOBILITY TRANSISTOR) AMPLIFIER THAT FOLLOWS THE MSA. WE REPORT MEASUREMENTS IN BOTH THE LINEAR (WEAK DRIVE) AND THE BISTABLE (STRONG DRIVE) OSCILLATOR REGIMES.

THIS WORK WAS FUNDED IN PART BY THE U.S. GOVERNMENT AND BY BBN TECHNOLOGIES.

1LA-01

(INVITED) **FULL POWER TEST OF A 36.5 MW HIGH TEMPERATURE SUPERCONDUCTOR PROPULSION MOTOR** ***G. L. SNITCHLER***[1]*, B. GAMBLE*[1]*, T. MACDONALD*[1]*, D. ALEXANDER*[2]*, D. RUMMLER*[2]*, B. HARTMAN*[2]*;* [1]AMERICAN SUPERCONDUCTOR, [2]NORTHRUP GRUMMAN ELECTRONIC SYSTEMS-MARINE SYSTEMS. — THIS PAPER DISCUSSES THE FULL-POWER TESTING OF A 36.5 MW HIGH TEMPERATURE SUPERCONDUCTOR (HTS) PROPULSION MOTOR AT THE NAVY'S LAND BASED TEST SITE (LBTS) LOCATED IN PHILADELPHIA, PA. THIS MOTOR WAS DEVELOPED UNDER FUNDING FROM THE OFFICE OF NAVAL RESEARCH AND PASSED NO-LOAD FACTORY TESTING AT A NORTHROP GRUMMAN FACILITY IN PHILADELPHIA IN MARCH 2007. A TEAM COMPRISED OF AMERICAN SUPERCONDUCTOR, NORTHROP GRUMMAN AND NAVAL SURFACE WARFARE CENTER (CARDEROCK DIVISION - PHILADELPHIA SITE) HAVE DESIGNED AND INSTALLED A TEST FACILITY AT LBTS TO SUPPORT FULL-POWER / FULL-TORQUE TESTING OF THE HTS MOTOR DELIVERED TO THE NAVY IN 2007. THE FACILITY, TEST PLAN AND FULL-POWER AND FULL-TORQUE TEST RESULTS OF THE HTS PROPULSION MOTOR ARE PRESENTED. THESE TEST RESULTS PROVIDE THE FINAL SUBSTANTIATION THAT THIS TECHNOLOGY IS READY FOR INTEGRATION IN TO A NAVY ELECTRIC DRIVE COMBATANT.

THIS WORK WAS SUPPORTED BY THE OFFICE OF NAVAL RESEARCH, THE NAVAL SEA SYSTEMS COMMAND, THE NAVAL SURFACE WARFARE CENTER, AMERICAN SUPERCONDUCTOR CORPORATION AND NORTHROP GRUMMAN CORPORATION.

1LA-02

DESIGN OF A 15,000 RPM, 2.5 MEGAWATT HTS GENERATOR SUITABLE FOR COMMERCIAL AND MILITARY APPLICATIONS AND THE RESULTS OF THE SUCCESSFUL 15,000 HTS ROTOR TEST ***L. J. LONG***[1]*, J. PARKER*[1]*, P. SCHRUM*[2]*, R. G. BUCKLEY*[3]*;* [1]LEI, [2]FOREFRONT ENGINEERING AND DESIGN, [3]INDUSTRIAL RESEARCH, LTD.. — DESIGN OF A 15,000 RPM, 2.5 MEGAWATT HTS GENERATOR SUITABLE FOR COMMERCIAL AND MILITARY APPLICATIONS AND THE RESULTS OF A SUCCESSFUL 15,000 RPM HTS ROTOR TEST. NEW COMMERCIAL AND MILITARY SYSTEMS ARE EVOLVING THAT WILL NOT BE POSSIBLE WITHOUT VERY LIGHTWEIGHT COMPACT MULTI-MEGAWATT ELECTRICAL GENERATORS. THE ADVENT OF HIGH STRENGTH HIGH PERFORMANCE 1G AND 2G HTS WIRE MAY MAKE IT POSSIBLE TO BUILD AND OPERATE RELIABLE HIGH POWER GENERATORS THAT ARE 30% THE SIZE AND WEIGHT OF CONVENTIONAL GENERATORS. WHILE HTS MACHINES HAVE BEEN SUCCESSFULLY OPERATED AT RELATIVELY LOW RPMS, MANY EMERGING SYSTEMS WILL REQUIRE GENERATORS TO OPERATE AT SPEEDS BETWEEN 12,000 AND 20,000 RPM, EXPOSING HTS COILS TO UNPRECEDENTED MECHANICAL STRESS.THIS PAPER PRESENTS THE RESULTS OF A USAF PROGRAM IN WHICH WE DEVELOPED A UNIQUE AND PRACTICAL DESIGN OF A LIGHTWEIGHT FULL-SCALE, 2.5 MEGAWATT, 15,000 RPM HTS GENERATOR THAT IS ADAPTABLE TO MANY COMMERCIAL AND MILITARY POWER SYSTEMS. THE PROGRAM CULMINATED IN THE FABRICATION AND SUCCESSFUL TEST OF A 15,000 RPM HTS ROTOR THAT SUBJECTED COILS TO MECHANICAL LOADS 9 TIMES HIGHER THAN IN ANY PREVIOUS MACHINE AND PROVED THE VIABILITY OF USING 1G AND 2G HTS CONDUCTORS IN EXTREME MECHANICAL ENVIRONMENTS. THIS PAPER PRESENTS THE DESIGN OF THIS GENERATOR, GUIDELINES FOR FUTURE HTS GENERATORS AND HTS ROTOR TEST RESULTS.

1LA-03

10 MW CLASS SUPERCONDUCTOR WIND TURBINE GENERATOR ***G. L. SNITCHLER****, B. GAMBLE, P. WINN, C. KING;*

AMERICAN SUPERCONDUCTOR. — HIGH TEMPERATURE SUPERCONDUCTOR (HTS) TECHNOLOGY BRINGS A BREAKTHROUGH IN WIND POWER. THE HIGH CURRENT CAPACITY, LOSSLESS SUPERCONDUCTOR WIRES ENABLE GENERATORS WITH ONE THIRD THE WEIGHT WITH ONE HALF THE LOSSES OF CONVENTIONAL MACHINES. THESE TECHNOLOGIES ENABLE A DRAMATIC REDUCTION IN THE SIZE AND WEIGHT OF 10 MW-CLASS GENERATORS FOR DIRECT-DRIVE WIND TURBINE SYSTEMS AND OPEN THE DOOR TO MAJOR REDUCTION IN THE COST OF CLEAN ENERGY PRECLUDED UP TO NOW BY THE LARGE SIZE AND WEIGHT OF CONVENTIONAL COPPER AND PERMANENT-MAGNET-BASED GENERATORS AND GEARBOXES. WITH INNOVATIVE, COMPACT AND LIGHT-WEIGHT 10 MW-CLASS HTS GENERATORS, INSTALLATION AND LOW MAINTENANCE OPERATION OF HIGH POWER WIND TURBINE SYSTEMS BECOMES PRACTICAL AND ENABLES COST-EFFECTIVE ACCESS TO WIND RESOURCES. UNDER A PROGRAM FUNDED UNDER THE NIST-ADVANCED TECHNOLOGY PROGRAM [1], KEY GENERATOR TECHNOLOGIES FOR A 10 MW CLASS GENERATOR HAVE BEEN DEVELOPED. THIS PAPER SUMMARIZES WORK UNDER THESE PROGRAMS AND PROJECTIONS FOR FUTURE DEVELOPMENT AND BENEFITS OF THIS TECHNOLOGY.[1] NIST ADVANCED TECHNOLOGY PROGRAM CONTRACT NUMBER 70NANB7H7647, “TECHNICAL INNOVATIONS ENABLING A NEW DIRECT DRIVE WIND TURBINE GENERATOR”

THIS WORK WAS SUPPORTED IN PART UNDER THE NIST ATP PROGRAM, AMERICAN SUPERCONDUCTOR CORPORATION AND TECO-WESTINGHOUSE MOTOR COMPANY.

1LA-04

DOUBLE-HELIX FULLY-SUPERCONDUCTING GENERATOR FOR NEW GENERATION OFF-SHORE WIND TURBINES ***P. J. MASSON****, J. LAMMERS, V. PRINCE;* ADVANCED MAGNET LAB. — THE INCREASING GLOBAL ADOPTION OF RENEWABLE ENERGY IS DRIVING THE DEVELOPMENT OF NEW TECHNOLOGIES IN POWER GENERATION. A MAJOR COMPONENT IS LARGE, OFFSHORE WIND TURBINES. FOR THESE TURBINES, DEVELOPMENT OF NEW TECHNOLOGIES WHICH REDUCE THE SIZE AND WEIGHT OF SYSTEM COMPONENTS IS CRITICAL SINCE CONTROL OF SIZE AND WEIGHT IS A MAJOR FACTOR IN DETERMINING THE COST OF ENERGY.CURRENT GENERATOR TECHNOLOGY SCALES UP POORLY AS POWER REQUIREMENTS ARE INCREASED. OVERCOMING THE LIMITATIONS OF CURRENT MACHINES REQUIRES MIGRATION TO A DIFFERENT TECHNOLOGY AND MATERIALS PLATFORM. DUE TO THEIR UNIQUE LACK OF ELECTRICAL RESISTANCE AND ABILITY TO CARRY HIGH CURRENTS DENSITIES, SUPERCONDUCTORS ENABLE THE DEVELOPMENT OF AIR-CORE MACHINES. THESE MACHINES EXHIBIT DRAMATIC MASS REDUCTION AND REMOVE THE AIR-GAP FLUX LIMITATION DUE TO MAGNETIC SATURATION. GENERATORS EXHIBITING SPECIFIC TORQUES IN THE 150 NM/KG RANGE ARE POSSIBLE, ENABLING COST EFFECTIVE, LARGE WIND TURBINES GENERATING POWER AT 10 MW AND BEYOND.A FULLY SUPERCONDUCTING 10 MW, 10 RPM DIRECT DRIVE GENERATOR BASED ON THE DOUBLE-HELIX WINDING TECHNOLOGY IS PRESENTED. A DETAILED PRESENTATION OF THE TECHNOLOGY IS PRESENTED ALONG WITH THE DESIGN AND PERFORMANCE OF THE GENERATOR. SINCE THE PROPOSED TECHNOLOGY CAN ALSO BENEFIT LOWER POWER LEVELS, A COMPARISON OF PERFORMANCE, WEIGHT AND COST WITH STATE OF THE ART RESISTIVE GENERATORS IS INCLUDED.

1LA-05

TRANSVERSE FLUX ENHANCED TYPE SUPERCONDUCTING SYNCHRONOUS MACHINES FOR WIND POWER GENERATION ***H. OHSAKI****[1], M. R. QUDDES[1], M. SEKINO[1], N. KASHIMA[2], S. NAGAYA[2];* [1]THE UNIVERSITY OF TOKYO, [2]CHUBU ELECTRIC POWER CO., INC.. — WE PROPOSE A TRANSVERSE FLUX ENHANCED TYPE SUPERCONDUCTING SYNCHRONOUS MACHINE, WHICH HAS MULTIPLE CIRCULAR SUPERCONDUCTING FIELD COILS IN THE ROTOR AND CONCENTRATED COPPER ARMATURE WINDINGS IN THE STATOR. A ONE-POLE SET OF FIELD COILS IS COMPOSED OF THREE SUPERCONDUCTING CIRCULAR COILS, AND PARTLY GENERATES A TRANSVERSE MAGNETIC FIELD TO THE ROTATIONAL DIRECTION. ALTHOUGH SUCH SUPERCONDUCTING FIELD COILS NEED RATHER LONG SUPERCONDUCTING WIRE IN THE WHOLE MACHINE, THEY HAVE A QUITE SIMPLE SHAPE AND CAN BE MORE EASILY FABRICATED THAN RACETRACK COILS, ETC. THIS TYPE OF SUPERCONDUCTING MACHINES WILL BE SUITABLE FOR LARGE-CAPACITY, LOW-SPEED, AND HIGH-TORQUE APPLICATIONS. SO A LARGE WIND TURBINE GENERATOR IS A GOOD TARGET OF THIS TYPE OF MACHINES. WE HAVE STUDIED AN 8-10 MW CLASS WIND TURBINE GENERATOR BASED ON THIS MACHINE CONCEPT. THE ROTATIONAL SPEED IS 10-12 RPM AND THE TORQUE IS AS HIGH AS 6-10 MN. THREE-DIMENSIONAL FEM ANALYSIS WAS CARRIED OUT TO STUDY THE DEPENDENCE OF ELECTROMAGNETIC CHARACTERISTICS OF THE GENERATORS ON THE MACHINE PARAMETERS. A 10-POLE, 5M-DIAMETER MACHINE IS AN EXAMPLE OF THE DESIGNED GENERATORS. MECHANICAL AND COOLING ISSUES ARE ALSO DISCUSSED.

1LA-06

ADVANCES IN HTS INDUCTION-SYNCHRONOUS MACHINE DEVELOPMENT -CHALLENGING TO INNOVATIVE ELECTRIC VEHICLE- ***T. NAKAMURA****[1], T. NISHIMURA[1], K. MATSUMURA[1], D. SEKIGUCHI[1], R. ASAI[1], M. FUKUI[1], T. MATSUO[1], N. AMEMIYA[1], Y. ITOH[2], M. YOSHIKAWA[2], T. TERAZAWA[2], K. OSAMURA[3], S. FUKUI[4], J. OGAWA[4], N. OKUMURA[5], Y. OHASHI[5], T. OKA[4];* [1]KYOTO UNIVERSITY, [2]IMRA MATERIAL R&D CO., LTD., [3]RESEARCH INSTITUTE FOR APPLIED SCIENCES, [4]NIIGATA UNIVERSITY, [5]AISIN SEIKI CO., LTD.. — OUR PROJECT GROUP HAS BEEN CHALLENGING TO THE DEVELOPMENT OF HIGH TEMPERATURE SUPERCONDUCTOR (HTS) DRIVE SYSTEM FOR THE NEXT GENERATION ELECTRIC VEHICLE, IN A FRAMEWORK OF THE NEDO NATIONAL PROJECT IN JAPAN. THE SYSTEM CONSISTS OF THE INNOVATIVE HTS INDUCTION-SYNCHRONOUS MACHINE(HTS-ISM) AND HIGH EFFICIENCY STIRLING REFRIGERATOR. ALTHOUGH BASIC STRUCTURE OF THE HTS-ISM IS THE SAME AS THAT OF THE CONVENTIONAL SQUIRREL-CAGE INDUCTION MOTOR, THE WONDERFUL PERFORMANCE SUCH AS HIGH EFFICIENCY FOR VARIABLE

SPEED CONTROL AND EXTREMELY HIGH TORQUE DENSITY CAN BE REALIZED BY REPLACING THE STATOR AS WELL AS ROTOR WINDINGS BY HTS CONDUCTORS. THESE CHARACTERISTICS LEAD TO THE REMOVAL OF THE TRANSMISSION GEAR THAT IS HEAVY AND GENERATE A LOT OF ENERGY LOSSES, AND THEN THE CORRESPONDING TOTAL SYSTEM EFFICIENCY OF THE DRIVE SYSTEM WILL DRASTICALLY INCREASE EVEN WE CONSIDER THE COOLING LOSSES OF THE REFRIGERATOR.IN THIS PAPER, WE PRESENT ABOUT THE CURRENT STATUS OF THE DEVELOPMENT OF THE HTS-ISM DRIVE SYSTEM.

THIS WORK HAS BEEN SUPPORTED BY NEW ENERGY AND INDUSTRIAL TECHNOLOGY DEVELOPMENT ORGANIZATION (NEDO) IN JAPAN.

1LA-07

DEVELOPMENT OF HIGH TEMPERATURE SUPERCONDUCTING MOTOR FOR INDUSTRIAL APPLICATION ***Y. KWON***[1]*, H. KIM*[1]*, S. BAIK*[1]*, J. LEE*[1]*, Y. KIM*[2]*, Y. CHO*[3]*;* [1]KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE, [2]RESEARCH & DEVELOPMENT CENTER, DOOSAN HEAVY INDUSTRIES & CONSTRUCTION CO.,LTD., [3]CENTER FOR APPLIED SUPERCONDUCTIVITY TECHNOLOGY. — THIS PAPER DESCRIBES THE DEVELOPMENT RESULTS OF THE HIGH TEMPERATURE SUPERCONDUCTING MOTOR WHICH CONSISTS OF HTS ROTOR AND AIR-CORE STATOR. THE MACHINE WAS DESIGNED FOR THE RATED POWER OF 1MW AT 3600 RPM. THE HTS FIELD WINDINGS ARE COMPOSED OF THE DOUBLE-PANCAKE COILS WOUND WITH BI-2223 TAPE CONDUCTOR. THESE WERE ASSEMBLED ON THE SUPPORT STRUCTURE AND FIXED BY A BANDAGE OF GLASS-FIBER COMPOSITE. THE ROTOR ASSEMBLY WAS TESTED INDEPENDENTLY AT THE STATIONARY STATE AND COMBINED WITH STATOR. CHARACTERISTIC PARAMETERS SUCH AS REACTANCE, INDUCTANCE, AND TIME CONSTANTS WERE DETERMINED TO OBTAIN A CONSISTENT OVERVIEW OF THE MACHINE OPERATION PROPERTIES. THIS MOTOR HAS MET ALL DESIGN PARAMETERS BY DEMONSTRATING HTS FIELD WINDING, CRYOGENIC REFRIGERATION SYSTEMS AND A AIR-CORE ARMATURE WINDING COOLED WITH WATER. THIS PAPER PRESENTS THE DESIGN AND EXPERIMENTAL TEST RESULTS OF 1MW HTS MOTOR AT KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE AND DOOSAN HEAVY INDUSTRY IN KOREA.

THIS WORK WAS SUPPORTED BY A GRANT FROM CENTER FOR APPLIED SUPERCONDUCTIVITY TECHNOLOGY OF THE 21ST CENTURY FRONTIER R&D PROGRAM FUNDED BY THE MINISTRY OF SCIENCE AND TECHNOLOGY, REPUBLIC OF KOREA.

1LB-01

(INVITED) **ESSENTIAL CONSIDERATIONS AND BASIC ESTIMATIONS FOR MgB_2 BASED FAULT CURRENT LIMITERS** ***M. D. SUMPTION****, M. MAJOROS, E. W. COLLINGS;* THE OHIO STATE UNIVERSITY. — A SERIES OF SIMPLE ANALYTIC ESTIMATIONS HAVE BEEN MADE FOR FAULT CURRENT LIMITING SYSTEMS BASED ON MgB_2 CONDUCTORS. THIS APPROACH IS BEING DEVELOPED AS AN AID TO FINDING GLOBAL MINIMUMS WHEN OPTIMIZING PARAMETERS FOR SYSTEM DESIGN, AS AN ADJUNCT TO THE TIME CONSUMING BUT MORE PRECISE FEM APPROACH. WE HAVE ASSUMED A TARGET FCL DEVICE RESISTANCE IN THE NORMAL (LIMITING) STATE, AND A MAXIMUM FAULT CURRENT VALUE. FROM THIS AND THE WIRE PROPERTIES, A SIMPLE METHOD FOR ESTIMATING THE OPTIMUM (MINIMUM) WIRE AND DEVICE SIZE IS PRESENTED. THIS SIMPLE MODEL, BASED ON AN ADIABATIC ASSUMPTION AND OPTIMUM ENERGY SHARING BETWEEN THE COIL AND THE SHUNT IS THEN USED TO DETERMINE OPTIMUM STRAND/CABLE CROSS SECTIONAL AREA. A MODIFICATION OF THIS APPROACH IS THEN USED TO ESTIMATE THE OPTIMUM SIZE FOR A VARIETY OF TARGET RECOVERY TIMES, BASED ON GIVEN CRYOCOOLER CAPACITY CHOICES. THE FUNCTIONAL DEPENDENCE OF SYSTEM SIZE ON VARIOUS CONDUCTOR PROPERTIES IS THEN DISCUSSED WITH THE AID OF THE ANALYTIC EXPRESSIONS, AND VARIOUS NUMERIC EXAMPLES ARE THEN PRESENTED. A COMPARISON TO AN FEM BASED MODEL AT ONE SPECIFIC DESIGN POINT IS THEN USED TO DISCUSS THE LIMITATIONS OF THIS APPROACH.

THIS WORK WAS SUPPORTED BY THE STATE OF OHIO DEPARTMENT OF DEVELOPMENT UNDER A THIRD FRONTIER GRANT

1LB-02

NUMERICAL VALIDATION OF PHENOMENOLOGICAL HTS MODELS IN THE FLUX-FLOW REGIME BASED ON DIRECT COMPARISON WITH QUENCH EXPERIMENTAL DATA OF COATED CONDUCTORS ***F. ROY***[1]*, B. DUTOIT*[1]*, F. SIROIS*[2]*;* [1]EPFL, [2]ECOLE POLYTECHNIQUE DE MONTREAL. — ABOVE THE CRITICAL CURRENT DENSITY, THE ELECTRICAL RESISTIVITY OF COATED CONDUCTORS IS STRONGLY RELATED TO THE INTER-DEPENDENT SET OF PARAMETERS (J,H,T), RESPECTIVELY CURRENT DENSITY, MAGNETIC FIELD AND TEMPERATURE. ON THE ONE HAND, IT IS DIFFICULT TO ISOLATE THE CONTRIBUTION OF EACH OF THESE PARAMETERS ON THE FLUX-FLOW RESISTIVITY MEASURED EXPERIMENTALLY. ON THE OTHER HAND, NUMERICAL METHODS, WHICH MAY ALLOW THIS SEPARATION, REQUIRE A GOOD KNOWLEDGE OF THE FUNDAMENTAL LAWS GOVERNING THE FLUX-FLOW REGIME WHICH ARE, UP TO NOW, DERIVED FROM CURVE FITTING WITH EXPERIMENTAL DATA.IN THIS PAPER, WE INVESTIGATE THE INFLUENCE OF PHENOMENOLOGICAL FORMULAS ON THE OUTPUTS OF A RECENTLY DEVELOPED FINITE ELEMENT MODEL. THE OUTPUTS ARE COMPARED AGAINST EXPERIMENTAL VOLTAGE CURVES, WHICH HAVE BEEN OBTAINED UNDER PULSED TRANSPORT CURRENTS BETWEEN 80 AND 160 A AND EXTERNAL MAGNETIC FIELDS OF 0 TO 350 MT.THE COMPARISONS INDICATE THAT THE NUMERICAL MODEL REPRODUCES WELL THE MEASUREMENTS, DESPITE THE USE OF EMPIRICAL MODELS IN THE FLUX FLOW REGIME. NEVERTHELESS, THE SOLUTION MAY STILL BE INACCURATE AT LOW VALUES OF I/IC(B), WHERE THE CURVATURE OF THE E-J CURVE IS MORE PRONOUNCED, INDICATING THAT FURTHER REFINEMENT IS REQUIRED IN ORDER TO OBTAIN MODELS VALID OVER A WIDER RANGE OF PARAMETERS.

1LB-03

SOME GRID CONSTRAINTS FOR SC FCL ***P. TIXADOR***[1]*, T. NGUYEN-NHAT*[1]*, T. TRAN-QUOC*[2]*, H. OKADA-VIEIRA*[3]*;* [1]GRENOBLE INP, [2]GIE-IDEA, [3]CNRS. — THE SUPERCONDUCTING (SC) FAULT CURRENT LIMITER (FCL) IS A VERY EFFECTIVE TOOL TO ENHANCE THE SECURITY AND THE POWER QUALITY OF THE ELECTRICITY GRIDS, TWO REAL DEMANDS TODAY. THIS EXPLAINS ITS GREAT INTEREST THROUGHOUT THE WORLD. ONLY REBACUO COATED CONDUCTOR WILL BE CONSIDERED. IT IS VERY IMPORTANT TO STUDY THE CONSTRAINTS ON THE SC ELEMENT. THE THREE PHASE BOLTED SHORT-CIRCUIT IS A RATHER RARE EVENT AND DOES NOT REPRESENT THE MOST SEVERE REQUIREMENT FOR THE SC ELEMENT. FAULTS WITH IMPEDANCE, SINGLE-PHASE FAULTS ARE MORE STRINGENT. WE HAVE DEVELOPED A MODEL TO REPRESENT THE SC ELEMENT IN MATLAB/SIMULINK THROUGH A RESISTANCE, WHICH DEPENDS ON THE CURRENT AND THE CONDUCTOR TEMPERATURE. IT IS A 1D MODEL. THE TEMPERATURE IS THE SAME ACROSS THE CONDUCTOR, NO PROPAGATION IS TAKEN INTO ACCOUNT. THE CONDUCTOR IS REPRESENTED BY TWO ELEMENTS IN PARALLEL: THE NON-SC LAYERS (SUBSTRATE, SHUNT, [[UNSUPPORTED CHARACTER - ⋯]]) AND THE REBACUO LAYER. UNDER THE CRITICAL TEMPERATURE A POWER LAW IS USED. THIS MODEL HAS BEEN VALIDATED ON SMALL FCL. SEVERAL EXAMPLES OF SHORT CIRCUITS HAVE BEEN INVESTIGATED. THE INFLUENCE OF NON-HOMOGENEOUS QUENCHES AND THE PARAMETERS OF THE CONDUCTOR WILL BE PRESENTED. THE NORMAL STATE RESISITIVITY OF THE CONDUCTOR PLAY FOR EXAMPLE AN IMPORTANT PART.

THE RESEARCH LEADING TO THESE RESULTS HAS RECEIVED FUNDING FROM THE EUROPEAN UNION SEVENTH FRAMEWORK PROGRAMME (FP7/2007 - 2013) UNDER GRANT AGREEMENT NO. 241285.

1LB-04

CONCEPTUAL DESIGN AND PARAMETER LIMITS OF A RESISTIVE TYPE SUPERCONDUCTING FAULT CURRENT LIMITER ***C. SCHACHERER****, M. NOE;* KARLSRUHE INSTITUTE OF TECHNOLOGY KIT. — THE DESIGN AND LIMITING BEHAVIOR OF RESISTIVE TYPE SUPERCONDUCTING FAULT CURRENT LIMITERS (SCFCL) WITH COATED CONDUCTORS ARE NOT ONLY DEPENDENT ON THE PHYSICAL PROPERTIES OF THE SUPERCONDUCTING MATERIAL, BUT ALSO ON THE SPECIAL REQUIREMENTS OF THE ELECTRICAL POWER SYSTEM SUCH AS EXISTING PROTECTING SYSTEMS.NEVERTHELESS, THE DESIGN OF A RESISTIVE TYPE SCFCL HAS TO STAY WITHIN SPECIFIC PHYSICAL LIMITS OF THE COATED CONDUCTORS, SUCH AS MAXIMAL TEMPERATURE AND MINIMAL ELECTRICAL STABILIZATION. APART FROM THIS, THERE ARE ALSO SOME ECONOMICAL REQUIREMENTS OF THE SCFCL WHICH HAVE TO BE CONSIDERED SUCH AS THE TOTAL AMOUNT OF COATED CONDUCTORS.IN THIS PAPER THE KEY DESIGN PARAMETERS OF A RESISTIVE TYPE SCFCL AND THEIR VARIATION LIMITS ARE DEFINED, CONSIDERING THE SPECIFIC REQUIREMENTS OF AN ELECTRICAL POWER SYSTEM AND THE PHYSICAL LIMITS OF THE COATED CONDUCTORS. MOREOVER, A FEASIBLE STEPWISE GUIDELINE USING THE INTRODUCED DESIGN PARAMETERS AND LIMITS IS ADOPTED FOR A CONCEPTUAL DESIGN OF A RESISTIVE TYPE SFCL FOR THE MEDIUM VOLTAGE LEVEL.

1LB-05

NUMERICAL ANALYSIS OF THE CURRENT AND VOLTAGE SHARING ISSUES FOR RESISTIVE FAULT CURRENT LIMITER USING YBCO COATED CONDUCTORS ***Z. HONG****, W. YUAN, M. AINSLIE, T. COOMBS;* CAMBRIDGE UNIVERSITY. — YBACUO-COATED CONDUCTORS OFFER GREAT POTENTIAL IN TERMS OF PERFORMANCE AND COST-SAVING FOR SUPERCONDUCTING FAULT CURRENT LIMITER (SFCL). A RESISTIVE SFCL BASED ON COATED CONDUCTORS CAN BE MADE FROM SEVERAL TAPES CONNECTED IN PARALLEL OR IN SERIES. IDEALLY, THE CURRENT AND VOLTAGE ARE SHARED UNIFORMLY BY THE TAPES WHEN QUENCH OCCURS. HOWEVER, DUE TO THE NON-UNIFORMITY OF PROPERTY OF THE TAPES, THE CURRENTS AND THE VOLTAGES OF THE TAPES ARE DIFFERENT. IN THIS PAPER, A NUMERICAL MODEL IS DEVELOPED TO INVESTIGATE THE CURRENT AND VOLTAGE SHARING PROBLEM FOR THE RESISTIVE SFCL. THIS MODEL IS ABLE TO SIMULATE THE DYNAMIC RESPONSE OF YBCO TAPES IN NORMAL AND QUENCH CONDITIONS. FIRSTLY, FOUR TAPES WITH DIFFERENT JC'S AND N VALUES IN E-J POWER LAW ARE CONNECTED IN PARALLEL TO CARRY THE FAULT CURRENT. THE MODEL DEMONSTRATES HOW THE CURRENTS ARE DISTRIBUTED AMONG THE FOUR TAPES AND THE SEQUENCE OF QUENCHES. THESE FOUR TAPES ARE THEN CONNECTED IN SERIES TO WITHSTAND THE LINE VOLTAGE. IN THIS CASE, THE MODEL INVESTIGATES THE VOLTAGE SHARING BETWEEN THE TAPES. SEVERAL FACTORS THAT WOULD AFFECT THE PROCESS OF QUENCHES ARE DISCUSSED INCLUDING THE FIELD DEPENDENCY OF JC, THE MAGNETIC COUPLING BETWEEN THE TAPES AND THE RELATIVE POSITIONS OF THE TAPES.

1LB-06

FEM MODELING OF A RESISTIVE FAULT CURRENT LIMITER COIL IN NETWORK ***M. MAJOROS****, M. D. SUMPTION, E. W. COLLINGS;* THE OHIO STATE UNIVERSITY. — A NUMERICAL MODEL WAS DEVELOPED FOR A RESISTIVE FAULT CURRENT LIMITER COIL, BASED ON MGB2 STRAND, WITH CRYOGEN-FREE COOLING AND EQUIPPED WITH A DUMP RESISTOR. THE MODEL ESTIMATED THE TOTAL CONDUCTOR NEEDED TO HANDLE VARIOUS SIZE FAULTS SAFELY. TYPICAL WIRE PROPERTIES WERE ASSUMED IN THE CALCULATIONS, INCLUDING 0.8 MM OD WIRE WITH A NON-MAGNETIC SHEATH. PROPERTIES OF IN-SITU BASED CONDUCTOR WERE USED, INCLUDING MEASURED IC AND N-VALUES, AS WELL AS HEAT CAPACITY, ELECTRICAL AND THERMAL CONDUCTIVITY AS A FUNCTION OF TEMPERATURE. EIGHT CYCLE HOLD TIMES AT 50 HZ WERE ASSUMED. RECOVERY TIMES WERE ALSO ESTIMATED BASED ON SIMPLE ASSUMPTIONS ABOUT CRYOCOOLER SIZE AND THERMAL CONNECTION. 2D AC POISSON EQUATION FOR DETERMINING THE HEAT TRANSFER WAS SOLVED SIMULTANEOUSLY WITH KIRCHHOFF'S LAWS OF THE NETWORK, BY FINITE ELEMENT METHOD (FEM), WITH INPUT PARAMETERS TAKEN FROM EXPERIMENTAL RESULTS. AS BOUNDARY CONDITIONS, WE TOOK THE FULL NON-LINEAR

CURVE OF THE HEAT FLUX INTO A CRYOCOOLER COLD HEAD AS WELL AS HEAT RADIATION FROM THE FREE SURFACES OF THE WIRE. CARE WAS TAKEN TO ESTIMATE THE LEVEL OF HEAT SHARING WITH THE WIRE SUPPORT STRUCTURE AS A FUNCTION OF TIME DURING THE EVENT, BASED ON ASSUMPTIONS ABOUT THE WIRE-ENVIRONMENT INTERFACE. THE IMPLICATIONS OF THIS FOR THE SYSTEM AS A WHOLE ARE DISCUSSED.

FUNDED BY A GRANT FROM THE STATE OF OHIO, USA

1LB-07

DESIGN OF A MGB_2-BASED CRYOGEN-FREE COOLED DC RESISTIVE SFCL PROTOTYPE ***A. MORANDI***[1]*, C. FERDEGHINI*[2]*, U. GAMBARDELLA*[3]*, A. MALAGOLI*[2]*, F. NEGRINI*[1]*, S. PACE*[4]*;* [1]UNIVERSITY OF BOLOGNA, DIE - DEPT. OF ELECTRICAL ENGINEERING, VIALE RISORGIMENTO 2, 40136 BOLOGNA, ITALY, [2]CNR-SPIN GENOVA, CORSO PERRONE 24, 16152 GENOA, ITALY, [3]CNR-SPIN SALERNO, VIA S. ALLENDE, 84081 BARONISSI - SALERNO, ITALY, [4]UNIVERSITY OF SALERNO, DEPT. OF PHYSICS E. R. CAIANIELLO, VIA S. ALLENDE, 84081 BARONISSI - SALERNO, ITALY. — A DC RESISTIVE SFCL CONSISTS OF SUPERCONDUCTING COIL EMBEDDED IN RECTIFIER BRIDGE. THE COIL IS DESIGNED IN ORDER TO QUENCH WHEN THE CURRENT EXCEEDS THE TRIGGER VALUE AND TO HAVE A PROPER INDUCTANCE WHICH IS ABLE TO CREATE A NEARLY DC CURRENT REGIME WITHOUT A SIGNIFICANT INFLUENCE ON THE PROTECTED SYSTEM IN NORMAL OPERATION. THE NEARLY DC CURRENT REGIME DRASTICALLY REDUCES THE AC LOSSES THUS ENABLING THE USE OF LOW COST MGB_2 CABLES AND CRYOGEN-FREE COOLING SYSTEM. IN THIS PAPER THE DESIGN OF A DC RESISTIVE SFCL PROTOTYPE WITH CRYOGEN-FREE COOLING IS REPORTED. THE DEVICE IS BASED ON A MGB_2 TAPE WHICH, DUE TO THE PARTICULAR CURRENT REGIME, IS OPTIMISED ON THE REQUIREMENTS OF HIGH THERMAL DIFFUSIVITY AND HIGH CRITICAL CURRENT AT LOW MAGNETIC FIELD. THE LAYOUT OF THE WINDINGS IS OBTAINED BY MEANS OF AN OPTIMIZATION PROCEDURE WHICH ALLOWS TO OBTAIN THE REQUIRED VALUES OF INDUCTANCE AND RESISTANCE WITH THE MINIMUM POSSIBLE FIELD ON THE CONDUCTOR. THE MAIN PURPOSE OF THE PROTOTYPE IS THE EXPERIMENTAL VERIFICATION OF THE FEASIBILITY OF THE CRYOGEN-FREE COOLING WITH PARTICULAR REFERENCE TO THE RECOVERY PERFORMANCE.

THIS WORK IS DONE IN THE FRAME OF PRIN, A TWO YEARS RESEARCH PROJECT FUNDED BY THE MIUR, ITALIAN MINISTRY OF EDUCATION, UNIVERSITY AND RESEARCH

1LPA-01

MODE COUPLING OF A FLEXIBLE ROTOR SUPPORTED BY A SUPERCONDUCTING MAGNETIC BEARING DUE TO THE NONLINEARITY OF ELECTROMAGNETIC FORCE ***H. GOTANDA****, T. SUGIURA;*** KEIO UNIVERSITY. — RECENTLY MAGNETIC BEARINGS HAVE BEEN APPLIED TO MANY ENGINEERING PRODUCTS, SUCH AS FLYWHEELS AND TURBO-CHARGERS. NOW DEVELOPMENT OF FLYWHEEL ENERGY STORAGE SYSTEMS USING SUPERCONDUCTING MAGNETIC BEARINGS HAS REACHED ITS VALIDATION PHASE. IN MOST OF THESE SYSTEMS, THE AMBS, AS AUXILIARY BEARINGS, ARE USED TO REDUCE THE VIBRATION OF THE ROTOR. HOWEVER, BECAUSE OF ITS HIGH ROTATIONAL SPEED, THE SPILL-OVER EFFECT OF ELASTIC DEFORMATION OF THE ROTOR HAS BECOME A PROBLEM. THIS COMPLICATED PHENOMENON CAN BE PARTLY CAUSED BY NONLINEAR COUPLING BETWEEN PLURAL VIBRATION MODES.THIS STUDY INVESTIGATES NONLINEAR MODE COUPLING OF A FLEXIBLE ROTOR SYSTEM. WE DEVELOPED AN ESSENTIAL MODEL OF A ROTOR WITH AN ELASTIC SHAFT SUPPORTED BY A SUPERCONDUCTING MAGNETIC BEARING. THE EQUATIONS OF MOTION OF THE ROTOR WERE DERIVED BY TAKING INTO ACCOUNT THE NONLINEARITY OF THE ELECTROMAGNETIC FORCE AND ALSO BY MODELING THE ELASTIC SHAFT AS A CONTINUUM BODY. THE OBTAINED EQUATIONS SHOW NONLINEAR COUPLING BETWEEN THE FIRST MODE AND SECOND MODE OF ELASTIC VIBRATION, AND ALSO SUGGEST THAT MUTUAL RESONANCE CAN OCCUR BETWEEN THESE MODES DUE TO THE CUBIC NONLINEARITY IF THE RATIO OF THEIR NATURAL FREQUENCIES IS ONE TO THREE. THIS PREDICTION WAS VERIFIED BY OUR NUMERICAL AND EXPERIMENTAL RESULTS. THE ABOVE FINDINGS MAY BE USEFUL FOR CONSIDERING AVOIDANCE OF THE SPILL-OVER EFFECT

WE WOULD LIKE TO THANK PROF. Y. OKADA IN IBARAKI UNIV. AND PROF. A. CHIBA IN TOKYO UNIVERSITY OF SCIENCE FOR THEIR HELPFUL ADVICE ON MAGNETIC BEARINGS.

1LPA-02

NEW CONCEPT OF FLYWHEEL ENERGY STORAGE SYSTEM USING SMB AND PMB *M. SUBKHAN,* ***M. KOMORI****;* KYUSHU INSTITUTE OF TECHNOLOGY, JAPAN. — **1. INTRODUCTION:** WE SUGGEST A NEW MODEL OF FLYWHEEL TO HAVE HIGH STORAGE ENERGY AMOUNT, IMPROVE THE SYSTEM TO HAVE GOOD STABILITY, AND IMPROVE OF THE CONVENTIONAL SYSTEM BY PERFORMING OF BEARING PART AND GENERATING MOTOR. WE ALSO PURPOSED TO EXAMINING AND EVALUATING OF CHARGE-DISCHARGE SYSTEM FOR MOMENTARY VOLTAGE DROP.**2. FLYWHEEL SYSTEM:** THE FLYWHEEL ROTOR IS SUPPORTED BY NON-CONTACT BEARINGS, A PMB IN THE UPPER PART AND A SMB IN THE LOWER PART. THE GENERATING MOTOR CONSISTS OF 2-PHASE 4-POLES BRUSH-LESS DC MOTOR AND A HALL SENSOR. THE MAGNETS INSTALLED IN THE UPPER PART OF THE FLYWHEEL ARE USED AS A ROTOR OF THE DC MOTOR.THE PMB USING REPULSION FORCE BETWEEN MAGNETS HAS ADVANTAGES MORE THAN THE CONVENTIONAL MAGNETIC BEARINGS. THE PMB CONSISTS OF TWO MAGNETS FOR THE STATOR, TWO MAGNETS FOR THE ROTOR AND ONE SPACER. BIG VIBRATION OCCURS TO ROTOR WHEN ROTATING AT STRUCTURE OF FLYWHEEL SYSTEM BEFORE IMPROVEMENT. THE RADIAL AND AXIAL TYPE SMB IS SUGGESTED TO MORE HOLD DOWN VIBRATION AND MORE SUPPORT THE WEIGHT OF THE ROTOR.**3.CONCLUSION:** THE SMB CONTROLS THE VIBRATION OF THE ROTOR, AND PMB ALSO CONTROL THE POSITION OF THE ROTOR PASSIVELY. AS FOR THE VIBRATION CHARACTERISTIC AT HIGH SPEEDS, THE VIBRATIONS AT TOP

SIDE AND BOTTOM SIDE OF THE FLYWHEEL BECOME LESS THAN 0.5 MM AND 0.3 MM, RESPECTIVELY.

1LPA-03

THE LOSS CHARACTERISTICS OF SFES WITH AMORPHOUS CORE FOR PMSM ***J. LEE***[1]*, S. HAN*[1]*, Y. HAN*[1]*, B. PARK*[1]*, B. PARK*[1]*, S. JUNG*[1]*, T. SUNG*[2]*;* [1]KOREA ELECTRIC POWER RESEARCH INSTITUTE, [2]HANYANG UNIVERSITY. — IN THIS PAPER, WE ASSESSED THE CHARACTERISTICS OF THE ROTATIONAL ENERGY LOSS OF SUPERCONDUCTOR FLYWHEEL ENERGY STORAGE SYSTEM(SFES) BY DRAG FORCE ACCORDING TO A SIZE CHANGE OF THE CONVENTIONAL LAMINATED SI-STEEL STATOR CORE AND THE NEW AMORPHOUS STATOR CORE USED ON PMSM/G.THE MATHEMATICAL MODEL FOR CORE LOSS OF BOTH TYPES WAS PROPOSED THROUGH THE EXPERIMENTAL DATA ANALYSIS FOR THE CORES OF PMSM/G AND THE ANALYTICAL METHOD USING THE ALTERNATING AND ROTATING MAGNETIC FIELD ANALYSIS. ROTATIONAL LOSSES IN THE CORES WERE MORE INFLUENCED BY ALTERNATING MAGNETIC FIELD THAN BY ROTATING MAGNETIC FIELD. EXPERIMENTAL RESULTS AND PROPOSED MATHEMATICAL MODEL OF CORE LOSS USING ALTERNATING AND ROTATING MAGNETIC FIELD WERE IN GOOD AGREEMENT.IT WAS CONFIRMED THAT USE OF THE NEW AMORPHOUS STATOR CORE ON PMSM/G CORE COULD CONSIDERABLY IMPROVE THE ENERGY STORAGE EFFICIENCY OF THE SFES. THE ENERGY LOSS OF SFES WITH NEW AMORPHOUS STATOR CORE WAS CONSIDERABLY DECREASED BY 75% AT 6000 RPM COMPARED WITH THAT BY LAMINATED SI-STEEL CORE. THESE RESULTS WILL BE VERY USEFUL FOR THE DESIGN OF A LOW LOSS SFES.

1LPA-04

SUBHARMONIC RESONANCE OF A ROTOR SUPPORTED BY A HIGH-TC SUPERCONDUCTOR ***T. SUDA****, S. KOBAYASHI, T. SUGIURA;* KEIO UNIVERSITY. — NONLINEAR DYNAMICS OF A ROTATING MAGNET LEVITATED ABOVE A HIGH-TC SUPERCONDUCTING BULK ARE STUDIED. DAMPING OF THE LEVITATED MAGNET IS SMALL, BECAUSE THEY HAVE NO CONTACT. FURTHER, THIS LEVITATION BY THE SUPERCONDUCTOR IS STABLE WITHOUT CONTROL. THEREFORE, IT CAN BE APPLIED TO SYSTEMS, SUCH AS FLYWHEELS AND TRANSPORTATION. HOWEVER, IN SUCH LOW-DAMPING SYSTEMS, COMPLEX DYNAMICAL BEHAVIORS CAN BE CAUSED BY NONLINEARITY OF THE MAGNETIC FORCE. IT MAY BE IMPORTANT TO CONSIDER SUCH NONLINEAR PHENOMENA FOR THE MECHANICAL DESIGN.IN THIS STUDY OCCURRENCE OF THE SUBHARMONIC RESONANCE, ONE OF TYPICAL NONLINEAR PHENOMENA, ARE INVESTIGATED BY NUMERICAL ANALYSIS AND EXPERIMENT. IN OUR MODEL AN UNBALANCED ROTOR INCLUDING A MAGNET SPINS AROUND THE HORIZONTAL AXIS WITH WHIRLING. THE ROTOR IS BOUND TO A D.C. MOTOR WITH A UNIVERSAL JOINT. THE SUBHARMONIC RESONANCE OF THE ROTOR CAN OCCUR WHEN THE ROTOR ROTATES, NOT AT ITS CRITICAL SPEED, BUT AT TWICE ITS CRITICAL SPEED. THE EQUATIONS OF MOTION WERE FIRST DERIVED AND THE POSSIBILITY OF THE SUBHARMONIC RESONANCE WAS DISCUSSED. THIS PHENOMENON CAN BE CAUSED BY THE QUADRATIC TERM OF THE MAGNETIC FORCE IN THE VERTICAL DIRECTION. NUMERICAL INTEGRATION BASED ON THOSE EQUATIONS SHOW THIS SUBHARMONIC RESONANCE. IT WAS CLEARLY OBSERVED ALSO IN OUR EXPERIMENT.

1LPA-05

TEST RESULTS OF A COMPACT DISK-TYPE MOTOR/GENERATOR UNIT WITH SUPERCONDUCTING BEARINGS FOR FLYWHEEL ENERGY STORAGE SYSTEMS WITH ULTRA-LOW IDLING LOSSES ***Z. KOHARI****;* BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS. — A 3 KW EXPERIMENTAL DISK TYPE PERMANENT MAGNET MOTOR/GENERATOR DESIGNED,FOR A SUPERCONDUCTING FLYWHEEL ENERGY STORAGE SYSTEM WAS CONSTRUCTED AND TESTED. THE SPECIAL DESIGN OF THE MACHINE ITSELF AIMED TO DECREASE THE NO-LOAD LOSSES SO THAT THEY BECOME EQUAL OR LESS THAN THE LOSSES OF THE SUPERCONDUCTING BEARING ITSELF. TO ACHIEVE THIS, NO-LOAD LOSSES HAD TO BE DECREASED BY SEVERAL ORDER OF MAGNITUDE COMPARED TO THE SIMILAR LOSSES OF ORDINARY MACHINES. HENCE WE APPLIED A SPECIAL DOUBLE-ROTOR, IRONLESS STATOR CONSTRUCTION, WITH COPPER WINDINGS MADE OF LITZ WIRE.THE MACHINE IS EQUIPPED WITH ITS OWN AXIAL FLUX SUPERCONDUCTING BEARING CONSISTING OF SEVERAL PERMANENT MAGNET RINGS WITHIN EACH OTHER TO DECREASE RADIAL MECHANICAL STRESSES ON THE PERMANENT MAGNETS. THE COMPACT ROTOR OF THE MACHINE AND THE BEARING ITSELF REPRESENTS A STORED ENERGY OF 50 KJ, SO IT COULD BE TESTED WITHOUT ADDITIONAL FLYWHEEL PARTS IN A VACUUM CHAMBER.IN THIS PAPER WE INTRODUCE SPIN-DOWN TEST RESULTS OF THE ABOVE MACHINE WITH DIFFERENT VACUUM LEVELS. ON THE BASIS OF THE MEASUREMENT IT WAS POSSIBLE TO SEPARATE THE LOSS COMPONENTS SUCH AS HYSTERESIS, EDDY-CURRENTS AND WINDAGE.

1LPA-06

DESIGN OF HYBRID SUSPENSION SYSTEM OF SUPERCONDUCTING AND ELECTROSTATIC SUSPENSION ***J. LIU***[1]*, Q. WANG*[2]*, X. LI*[1]*;* [1]INSTITUTE OF ELECTRICAL ENGINEERING & GRUADUATE UNIVERSITY, CAS, [2]INSTITUTE OF ELECTRICAL ENGINEERING, CAS. — BASED ON A METHOD USED TO CALCULATE THE MAGNETIC FIELD IN A THIN CLEARANCE BETWEEN SUPERCONDUCTING BLOCKS, THIS PAPER ANALYZES THE FORCE CHARACTERISTICS OF THE SUPERCONDUCTING PASSIVE SUSPENSION SYSTEM. SUPERCONDUCTING MAGNETIC SUSPENSION SYSTEM IS AN ESSENTIALLY SELF-STABILIZATION SYSTEM. AT THE BASIS OF THE EXISTING STRUCTURE, AN ELECTROSTATIC SUSPENSION SYSTEM IS INTRODUCED TO OBTAIN GREAT SUSPENSION STIFFNESS. THEN, THE CORRESPONDING CONTROLLER IS DESIGNED AND MANY DETAILS ABOUT OPERATING CONDITIONS ARE ALSO ANALYZED. SIMULATION RESULTS SHOW THE FEASIBILITY OF THIS MODEL. THIS PAPER PROVIDES A THEORETICAL GUIDANCE FOR THE NEXT EXPERIMENT, AND ALSO HAS REFERENCE MEANING TO OTHER SUPPORTING SYSTEMS.

1LPB-01

BASIC STUDY ON MAGNETICALLY LEVITATED CONVEYER SYSTEM USING FIELD-COOLING MAGNETIZATION AND PULSE-FIELD MAGNETIZATION *Y. MIYATAKE[1], **M. KOMORI**[2];* [1]KYUSHU INSTITUTE OF TECHNOLOGY, [2]KYUSHU INSTITUTE OF TECHNOLOGY, JAPAN. — 1. INTRODUCTION: WE PROPOSE A NEW SUPERCONDUCTING LEVITATION TECHNIQUE, HYBRID-MAGNETIZATION. THE HYBRID-MAGNETIZATION MEANS THAT BOTH FIELD-COOLING MAGNETIZATION AND PULSE-FIELD MAGNETIZATION ARE APPLIED TO THE SYSTEM.2. SYSTEM: A TOTAL CONVEYER SYSTEM CONSISTS OF A LEVITATED STAGE, MAGNETIC RAILS, AND ELECTROMAGNETS OVER THE RAIL, A POWER SUPPLY FOR DRIVING, AND A PULSE POWER SUPPLY. A THREE-PHASE LINEAR INDUCTION MOTOR IS INSTALLED IN THE SYSTEM. THE MOVING STAGE MADE OF STAINLESS STEEL HAS FOUR SUPERCONDUCTORS. ELECTROMAGNETS FOR PULSE-FIELD MAGNETIZATION ARE INSTALLED OVER THE MAGNETIC RAILS.3. EXPERIMENTS: AFTER THE SUPERCONDUCTORS ARE FIELD-COOLED, PULSE-FIELD MAGNETIZATIONS ARE APPLIED TO THE SUPERCONDUCTORS OF THE LEVITATED STAGE. IN THE EXPERIMENTS, THE PULSE-FIELD MAGNETIZATIONS ARE PERFORMED IN THE SAME DIRECTION AS FIELD-COOLING DIRECTION AND OPPOSITE DIRECTIONS TO FIELD-COOLING DIRECTION. THEN, THE SURFACE MAGNETIC FLUX DENSITY OF THE SUPERCONDUCTOR IS MEASURED. THE EXPERIMENTAL RESULTS SHOW THAT THE MAGNETIC FLUX DENSITY INCREASES IN THE CASE OF SAME DIRECTION AND DECREASES IN THE CASE OF OPPOSITE DIRECTION.4. SUMMARY: THE METHOD OF HYBRID-MAGNETIZATION USING BOTH FIELD-COOLING MAGNETIZATION AND PULSE-FIELD MAGNETIZATION IS USEFUL FOR THE SUPERCONDUCTING SYSTEM.

1LPB-02

SIMPLE SEMI-ANALYTICAL APPROACH TO ESTIMATE THE LEVITATION FORCE AND PENETRATION PROFILE OF AXIAL FLUX SUPERCONDUCTING BEARINGS ***Z. KOHARI**;* BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS. — SEMI-ANALITICAL CALCULATION FOR ESTIMATING THE LEVITATION FORCE IN AN AXIAL FLUX PM-SC ARRANGEMENT WAS DEVELOPED. THE CALCULATION IS BASED ON THE DIRECT CALCULATION OF THE MAGNETIC FIELD STRENGTH ON THE SURFACE OF THE SUPERCONDUCTOR. THIS FIELD STRENGTH IS SUPPOSED TO BE THE FUNCTION OF THE RADIUS ONLY, SO THE METHOD CAN BE CONSIDERED AS A ONE DIMENSIONAL, AXISSYMMETRIC APPROACH. FOR IDEAL SUPERCONDUCTORS DIRECT ANALYTICAL SOLUTION CAN BE OBTAINED. NUMERICAL SOLUTION CAN BE GOT FOR THE CASE OF THE BEAN MODEL OR MORE COMPLICATED MODELS. WE SHOW OUR SOLUTION WITH THE SUPERCONDUCTOR CHARACTERIZED BY ITS CONSTANT CRITICAL CURRENT DENSITY. CALCULATED AND MEASURED RESULTS ARE COMPARED AND EVALUATED.

1LPB-03

LATERAL AND LEVITATION FORCES BETWEEN A SMALL MAGNET AND SUPERCONDUCTING SPHERE AND THE STABILITY OF THE MAGNET ***H. AL-KHATEEB**[1], M. NUSEIRAT[2], N. AYOUB[3];* [1]JORDAN UNIVERSITY OF SCIENCE AND TECHNOLOGY, [2]KING SAUD BIN ABDULAZIZ UNIV. FOR HEALTH SCIENCES, COLLEGE OF MEDICINE, [3]SCHOOL OF APPLIED NATURAL SCIENCES, GERMAN JORDANIAN UNIVERSITY. — BASED ON A DIPOLE-DIPOLE INTERACTION MODEL, WE OBTAINED ANALYTICAL EXPRESSIONS FOR THE LEVITATION AND LATERAL FORCES ACT ON A SMALL MAGNET FOR ASYMMETRIC MAGNET/SPHERICAL SUPERCONDUCTOR SYSTEM. THE OBTAINED FORMULAS ARE WRITTEN IN TERMS OF THE RADIUS OF THE SUPERCONDUCTOR AS WELL AS THE HEIGHT AND THE ORIENTATION OF THE MAGNETIC MOMENT OF THE MAGNET. THE LEVITATION FORCE IS LINEARLY DEPENDENT OF THE LATERAL DISPLACEMENT WHEREAS THE LATERAL FORCE IS INDEPENDENT OF THE LATERAL DISPLACEMENT. BOTH THE LEVITATION AND LATERAL FORCES ARE VARYING SOLINOUDALLY WITH THE POLAR AND AZIMUTHAL ANGLE OF THE ORIENTATION OF THE MOMENT OF THE MAGNET. THE STABILITY OF THE MAGNET HAS BEEN STUDIED FOR SPECIAL ORIENTATION OF THE MOMENT OF THE MAGNET.

1LPB-04

LEVITATION PROPERTIES OF THE SUPERCONDUCTING MAGNETIC BEARINGS ***Y. ARAI**, H. SEINO, K. NAGASHIMA;* RAILWAY TECHNICAL RESEARCH INSTITUTE. — REGENERATED ENERGY WHILE AN ELECTRICAL TRAIN BRAKES IS WASTED BY RESISTORS UNLESS OTHER TRAIN ACCELERATES AT THE SAME TIME. FLYWHEEL ENERGY STORAGE SYSTEM (FESS) ENABLES TRAINS TO ACCELERATE USING THEIR OWN REGENERATED ENERGY AT ANY TIME AFTER BRAKING. WE HAVE BEEN DEVELOPING SUPERCONDUCTING MAGNETIC BEARINGS (SMBS) TO BE APPLIED TO A 36 MJ FESS FOR MORE ENERGY-SAVING ELECTRIC RAILWAYS. WE PREPARED TWO MODELS: ONE IS A MINIATURE MODEL WITH 12 MJ ENERGY CAPACITY WHICH CONSISTS OF THRUST SMBS AND RADIAL MECHANICAL BEARINGS TO CONFIRM LOAD CAPACITY OF 19.6 KN, AND THE OTHER IS A DEMONSTRATION MODEL WHICH CONSISTS OF BOTH THRUST AND RADIAL SMBS AND AUXILIARY ACTIVE MAGNETIC BEARINGS TO CONFIRM THE FEASIBILITY OF SMBS WITHOUT MECHANICAL BEARINGS. THE MINIATURE MODEL HAS A ROTOR WITH LIQUID NITROGEN COOLED HIGH TEMPERATURE SUPERCONDUCTING (HTS) BULKS AND 2,000 KG FLYWHEEL, AND A STATOR WITH CRYO-COOLED LOW TEMPERATURE SUPERCONDUCTING COILS. THE DEMONSTRATION MODEL HAS A ROTOR WITH HTS BULKS AND 50 KG FLYWHEEL AND A STATOR WITH CRYO-COOLED HTS COILS. THE BULKS ARE COOLED BELOW T_C BY HELIUM GAS MOLECULE CONDUCTION. CHARGE/DISCHARGE ENERGY IS TRANSMITTED BY A NON-CONTACT MAGNETIC FORCE COUPLING. THE ROTOR IS SUSPENDED BY SMBS WITHOUT ANY MECHANICAL CONTACT. IN THIS PAPER, THE EXPERIMENTAL RESULTS OF THE MINIATURE MODEL IS DISCUSSED AND RESCENT PROGRESS IN THE DEMONSTRATION MODEL IS PRESENTED.

THIS STUDY IS FINANCIALLY SUPPORTED BY THE MINISTRY OF LAND, INFRASTRUCTURE, TRANSPORT AND TOURISM, JAPAN

1LPB-05

APPLICATION OF 2G-TAPE FOR PASSIVE AND CONTROLLED SUPERCONDUCTING LEVITATION *F. SASS[1], G. G. SOTELO[2],* ***R. DE ANDRADE JR.****[1];* [1]FEDERAL UNIVERSITY OF RIO DE JANEIRO, [2]FLUMINENSE FEDERAL UNIVERSITY. — THE SECOND GENERATION YBCO TAPE HAS BEEN USED FOR SEVERAL APPLICATIONS LATELY. IN THIS WORK, A NEW APPLICATION FOR THE SECOND GENERATION YBCO TAPE IS PRESENTED: THE SUPERCONDUCTING LEVITATION. THE 2G-TAPE CAN BE USED FOR TWO POSSIBLE SUPERCONDUCTING MAGNETIC BEARINGS (SMB): LINEAR (FOR MAGLEV VEHICLES), OR ROTATIONAL (FOR HIGH SPEED FLYWHEELS). IN BOTH APPLICATIONS THE TAPE CAN BE CONNECTED AS A CLOSED LOOP COIL (FOR PASSIVE LEVITATORS), OR AS AN OPENED COIL (FOR APPLICATIONS WERE A CONTROLLED LEVITATION GAP IS NEEDED). TWO ROTATIONAL SMBS WERE MADE TO INVESTIGATE THE LEVITATION FORCE BETWEEN THE 2G-TAPE COIL AND A PERMANENT MAGNET RING. ONE OF THESE COILS HAS TERMINALS TO CONTROL THE CURRENT ON IT AND THE OTHER IS SHORT CIRCUITED. THESE COILS WERE PROJECTED USING SIMULATIONS WITH THE FINITE ELEMENT METHOD. AFTER THAT, SOME TESTS WERE MADE TO OBTAIN THE MAGNETIC INDUCTION, LEVITATION FORCE AND STIFFNESS OF THE ROTATIONAL SMB WITH THE 2G-TAPE. FINALLY, THE SIMULATED AND MEASURED RESULTS ARE COMPARED. THESE RESULTS INDICATE A NEW POTENTIAL APPLICATION FOR THE 2G-TAPE.

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1LPB-06

ANALYSIS ON THE LEVITATION CHARACTERISTICS OF THE SUPERCONDUCTING BALL ***S. ZHAO****;* INSTITUTE OF ELECTRICAL ENGINEERING, CHINESE ACADEMY OF SCIENCES. — THE DISTRIBUTION CHARACTERISTICS OF THE MAGNETIC FIELD ARE STUDIED IN A LEVITATION SYSTEM, WHICH CONSISTS OF EXCITING COILS, SHAPING NIOBIUM RINGS AND THE SUPERCONDUCTING BALL, AND THE VIBRATION PROPERTIES OF THE LEVITATED NIOBIUM BALL WHEN IT IS DISTURBED. WE DETAILEDLY CALCULATE THE MAGNETIC FLUX DENSITY OUT OF THE BALL WITH FEM METHOD. THE RESULTS SHOW THE SHAPING NIOBIUM RINGS CAN EFFECTIVELY CHANGE THE DISTRIBUTION OF THE MAGNETIC FIELD. WE ANALYZE THE CHANGING TREND OF THE LEVITATION FORCE AND THE VIBRATION VELOCITY, AND OBTAIN THE LEVITATION STIFFNESS OF THE SUPERCONDUCTING BALL AND THE MAXIMUM VERTICAL DISTURBANCE THAT THE BALL CAN TOLERATE IN ORDER TO KEEP IN THE MEISSNER STATE. AFTER THAT WE CALCULATE THE ELECTROMAGNETIC FIELD IN THE PENETRATION DEPTH AND THE AC LOSS OF THE BALL WHEN IT VIBRATES.

1LPC-01

THE ELECTRICAL INSULATION CHARACTERISTICS OF GFRP FOR SUPERCONDUCTING DEVICES ***H. KIM****[1], K. SEONG[1], J. CHOI[2], J. CHOI[3], H. CHEON[3], S. KIM[3];* [1]KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE, [2]LS CABLE, [3]GYEONGSANG NATIONAL UNIVERSITY. — A POWER APPARATUS APPLYING SUPERCONDUCTIVITY IS OPERATED IN A SPECIFIC ENVIRONMENT OF CRYOGENIC TEMPERATURE. THE CONVENTIONAL SOLID INSULATOR WAS NOT ABLE TO MAINTAIN ITS PERFORMANCE OF INSULATION DUE TO ITS CRACKING OR TRANSFORMATION FROM CONTRACTION UNDER CRYOGENIC TEMPERATURE. HOWEVER, GFRP HAS EXCELLENT MECHANICAL AND ELECTRICAL PROPERTIES EVEN IN EXTREMELY LOW TEMPERATURE, SO IT HAS BEEN FREQUENTLY USED AS A BOBBIN OR INSULATOR FOR THE SUPERCONDUCTING POWER APPARATUS SUCH AS THE SUPERCONDUCTING TRANSFORMER, FAULT CURRENT LIMITER, AND HTS SMES. IN THIS PAPER, WE HAS INVESTIGATED THE ELECTRICAL CHARACTERISTICS OF INSULATION ACCORDING TO THE THICKNESS AND SHAPE OF GFRP

THIS WORK WAS SUPPORTED BY ELECTRIC POWER INDUSTRY TECHNOLOGY EVALUATION & PLANNING, REPUBLIC OF KOREA

1LPC-02

LIQUID NITROGEN BREAKDOWN DUE TO THERMALLY GENERATED BUBBLES IN PLANE-PLANE ELECTRODE GEOMETRY ***I. SAUERS****, D. R. JAMES, A. R. ELLIS, E. TUNCER, G. POLIZOS, M. O. PACE;* OAK RIDGE NATIONAL LABORATORY. — LIQUID NITROGEN IS USED AS THE CRYOGEN AND DIELECTRIC FOR MANY HIGH TEMPERATURE SUPERCONDUCTING HIGH VOLTAGE APPLICATIONS. WHEN A QUENCH IN THE SUPERCONDUCTOR OCCURS, BUBBLES ARE GENERATED WHICH CAN AFFECT THE DIELECTRIC BREAKDOWN PROPERTIES OF THE LIQUID NITROGEN. EXPERIMENTS WERE PERFORMED USING PLANE-PLANE ELECTRODE GEOMETRY WHERE BUBBLES WERE INTRODUCED INTO THE GAP THROUGH A PINHOLE IN THE GROUND ELECTRODE. BUBBLES WERE GENERATED USING ONE OR MORE KAPTON HEATERS PRODUCING HEATER POWERS UP TO 30 W. PRESSURE WAS VARIED FROM 100-300 KPA. AS HEATER POWER IS INCREASED FROM ZERO, BREAKDOWN STRENGTH WAS FOUND TO BE RELATIVELY CONSTANT UP TO A GIVEN HEATER POWER AND PRESSURE, AT WHICH THE BREAKDOWN STRENGTH DROPS TO A LOWER VALUE DEPENDING ON THE PRESSURE. AT LOW HEATER POWER THE BREAKDOWN STRENGTH INCREASES WITH PRESSURE NONLINEARLY SATURATING AT AROUND 300 KPA, WHILE THE BREAKDOWN STRENGTH AT HIGH HEATER POWER INCREASES ACCORDING TO PASCHEN'S LAW, IMPLYING GAS GAP BREAKDOWN. THE GAS GAP IS BELIEVED TO BE DUE TO THE FORMATION OF A VAPOR BRIDGE BETWEEN THE ELECTRODES IN LIQUID NITROGEN. THE HEATER POWER AT WHICH THE BREAKDOWN STRENGTH CHANGES FROM THAT OF LIQUID NITROGEN TO THAT OF GAS NITROGEN INCREASES WITH INCREASING PRESSURE. THE DATA CAN PROVIDE DESIGN CONSTRAINTS FOR HIGH TEMPERATURE SUPERCONDUCTING FAULT CURRENT LIMITERS SO THAT THE FORMATION OF A VAPOR BRIDGE CAN BE SUPPRESSED.

RESEARCH SPONSORED BY THE U.S. DEPARTMENT OF ENERGY - OFFICE OF ELECTRICITY DELIVERY AND ENERGY RELIABILITY, UNDER CONTRACT DE-AC05-00OR22725 WITH OAK RIDGE NATIONAL LABORATORY, MANAGED AND OPERATED BY UT-BATTELLE, LLC.

1LPC-03

VERY LOW FREQUENCY (0.1 HZ) BREAKDOWN OF VARIOUS POLYMERS IMMERSED IN LIQUID NITROGEN ***I. SAUERS****, D. R. JAMES, A. R. ELLIS, E. TUNCER, G. POLIZOS, M. O. PACE;* OAK RIDGE NATIONAL LABORATORY. — FOR LONG CABLES OR EQUIPMENT WITH LARGE CAPACITANCE IT IS NOT ALWAYS POSSIBLE TO CONDUCT HIGH VOLTAGE WITHSTAND TESTS DUE TO LIMITATIONS IN CHARGING CURRENTS OF THE POWER SUPPLY. VERY LOW FREQUENCY (TYPICALLY AT A FREQUENCY OF 0.1 HZ) HAS BEEN USED FOR CONVENTIONAL CABLES AS A WAY OF GETTING AROUND THE CHARGING CURRENT LIMITATION. FOR SUPERCONDUCTING GRID APPLICATIONS THE SAME ISSUES APPLY. HOWEVER THERE IS VERY LITTLE DATA AT CRYOGENIC TEMPERATURES ON HOW MATERIALS PERFORM AT LOW FREQUENCY COMPARED TO 60 HZ AND WHETHER HIGHER VOLTAGES SHOULD BE APPLIED WHEN PERFORMING A HIGH VOLTAGE ACCEPTABILITY TEST. IN THIS PAPER WE REPORT ON THE BREAKDOWN STRENGTH OF VARIOUS POLYMERIC MATERIALS AT 0.1 HZ IN LIQUID NITROGEN AND COMPARE THE DATA WITH 60 HZ AND WITH DC BREAKDOWN. IN GENERAL THE STRENGTH INCREASES WITH DECREASING FREQUENCY AND THE DC STRENGTH IS EVEN HIGHER WHEN COMPARED WITH THE PEAK ELECTRIC FIELD OF BOTH LOW AND POWER FREQUENCY.

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1LPC-04

INFLUENCE OF BUBBLE FORMATION ON THE DIELECTRIC BEHAVIOUR OF LIQUID NITROGEN ***M. BLAZ****, M. KURRAT;* UNIVERSITY OF BRAUNSCHWEIG. — SUPERCONDUCTING POWER APPLICATIONS ARE COOLED DOWN WITH LIQUID COOLANTS. THESE COOLANTS ARE STRESSED BY ELECTRIC FIELDS AND HAVE TO WITHSTAND THESE STRESSES AT ANY WORKING POINT. DUE TO THE TEMPERATURE OF THE COOLING LIQUID CLOSE TO ITS BOILING POINT IT CAN BE POSSIBLE THAT BUBBLES OCCUR AT THE LIVE PARTS DUE TO AC LOSSES, QUENCHING LOSSES, WHICH CAN OCCUR IN RESISTIVE FAULT CURRENT LIMITERS, OR CORONA LOSSES. THEREFORE IT IS ESSENTIAL TO KNOW THE INFLUENCE OF THESE BUBBLES ON THE BREAKDOWN STRENGTH OF THE COOLING AND INSULATING LIQUID.THIS PAPER DEALS WITH LIQUID NITROGEN AS INSULATION. THE BREAKDOWN STRENGTH IS INVESTIGATED IN A HOMOGENEOUS ELECTRIC FIELD BETWEEN TWO ROGOWSKI ELECTRODES. BETWEEN THESE ELECTRODES BUBBLES ARE INDUCED WITH A HEATED ELECTRODE AND THEIR INFLUENCE ON THE BREAKDOWN STRENGTH OF THE LIQUID NITROGEN IS DETERMINED.

1LPC-05

ELECTRICAL BREAKDOWN OF COMPRESSED HELIUM GAS ***H. RODRIGO****, G. H. HELLER, S. PAMIDI, D. G. CROOK, S. L. RANNER, B. TROCIEWITZ, S. DALE;* FLORIDA STATE UNIVERSITY, CENTER FOR ADVANCED POWER SYSTEMS. — CRYOGENIC HELIUM GAS CIRCULATION IS ONE OF THE OPTIONS FOR PROVIDING THE NECESSARY CRYOGENIC ENVIRONMENT FOR SUPERCONDUCTING POWER SYSTEMS. UNDERSTANDING DIELECTRIC BEHAVIOR OF HELIUM GAS AS WELL AS SOLID INSULATION MATERIALS IN CRYOGENIC HELIUM GAS ENVIRONMENT IS CRITICAL FOR THE DESIGN OF POWER DEVICES. AT FLORIDA STATE UNIVERSITY CENTER FOR ADVANCED POWER SYSTEMS, COMPREHENSIVE INVESTIGATIONS ARE BEING CONDUCTED TO UNDERSTAND DIELECTRIC PROPERTIES OF HELIUM GAS AND SEVERAL POTENTIAL SOLID INSULATION MATERIALS AT CRYOGENIC TEMPERATURES AS A FUNCTION OF PRESSURE AND TEMPERATURE. THE EMPHASIS OF THE STUDIES IS TO GENERATE THE CRITICAL DATA ON DIELECTRIC PROPERTIES PERTINENT TO THE DESIGN OF A SUPERCONDUCTING DC CABLE AND ITS TERMINATIONS. THE PAPER PRESENTS DATA ON THE ELECTRICAL BREAKDOWN OF COMPRESSED GASEOUS HELIUM AT 293 K AND CRYOGENIC TEMPERATURES FROM 1 TO 15 ATMOSPHERES. THE DATA PRESENTED INCLUDE BREAKDOWN VOLTAGES UNDER AC, DC, AND IMPULSE (LIGHTNING) CONDITIONS. THE RESULTS SHOW SIGNIFICANT IMPROVEMENT IN BREAKDOWN CHARACTERISTICS AT CRYOGENIC TEMPERATURES AND HIGH PRESSURE COMPARED TO THOSE AT AMBIENT CONDITIONS. IMPLICATIONS OF THE RESULTS ON THE DESIGN OF HELIUM GAS COOLED POWER DEVICES ARE DISCUSSED.

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1LPC-06

ANALYSIS OF INSULATION DESIGN FOR HIGH VOLTAGE AC AND DC HTS CABLES ***Q. QIU;*** INSTITUTE OF ELECTRICAL ENGINEERING, CHINESE ACADEMY OF SCIENCES. — HTS POWER CABLE IS CHARACTERIZED BY ITS LARGE TRANSMISSION CAPACITY, LOW LOSS AND ENVIRONMENTAL ADVANTAGES COMPARING TO EXISTING COMMERCIAL POWER CABLES. DUE TO THESE ADVANTAGES, MANY HTS AC CABLES ARE DEVELOPED TO APPLY IN CURRENT HIGH VOLTAGE AC POWER SYSTEM. IN THE OTHER HAND, THE HTS DC CABLE GETS MORE AND MORE ATTENTION WITH THE RAPID DEVELOPMENT OF DC POWER TRANSMISSION. HTS DC CABLE COULD UTILIZE THE ADVANTAGES OF SUPERCONDUCTIVITY MORE SUFFICIENTLY AND SOLVE THE PROBLEMS INHERENT TO HTS AC CABLE. THE ELECTRICAL INSULATION IS IMPORTANT TO DEVELOP THE HIGH VOLTAGE HTS AC AND DC CABLES. THIS PAPER ANALYZED THE DESIGN OF INSULATION STRUCTURE FOR DIFFERENT KINDS OF HTS AC AND DC CABLES, THE SELECTION OF INSULATION MATERIALS, THE DETERMINATION OF INSULATION PARAMETERS, THE EXPERIMENT OF AC, DC AND IMPULSE DIELECTRIC

CHARACTERISTICS FOR INSULATION MATERIAL AND MODEL CABLE.

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1LPC-07

DESIGN AND ANALYSIS OF 110KV/3KA COLD DIELECTRIC SUPERCONDUCTING POWER CABLES ***H. LIU****, Y. WANG, H. ZHANG, W. PI;* NORTH CHINA ELECTRIC POWER UNIVERSITY. — SUPERCONDUCTING POWER CABLES ARE ONE OF MOST HOPEFUL APPLICATIONS OF HIGH-TEMPERATURE SUPERCONDUCTORS. MANY PLANS OR PROPOSALS ARE UNDER DESIGN OR CONSTRUCTION ALL OVER THE WORLD TO PUT SUPERCONDUCTING POWER CABLES INTO THE POWER GRID TO REPLACE HIGH-VOLTAGE OVERHEAD TRANSMISSION LINE OR CONVENTIONAL METAL CABLES. A DESIGN FOR A 110KV/3KA COLD DIELECTRIC TRANSMISSION CABLE IS PRESENTED WHICH IS ONE OF THE CHINESE NATIONAL POWER GRID PROJECTS TO CONSTRUCT A DEMONSTRATION TRANSMISSION LINE BY USING YBCO HIGH-TEMPERATURE SUPERCONDUCTORS. THE DESIGN INDICATES THAT THERE ARE GREAT DIFFERENCES BETWEEN WARM DIELECTRIC AND COLD DIELECTRIC POWER CABLES. THE MARGIN OF OPERATING CURRENT IS LARGELY DEPENDENT ON THE CURRENT OF SHIELD LAYERS. MAGNETIC FIELD, STRESS AND LOSS ANALYSIS ARE ALSO CARRIED OUT BY USING FINITE ELEMENT METHOD.

1LPD-01

NUMERICAL ANALYSIS AND DESIGN CONSIDERATIONS OF ADVANCED LINEAR TYPE MAGNETIC FLUX PUMP DEPENDED ON PERMANENT MAGNET EXCITATION ***Y. CHUNG****[1], Y. YOON[2], D. BAE[3], T. KO[4];* [1]THE UNIVERSITY OF SUWON, [2]ANSAN COLLEGE OF TECHNOLOGY, [3]CHUNGJU NATIONAL UNIVERSITY, [4]YONSEI UNIVERSITY. — DUE TO INCREMENT OF DEMANDS VARIOUS HIGH FIELD MAGNET APPLICATION SYSTEM, THE REQUIREMENTS OF IMPROVED SUPERCONDUCTING POWER SUPPLIES HAVE BEEN SIGNIFICANTLY CONSIDERED IN THE HIGH FIELD SUPERCONDUCTING MAGNETS.FROM THIS POINT OF VIEW, WE ALREADY DEVELOPED A LINEAR TYPE MAGNETIC FLUX PUMP (LTMFP) THAT AS A CURRENT COMPENSATOR FOR SUPERCONDUCTING HIGH FIELD MAGNET. IN THE MECHANISM OF THE SUPERCONDUCTING MAGNETIC FLUX PUMP WITH SUPERCONDUCTING NB FOIL, THE HOMOPOLAR TRAVELING MAGNETIC FIELD PLAYS AN IMPORTANT ROLE TO GENERATE PUMPING CURRENT. THE LTMFP SUFFICIENTLY REALIZED THE HOMOPOLAR TRAVELING MAGNETIC FIELD BY MEANS OF 3 PHASE ARMATURE CURRENT AND DC BIAS CURRENT. THE LTMFP SUFFICIENTLY SOLVED THE AFOREMENTIONED PROBLEMS OF THE DTPS WITHOUT MOVING SYSTEM.IN THIS PAPER, WE PROPOSE ADVANCED LINEAR TYPE MAGNETIC FLUX PUMP (ALTMFP) WITH 3 PHASE ARMATURE CURRENT AND PERMANENT MAGNET EXCITATION. IN THIS CASE, THE STRUCTURE BECOMES SIMPLER AS WELL AS IT IS EASILY TREATED COMPARED WITH LTMFP.THE MAIN PURPOSE OF THIS PAPER, AS A FIRST STEP OF THIS WORK, IS TO EXPLAIN THE SIMPLICITY OF ITS STRUCTURE AND ANALYZE THE MAGNETIC DISTRIBUTION OF HOMOPOLAR TRAVELING MAGNETIC FIELD DEPENDED ON POSITION AND ARRAY OF PERMANENT MAGNET EXCITATION.

1LPD-02

TOWARDS A FEM TOOL FOR FLEXIBLE ANALYSIS OF SUPERCONDUCTING MOTORS ***J. LLOBERAS****[1], J. LÓPEZ[2], E. BARTOLOMÉ[1];* [1]EUSS, [2]UPC. — NUMERICAL METHODS BASED ON FINITE ELEMENTS (FEM) REPRESENT A POWERFUL APPROACH TO SOLVE ELECTROMAGNETIC PROBLEMS IN SUPERCONDUCTORS. FOR INSTANCE, FEM METHODS HAVE BEEN BROADLY USED TO CALCULATE THE CRITICAL STATE CURRENT DISTRIBUTION IN SUPERCONDUCTORS OF VARIOUS GEOMETRIES. WE ARE DEVELOPING A FEM TOOL SPECIFICALLY CONCEIVED FOR THE ANALYSIS OF POWER APPLICATIONS, SUCH AS MOTORS AND GENERATORS. THE TOOL IS IMPLEMENTED IN COMMERCIAL MULTIPHYSICS SOFTWARE (COMSOL) TO MAKE IT A FLEXIBLE, EXTENDABLE AND EASILY AVAILABLE SOLUTION FOR A LARGE USER'S COMMUNITY. OUR APPROACH IS TO DEFINE THE PARTIAL DIFFERENTIAL EQUATIONS MODULE, AND ANALYZE SOME OF THE RELEVANT TECHNICAL PARAMETERS IN POWER APPLICATIONS E.G. TORQUE, ANGULAR SPEED. IN THIS CONTRIBUTION WE PRESENT THE PROGRESS ON THE DEVELOPMENT OF SUCH MOTOR FEM TOOL.

1LPD-03

ANALYSES AND CONTROL OF A HIGH TEMPERATURE SUPERCONDUCTING MOTOR ***H. WANG****, Y. DAI, Q. WANG;* INSTITUTE OF ELECTRICAL ENGINEERING,CHINESE ACADEMY OF SCIENCES. — A HIGH TEMPERATURE SUPERCONDUCTING (HTSC) DIAMAGNETIC MOTOR BASED ON MEISSNER EFFECT HAS BEEN STUDIED. THE MOTOR WAS DESIGNED FOR THE POWER SOURCE EQUIPMENT WHICH IS MADE TO DRIVE A SIMILAR LOW TEMPERATURE SUPERCONDUCTING (LTSC) MOTOR RUN AT VERY LOW TEMPERATURE 4.2 K (LIQUID HELIUM). THE HTSC MOTOR HAS THE SAME WORK PRINCIPLE AND ELECTROMAGNETIC PARAMETERS AS THE LTSC MOTOR BUT RUNS IN LOWER SPEED AND HAS SIMPLER COOLING SYSTEM. IT IS USED TO TEST AND DEBUG THE POWER SOURCE EQUIPMENT'S OPERATING PERFORMANCE IN HIGH TEMPERATURE ENVIRONMENT AND WITH LOWER OPERATING COST. THE MOTOR COULD RUN AT THE TEMPERATURE 77 K (LIQUID NITROGEN). THE DESIGN AND FABRICATION AND ALSO THE ELECTROMAGNETIC AND MECHANICAL ANALYSIS ON THE MOTOR ARE DESCRIBED IN DETAIL. AT LAST, THE EXPERIMENTAL RESULTS ARE GIVEN AND ANALYZED.

MUXI SHANG

1LPD-04

DESIGN OF THE AXIAL AND RADIAL FLUX HTS MOTOR WITH SUPERCONDUCTING ARMATURE WINDING ***L. LI****, J. CAO, B. KOU, S. YANG, X. LIU;* HARBIN INSTITUTE OF TECHNOLOGY. — THIS PAPER GIVES THE PARAMETERS OF A NOVEL SUPERCONDUCTING PERMANENT MAGNET SYNCHRONOUS MOTOR. THIS MOTOR'S STATOR USES THE FERROMAGNETIC

MATERIAL AS THE TOOTH-SLOT STRUCTURE AND THE SUPERCONDUCTING WINDINGS ARE LOCATED IN THE SLOTS. THE MOTOR'S ROTOR USES THE PERMANENT MAGNETS AS THE EXCITATION AND AT THE SAME TIME USES THE SUPERCONDUCTING AXIAL EXCITATION AS THE ASSISTANCE EXCITATION. THIS MOTOR RUNS IN LOW MAGNETIC FIELD DENSITY AND HIGH CURRENT DENSITY WHICH IS DIFFERENT FROM THE CONVENTIONAL HTS MOTOR. THOSE STRUCTURES OF THE STATOR AND ROTOR CAN ENSURE THE SUPERCONDUCTING COILS CAN AFFORD LARGER CURRENT AND PRODUCE LESS AC LOSS. THIS PAPER CALCULATES THE ELECTROMAGNETIC FIELD DISTRIBUTION OF THE HTS MOTOR, AND GIVES THE DETAILED SIZE OF THE HTS MOTOR.

THIS WORK WAS SUPPORTED IN PART BY THE P.R. CHINA DEPARTMENT OF THE MINISTRY OF SCIENCE AND TECHNOLOGY UNDER GRANT 2008DFR70120.

1LPD-05

DESIGN AND AC LOSS ANALYSIS OF A FULLY SUPERCONDUCTING 10HP HOMOPOLAR MOTOR WITH YBCO CC WINDINGS ***S. PARK***[1], *Y. KIM*[1], *S. LEE*[1], *J. LEE*[2], *W. KIM*[3], *C. PARK*[4], *I. PARK*[5], *K. CHOI*[1], *S. HAHN*[6]; [1]KOREA POLYTECHNIC UNIVERSITY, [2]WOOSUK UNIVERSITY, [3]KOREA ELECTRIC POWER RESEARCH INSTITUTE, [4]SEOUL NATIONAL UNIVERSITY, [5]SUNGKYUNKWAN UNIVERSITY, [6]ELECTRICAL ENGINEERING AND SCIENCE RESEARCH INSTITUTE. — THE SUPERCONDUCTING MOTOR HAS A LOT OF BENEFITS FROM HIGH POWER DENSITY FOR SHIP PROPULSIONS. DESPITE OF THE BENEFITS, THERE IS ALWAYS A DIFFICULTY OF CRYO-MOVING PART FOR AIR-CORE SUPERCONDUCTING SYNCHRONOUS MOTORS. IN ORDER TO GET RID OF THIS MOVING CRYOGENIC PART, WE PROPOSE A HOMOPOLAR SUPERCONDUCTING SYNCHRONOUS MOTOR, WHICH HAS HIGH TEMPERATURE SUPERCONDUCTING ARMATURE AND FIELD COILS. THE STATIONARY FIELD COILS MAKE THE COOLING SYSTEM SIMPLE AND EASY BECAUSE THERE IS NO CRYO-MOVING PART.IN THIS PAPER, WE PRESENT A DESIGNED RESULT OF A 10 HP HOMOPOLAR FULLY SUPERCONDUCTING SYNCHRONOUS MOTOR. ALSO, AC LOSS OF SUPERCONDUCTING WINDINGS ARE ANALYZED BY USING 3D FINITE ELEMENT METHOD FOR HOMOPOLAR SUPERCONDUCTING SYNCHRONOUS MOTOR. THE OPERATING FREQUENCY IS TO BE UNDER 5 HZ FOR LOW ROTATING SPEED WHICH IS NEEDED FOR A PURPOSE OF SHIP PROPULSION.

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1LPD-07

ELECTROMAGNETIC DESIGN STUDY OF TRANSVERSE FLUX ENHANCED TYPE SUPERCONDUCTING WIND TURBINE GENERATORS ***M. R. QUDDES***[1], *M. SEKINO*[1], *H. OHSAKI*[1], *N. KASHIMA*[2], *S. NAGAYA*[2]; [1]THE UNIVERSITY OF TOKYO, [2]CHUBU ELECTRIC POWER CO., INC.. — TRANSVERSE FLUX ENHANCED TYPE SUPERCONDUCTING SYNCHRONOUS MACHINES HAVE BEEN STUDIED FOR LARGE-CAPACITY WIND POWER GENERATION. THE GENERATORS HAVE MULTIPLE CIRCULAR SUPERCONDUCTING FIELD COILS IN THE ROTOR AND COPPER ARMATURE WINDINGS IN THE STATOR. A PARAMETRIC DESIGN STUDY AND ELECTROMAGNETIC CHARACTERISTICS ANALYSIS OF THE SUPERCONDUCTING WIND TURBINE GENERATORS (WTGS) HAVE BEEN CARRIED OUT. A TARGET OUTPUT POWER IS 10 MW, THE ROTATIONAL SPEED IS ASSUMED 10 RPM, AND THE MACHINE DIAMETER SHOULD BE LESS THAN 5 M. SUPERCONDUCTING TECHNOLOGY IS QUITE EFFECTIVE FOR COMPACT AND LIGHT-WEIGHT DESIGN OF LARGE-CAPACITY, LOW-SPEED, HIGH-TORQUE GENERATORS. ARMATURE AND FIELD COIL DIMENSIONS AND THE NUMBER OF POLES ARE KEY PARAMETERS FOR DESIGN STUDY. FEM ANALYSIS WAS CARRIED OUT TO OBTAIN MAGNETIC FLUX DENSITY, INTERLINKAGE MAGNETIC FLUX, INDUCED VOLTAGE, FUNDAMENTAL GENERATOR CHARACTERISTICS, ETC. REQUIRED SUPERCONDUCTOR WIRE LENGTH WAS CALCULATED, AND THE GENERATOR WEIGHT WAS ALSO ROUGHLY ESTIMATED.

1LPD-08

A SMALL-SIZED HTS HOMOPOLAR SYNCHRONOUS ROTATING MACHINE ***J. LEE***[1], *H. KIM*[2], *S. BAIK*[2], *Y. KWON*[2], *S. LEE*[3], *J. HONG*[3], *M. PARK*[1], *I. YU*[1]; [1]CHANGWON NATIONAL UNIVERSITY, [2]KERI, [3]HANYANG UNIVERSITY. — IN GENERAL, HIGH TEMPERATURE SUPERCONDUCTING (HTS) ROTATING MACHINE IS DRAMATICALLY REDUCED THE WEIGHT AND SIZE COMPARED WITH CONVENTIONAL ROTATING MACHINE. THIS ADVANTAGE IS VERY ATTRACTIVE TO SHIP PROPULSION SYSTEM AND WIND POWER GENERATION SYSTEM. IN MOST CASE OF AIR-CORED HTS SYNCHRONOUS MACHINE, HTS FIELD COIL IS ROTATED. ON THE OTHER HAND, HTS HOMOPOLAR MACHINE HTS FIELD COIL IS PLACED BETWEEN TWO INDUCTORS OF THE ROTOR. AND THE HTS FIELD COIL IS NOT ROTATED. THEREFORE, HTS HOMOPOLAR MACHINE HAS A SUPERIOR MECHANICAL STABILITY COMPARING WITH AIR-CORED HTS SYNCHRONOUS MACHINE. ALSO, HTS HOMOPOLAR MACHINE CAN BE REDUCED SUPERCONDUCTING WIRE BECAUSE ROTOR CONSISTED OF MAGNETIC MATERIALS. IN THIS PAPER, WE ARE DEVELOPED A SMALL-SIZED HTS HOMOPOLAR MACHINE WITH A ROTOR OF 12-POLES AND A STATOR OF 3 PHASE WINDINGS. THE HTS FIELD COIL WAS WOUND WITH A STAINLESS-STEEL REINFORCED BI-2223 HTS WIRE. HTS FIELD COIL WAS COOLED BY LIQUID NITROGEN (LN2). THE TEST DETAILS AND RESULTS ARE PRESENTED IN THIS PAPER, AND DISCUSSED.

THIS RESEARCH WAS SUPPORTED BY A GRANT FROM CENTER FOR APPLIED SUPERCONDUCTIVITY TECHNOLOGY OF THE 21ST CENTURY FRONTIER R&D PROGRAM FUNDED BY THE MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY, REPUBLIC OF KOREA

1LPD-09

LOAD ANGLE CALCULATION OF A SUPERCONDUCTING SYNCHRONOUS MOTOR ***S. BAIK***[1], *Y. KWON*[1], *H. KIM*[1], *J. LEE*[1], *Y. KIM*[2]; [1]KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE, [2]DOOSAN HEAVY INDUSTRIES. — GENERALLY THE

SYNCHRONOUS MOTOR CONSISTS OF A ROTOR MADE OF DIRECT CURRENT COILS OR PERMANENT MAGNETS, SO IT ROTATES AT THE SAME(SYNCHRONOUS) SPEED WITH ROTATING MAGNETIC FLUX GENERATED BY THE STATOR COILS. TORQUE IS GENERATED BY ALIGNING TENDENCY OF THE MAGNETIC FLUX OF THE ROTOR AND THE STATOR. BECAUSE THE ROTOR COIL ROTATES, ROTATING MAGNETIC FLUX IS ALSO GENERATED BY THE ROTOR AND INDUCES VOLTAGE CALLED "BACK ELECTROMOTIVE FORCE(EMF)" AT THE STATOR COILS.THE LOAD ANGLE OF A SYNCHRONOUS MOTOR, GENERALLY DENOTED AS Δ, IS DEFINED AS PHASE ANGLE DIFFERENCE BETWEEN THE BACK EMF AND THE STATOR TERMINAL VOLTAGES. THE GENERATED TORQUE IS PROPORTIONAL TO SINΔ AND THE MAXIMUM TORQUE IS GENERATED WHEN THIS ANGLE IS 90°. THE SUPERCONDUCTING SYNCHRONOUS MOTOR HAS SMALLER LOAD ANGLE THAN CONVENTIONAL SYNCHRONOUS MOTOR DUE TO SMALLER REACTANCE OF THE STATOR COILS. THEREFORE, IT HAS LARGER MAXIMUM TORQUE CAPACITY THAN CONVENTIONAL ONE.IN THIS PAPER, A 1 MW CLASS SUPERCONDUCTING SYNCHRONOUS ROTATING MACHINE WITH HIGH-TEMPERATURE SUPERCONDUCTING(HTS) ROTOR COIL IS CONSIDERED TO CALCULATE THE LOAD ANGLE. THE DEVELOPED HTS SYNCHRONOUS MACHINE HAS BEEN TESTED WHILE CONNECTED TO A DRIVING AND LOAD INDUCTION MACHINE WITH 1.1-MW RATING. THROUGH OPEN CIRCUIT TEST BACK EMF VOLTAGES WERE MEASURED AND THE LOAD ANGLES AT LOAD CONDITIONS WERE CALCULATED BY USING AN EQUIVALENT CIRCUIT OF THE TEST HTS SYNCHRONOUS MOTOR.

THIS RESEARCH WAS SUPPORTED BY A GRANT FROM CENTER FOR APPLIED SUPERCONDUCTIVITY TECHNOLOGY OF THE 21ST CENTURY FRONTIER R&D PROGRAM FUNDED BY THE MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY, REPUBLIC OF KOREA.

1LPE-01

SMES BASED EXCITATION SYSTEM FOR DOUBLY-FED INDUCTION GENERATOR IN WIND POWER APPLICATION ***J. SHI,*** *Y. TANG, Y. XIA, L. REN, J. LI;* R&D CENTER OF APPLIED SUPERCONDUCTIVITY, HUAZHONG UNIVERSITY OF SCIENCE & TECHNOLOGY. — THIS PAPER PROPOSES A SUPERCONDUCTING MAGNET ENERGY STORAGE (SMES) BASED EXCITATION SYSTEM FOR DOUBLY-FED INDUCTION GENERATOR (DFIG) USED IN WIND POWER GENERATION. THE EXCITATION SYSTEM IS COMPOSED OF THE ROTOR-SIDE CONVERTER, THE GRID-SIDE CONVERTER, THE DC CHOPPER AND THE SUPERCONDUCTING MAGNET. THE SUPERCONDUCTING MAGNET IS CONNECTED WITH THE DC SIDE OF THE TWO CONVERTERS, WHICH CAN HANDLE THE ACTIVE POWER TRANSFER WITH THE ROTOR OF DFIG AND THE POWER GRID INDEPENDENTLY. UTILIZING THE CHARACTERISTIC OF HIGH EFFICIENT ENERGY STORAGE AND QUICK RESPONSE OF SUPERCONDUCTING MAGNET, THE SYSTEM CAN BE UTILIZED TO LEVEL THE WIND POWER FLUCTUATION, ALLEVIATE THE INFLUENCE ON POWER QUALITY, AND IMPROVE FAULT RIDE-THROUGH CAPABILITY FOR THE GRID-CONNECTED WIND FARMS. ACCORDING TO THE SYSTEM CONTROL OBJECTIVE, THE SYSTEM CAN CONTRIBUTE TO THE STABILITY AND RELIABILITY OF THE WIND POWER GRID-CONNECTED SYSTEM. USING MATLAB SIMULINK, THE MODEL OF THE SMES BASED EXCITATION SYSTEM FOR DFIG IS ESTABLISHED, AND THE SIMULATION TESTS ARE PERFORMED TO EVALUATE THE SYSTEM PERFORMANCE.

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1LPE-02

A LINEAR DOUBLY-SALIENT HTS MACHINE FOR WAVE ENERGY CONVERSION *Y. DU[1,2], K. CHAU[1,3], M. CHENG [1], Y. WANG[1] J. LI[3];* [1]SCHOOL OF ELECTRICAL ENGINEERING, SOUTHEAST UNIVERSITY, NANJING,[2] SCHOOL OF ELECTRICAL AND INFORMATION ENGINEERING, JIANGSU UNIVERSITY, [3]DEPT. OF ELECTRICAL AND ELECTRONIC ENGINEERING, THE UNIVERSITY OF HONG KONG. WITH EVER INCREASING DEMAND OF CLEAN AND RENEWABLE ENERGY, THERE IS A FAST GROWING INTEREST IN WAVE ENERGY CONVERSION. DUE TO THE RECIPROCATING NATURE OF WAVE MOTION, THE LINEAR MACHINE IS PREFERRED TO THE ROTATIONAL MACHINE TO CAPTURE THE WAVE ENERGY AS IT CAN ELIMINATE THE BULKY AND INEFFICIENT LINEAR-TO-ROTARY CONVERSION MECHANISM. THE PURPOSE OF THIS PAPER IS TO PROPOSE A NEW LINEAR TUBULAR DOUBLY-SALIENT HIGH-TEMPERATURE SUPERCONDUCTOR (DS-HTS) MACHINE WHICH CAN OFFER HIGH POWER DENSITY AND ROBUST STRUCTURE TO EFFECTIVELY CAPTURE THE RECIPROCATING WAVE ENERGY. THE PROPOSED MACHINE IS COMPOSED OF A TUBULAR STATOR AND A TUBULAR TRANSLATOR. THE STATOR CONSISTS OF AN IRON CORE WITH SALIENT POLES, 3-PHASE COPPER ARMATURE WINDINGS AND HTS FIELD COILS, WHILE THE TRANSLATOR IS A SIMPLE IRON CORE WITH SALIENT POLES. THUS, THE TRANSLATOR IS SO ROBUST THAT CAN BE DIRECTLY COUPLED WITH THE RECIPROCATING BUOY. THE STATOR IS LOCATED AT THE SEABED WHICH IS CONNECTED TO THE ONSHORE GRID VIA A SUBMARINE CABLE. BOTH CHARACTERISTICS AND PERFORMANCES OF THE PROPOSED MACHINE ARE ASSESSED BY USING FINITE ELEMENT ANALYSIS. ALSO, THE PROPOSED MACHINE IS QUANTITATIVELY COMPARED WITH THE EXISTING LINEAR PERMANENT MAGNET (PM) SYNCHRONOUS MACHINE AND THE LATEST LINEAR DS-PM MACHINE, HENCE JUSTIFYING THE USE OF HTS AND VERIFYING THE MERITS OF HIGH POWER DENSITY AND ROBUSTNESS.

1LPE-03

ROTATION TESTS OF A SUPERCONDUCTING INDUCTION/SYNCHRONOUS MOTOR WITH MGB_2 WIRE IN

LIQUID AND GASEOUS HELIUM ***K. KAJIKAWA***[1]*, T. NAKAMURA*[2]*, M. TAKAHASHI*[3]*, T. WAKUDA*[3]*;* [1]KYUSHU UNIVERSITY, [2]KYOTO UNIVERSITY, [3]HITACHI. — THE PRESENT AUTHORS HAVE PROPOSED A FULLY SUPERCONDUCTING MOTOR TO DRIVE AN ELECTRIC PUMP USED FOR THE CIRCULATION OR TRANSFER OF LIQUID HYDROGEN. THE MOTOR COMPOSED OF AN MGB_2 ROTOR WINDING WOULD ENABLE US TO SUPPRESS THE OPERATION LOSS IN THE CRYOGENIC ENVIRONMENT DUE TO THE SYNCHRONOUS ROTATION MODE AND FURTHERMORE TO INCREASE THE SYNCHRONOUS TORQUE AND OUTPUT POWER. THE USE OF AN MGB_2 STATOR WINDING COULD ALSO CONTRIBUTE TO DECREASE THE PRIMARY POWER CONSUMPTION SMALLER THAN THAT FOR THE COPPER WINDING COOLED DOWN TO LIQUID HYDROGEN TEMPERATURE. IN THIS STUDY, THE ROTATION TESTS FOR AN MGB_2 SUPERCONDUCTING MOTOR ARE CARRIED OUT IN BOTH THE LIQUID HELIUM BATH AND THE GASEOUS HELIUM ATMOSPHERE. THE SQUIRREL-CAGE TYPE ROTOR WINDING IS COMPOSED OF A MGB_2 WIRE WITH THE DIAMETER OF 0.8 MM AND THE CRITICAL CURRENT OF 534 A AT 4 K IN THE SELF-FIELD. A COPPER WIRE IS USED FOR THE STATOR WINDING. THE SYNCHRONOUS ROTATIONS ARE SUCCESSFULLY CONFIRMED DURING BOTH THE NO-LOAD AND LOAD TESTS. THE MAXIMUM SYNCHRONOUS TORQUE ALSO REACHES SEVERAL TENS NM LARGER THAN THE RATED TORQUE IN A CONVENTIONAL INDUCTION MOTOR.

THIS WORK WAS SUPPORTED BY THE INDUSTRIAL TECHNOLOGY RESEARCH GRANT PROGRAM IN 2008 (08B38006A) FROM THE NEW ENERGY AND INDUSTRIAL TECHNOLOGY DEVELOPMENT ORGANIZATION (NEDO) OF JAPAN.

1LPE-04

FUNDAMENTAL CHARACTERISTICS OF FULLY SUPERCONDUCTING HTS INDUCTION-SYNCHRONOUS MACHINE FOR ELECTRIC VEHICLE ***D. SEKIGUCHI***[1]*, T. NAKAMURA*[1]*, M. FUKUI*[1]*, T. NISHIMURA*[1]*, K. MATSUMURA*[1]*, N. AMEMIYA*[1]*, Y. ITOH*[2]*, M. YOSIKAWA*[2]*, T. TERAZAWA*[2]*;* [1]KYOTO UNIVERSITY, [2]IMRA MATERIALS R&D CO., LTD.,. — IN THIS STUDY, FUNDAMENTAL CHARACTERISTICS OF FULLY SUPERCONDUCTING HIGH TEMPERATURE INDUCTION-SYNCHRONOUS MACHINE (HTS-ISM) IS INVESTIGATED BASED ON THE ANALYSIS AND THE EXPERIMENT. TARGET APPLICATION OF THE HTS-ISM IS THE DRIVE SYSTEM FOR THE NEXT GENERATION ELECTRIC VEHICLE. THE STATOR WINDINGS ARE FABRICATED BY COMBINING THE HTS RACETRACK-SHAPED DOUBLE PANCAKE COILS, IN ORDER FOR THE REALIZATION OF THE QUASI-SINUSOIDAL AIR-GAP MAGNETIC FLUX DENSITY. SINCE HTS WINDINGS GENERATE LESS OHMIC LOSSES, THE HTS-ISM CAN ENHANCE THE ELECTRIC LOADING. USING THIS CHARACTERISTIC, THE HTS-ISM CAN POSSESS NOT ONLY THE HIGHER EFFICIENCY FOR VARIABLE SPEED CONTROL BUT ALSO GENERATE EXTREMELY HIGH TORQUE DENSITY. IN THE PRESENT SYSTEMS, VEHICLES NEED TRANSMISSION GEARS TO GET ENOUGH TRACTION FORCE, EVEN IT'S VERY BULKY AND HEAVY, AND RESULTS IN LOWERING THE TOTAL EFFICIENCY. ON THE OTHER HAND, THE ELECTRIC VEHICLE EQUIPPED THE HTS-ISM DOESN'T NEED SUCH GEARS BECAUSE OF LARGE TORQUE DENSITY, AND SO IT HAS A HIGHER EFFICIENCY THAN CONVENTIONAL CARS IN A TOTAL SYSTEM. IN ORDER TO INVESTIGATE THE ABOVE-MENTIONED CHARACTERISTICS, THE MODEL HTS-ISM IS FABRICATED AND TESTED. THE OBTAINED RESULTS ARE ALSO DISCUSSED BY COMPARING WITH THE ANALYSIS.

THIS WORK HAS BEEN SUPPORTED BY NEW ENERGY AND INDUSTRIAL TECHNOLOGY DEVELOPMENT ORGANIZATION (NEDO) JAPAN.

1LPE-05

A FAST ANALYTICAL METHOD TO COMPUTE THE RADIAL FLUX DENSITY DISTRIBUTION IN THE AIRGAP OF A SUPERCONDUCTING INDUCTOR. ***G. MALE****, T. LUBIN, S. MEZANI, J. LEVEQUE;* LABORATOIRE GREEN. — THE SHIELDING PROPERTIES OF SUPERCONDUCTING MATERIALS HAVE GIVEN RISE TO A VARIETY OF ELECTRICAL MACHINE TOPOLOGIES. AN ORIGINAL SUPERCONDUCTING INDUCTOR HAS BEEN REALISED AND TESTED IN OUR LABORATORY. IT USES YBCO SUPERCONDUCTING BULKS TO SHIELD THE MAGNETIC FIELD CREATED BY TWO SOLENOIDS SUPPLIED BY DC CURRENTS IN CONTRA-DIRECTIONS. THE OBTAINED AIRGAP FIELD IS MULTIPOLAR AS IN CONVENTIONAL AC MACHINES.SEVERAL METHODS HAVE BEEN DEVELOPED TO COMPUTE THE MAGNETIC FIELD DISTRIBUTION IN THIS 3D STRUCTURE. NUMERICAL TECHNIQUES LIKE FINITE ELEMENTS OR FINITE DIFFERENCES CAN BE USED BUT THIS LEADS TO VERY LARGE COMPUTATION TIME.ANOTHER APPROACH WHICH WILL BE PRESENTED IN THIS PAPER IS BASED ON THE DETERMINATION OF THE MODULATING FUNCTION ASSOCIATED WITH THE RADIAL FLUX DENSITY DISTRIBUTION RESULTING FROM THE INTRODUCTION OF THE SUPERCONDUCTING BULKS.IN A FIRST STEP, THE ANALYTICAL METHOD BASED ON THE RESOLUTION OF LAPLACE'S EQUATIONS FOR EACH SUB-DOMAIN ALLOWS THE COMPUTATION OF THE MODULATING FUNCTION.IN A SECOND STEP, THE LATER IS USED TOGETHER WITH THE FIELD PRODUCED BY THE TWO SOLENOIDS (COMPUTED USING BIOT-SAVART LAW) TO CALCULATE THE RADIAL FLUX DENSITY DISTRIBUTION IN THE AIRGAP OF THIS INDUCTOR.COMPARISONS TO EXPERIMENTS AND TO 3D FE RESULTS SHOW THE VALIDITY OF THE PROPOSED APPROACH WITH THE BENEFIT OF HUGE SAVINGS IN COMPUTATION TIME TO OPTIMIZE THE DESIGN OF THE STUDIED INDUCTOR.

1LPE-06

DESIGN AND ANALYSIS OF A HTS BRUSHLESS DOUBLY-FED DOUBLY-SALIENT MACHINE ***C. LIU****, K. T. CHAU, J. ZHONG, J. LI;* THE UNIVERSITY OF HONG KONG. — BRUSHLESS DOUBLY-FED DOUBLY-SALIENT MACHINES (BDFDS) ARE A NEW BREED OF FLUX CONTROLLABLE BRUSHLESS MACHINES. HOWEVER, DUE TO THE FIELD EXCITATION BY COPPER WINDINGS, THEY INHERENTLY HAVE MANY DRAWBACKS, NAMELY LOW OUTPUT TORQUE AND LOW EFFICIENCY. THE PURPOSE OF THIS PAPER IS TO PROPOSE A NEW BDFDS MACHINE USING BSCCO-2223 HTS MATERIAL AS THE FIELD WINDING.THE PROPOSED HTS BDFDS MACHINE HAS THE DOUBLE-SALIENT 12/8-POLE TOPOLOGY. THE STATOR HAS 12 SALIENT POLES,

AND ACCOMMODATES THE COPPER ARMATURE WINDING AND THE HTS FIELD WINDING. THE INNER ROTOR HAS ONLY 8 SALIENT POLES. THE KEY IS TO USE THE HTS FIELD WINDING TO EXCITE THE AIRGAP FLUX IN SUCH A WAY THAT THIS MACHINE CAN OPERATE IN DIFFERENT MODES ACCORDING TO WORKING REQUIREMENTS. IN ADDITION, DUE TO THE DOUBLY-SALIENT STRUCTURE, THE PROPOSED MACHINE CAN ALSO WORK AS A SWITCHED RELUCTANCE MACHINE WHEN THE HTS FIELD WINDING IS NOT ACTIVE. HENCE, THIS HTS-BDFDS MACHINE INHERENTLY NOT ONLY OVERCOMES THE DRAWBACKS OF THE TRADITIONAL BDFDS MACHINE, BUT ALSO SHOWS MORE FLEXIBLE OPERATIONS.IN THIS PAPER, THE DESIGN CRITERIA, DIFFERENT OPERATION MODES, AND FINITE ELEMENT ANALYSIS OF THE PROPOSED HTS-BDFDS MACHINE ARE PRESENTED. ALSO, A QUANTITATIVE COMPARISON BETWEEN THE PROPOSED HTS-BDFDS MACHINE AND THE TRADITIONAL BDFDS ONE IS CONDUCTED, HENCE VERIFYING ITS EFFECTIVENESS.

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1LPE-07

ANALYTIC EVALUATION OF HTS INDUCTION MOTOR FOR ELECTRIC ROLLING STOCK ***T. KONISHI***[1]*, T. NAKAMURA*[2]*, T. NISHIMURA*[2]*, N. AMEMIYA*[2]*;* [1]RAILWAY TECHNICAL RESEARCH INSTITUTE, [2]KYOTO UNIVERSITY. — IN THIS STUDY, THE NEXT GENERATION DC ELECTRIC ROLLING STOCK SYSTEM HAS BEEN INVESTIGATED WITH THE USE OF HIGH TEMPERATURE SUPERCONDUCTING (HTS) TECHNOLOGY.DC MOTOR HAD BEEN APPLIED FOR STANDARD DRIVE SYSTEM OF DC ROLLING STOCK IN JAPAN. NOWADAYS, INDUCTION MOTOR OR PERMANENT MAGNET SYNCHRONOUS MOTOR INSTEAD OF DC ONE HAVE BEEN APPLIED WIDELY, BECAUSE OF THE ADVANTAGE OF THEIR UTILITY AND EFFICIENCY. HOWEVER, FURTHER IMPROVEMENT OF MOTOR CHARACTERISTICS WILL BE REQUIRED IN ORDER TO REALIZE ENVIRONMENT-FRIENDLY DC RAILWAY SYSTEM IN THE FUTURE. THEREFORE, IT IS IMPORTANT TO STUDY MORE EFFICIENT MACHINE FOR NEXT GENERATION. RECENTLY, THE CURRENT CARRYING PERFORMANCE OF HTS CONDUCTORS HAS REMARKABLY BEEN IMPROVED BY THE TREMENDOUS EFFORTS IN RESEARCH AND DEVELOPMENT. AS ONE OF THE PROMISING APPLICATIONS FOR THE USE OF SUCH CONDUCTORS, THE HTS INDUCTION/SYNCHRONOUS MOTOR (HTS-ISM) HAS BEEN INVESTIGATED. THE STRUCTURE OF THIS MOTOR IS THE SAME AS THAT OF THE CONVENTIONAL (NORMAL CONDUCTING) SQUIRREL-CAGE INDUCTION MOTOR. BY APPLYING HTS-ISM TO THE DRIVE SYSTEM OF DC ROLLING STOCK, IT IS EXPECTED TO IMPROVE ELECTRIC CHARACTERISTICS OF DC ELECTRIFIED RAILWAY. THEREFORE, WE EVALUATE THE PERFORMANCE OF DC MOTOR, CONVENTIONAL (NORMAL CONDUCTING) INDUCTION MOTOR, AND HTS-ISM. WE HAVE CLEARLY SHOWN THE EFFECTIVENESS OF THE INTRODUCTION OF THE HTS-ISM INTO THE DC ELECTRIC ROLLING STOCK.

1LPE-08

DESIGN AND MANUFACTURING OF HTS COILS FOR 30KVA SYNCHRONOUS ELECTRICAL MACHINE *G. CELENTANO, G. MESSINA, G. GIORGI, F. MAIERNA, S. RUECA, R. VIOLA, A. DELLA CORTE;* ENEA. — - IN THIS PAPER WE REPORT ON THE DESIGN AND EXPERIMENTAL STUDIES ON HTS ROTOR WINDING FOR 30KVA, THREE PHASES, AXIAL FLUX SYNCHRONOUS ELECTRICAL MACHINE. A MAGNETIC FLUX DENSITY OF 1.5-2 T IN AIR GAP WILL BE OBTAINED BY HTS COILS OPERATING AT LN2 TEMPERATURES WITHOUT FERROMAGNETIC MATERIALS, ARRANGED ON A FIBERGLASS SUPPORT DISC OF 200 MM IN DIAMETER. DESIGN STUDY IN TERMS OF COIL NUMBER, DIMENSION AND THE ARRANGEMENT IS CARRIED OUT AND DISCUSSED TO OBTAIN AN OPTIMIZED SINUSOIDAL FIELD PROFILE IN COMSOL ENVIRONMENT. IN ORDER TO DEVELOP A PROPER WINDING TECHNOLOGY, DOUBLE PANCAKE PROTOTYPES HAVE BEEN MANUFACTURED USING SCS 4050 TYPE REBCO-COATED CONDUCTORS PROVIDED BY SUPERPOWER. COILS WOUND ON A 20 MM PVC CORE CONSISTING IN 30 TURNS INSULATED BY 0.025 MM THICK KAPTON TAPE, WERE MADE AND TESTED AT LN2 TEMPERATURE RANGE. THE CRITICAL VALUE OF THE CURRENT TRANSPORT, I_C, AND MAGNETIC FLUX DENSITY MEASURED BY HALL SENSORS OF THE PROTOTYPE COIL ARE IN AGREEMENT WITH THAT OBTAINED FROM SIMULATIONS. THE OPERATIONAL STABILITY AGAINST OVERCURRENTS AND THERMAL CYCLING EFFECTS IN SUCH A COIL ARE ALSO INVESTIGATED.

1LPF-01

CURRENT CAPACITY OF HTS TAPE UNDER AC EXTERNAL MAGNETIC FIELD ***L. LI****, J. CAO, S. YANG;* HARBIN INSTITUTE OF TECHNOLOGY. — AT A CERTAIN TEMPERATURE, I_C OF HTS TAPE IS DEPENDENT ON DIFFERENT MAGNETIC FIELDS. FOR A AC MAGNETIC FIELD, THE AMPLITUDE IS TRANSIENT. WE CAN'T USE THE I_{CA}, THE CRITICAL CURRENT CORRESPONDED TO AMPLITUDE FIELD, AS THE MAXIMUM CURRENT WHICH HTS TAPE CAN TRANSPORT. WHEN HTS TAPE IS UNDER THE AC EXTERNAL MAGNETIC FIELD, THE CURRENT CAPACITY OF HTS TAPE DEPENDS NOT ONLY ON THE AMPLITUDE FIELD, BUT ALSO ON THE COOLING POWER OF REFRIGERATION SYSTEM. IN THIS PAPER, THE RELATIONSHIP BETWEEN AC EXTERNAL MAGNETIC FIELD AND CURRENT CAPACITY OF THE HTS TAPE ARE STUDIED. THE CRITICAL CURRENT CORRESPONDS TO EQUIVALENT FIELD INDICATES THE CURRENT CAPACITY OF HTS TAPE UNDER AC EXTERNAL MAGNETIC FIELD.

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1LPF-02

CRITICAL CURRENT AND ELECTRIC LOSS UNDER MAGNETIC FIELD AT 30 K ON BI-2223 SUPERCONDUCTING COIL FOR SHIP PROPULSION MOTOR ***Y. KOSHIBA***[1]*, S. YUAN*[1]*, N. MAKI*[1]*, M. IZUMI*[1]*, K. UMEMOTO*[2]*, K. AIZAWA*[2]*, Y. KIMURA*[2]*, M. YOKOYAMA*[2]*;* [1]TOKYO UNIVERSITY OF MARINE SCIENCE AND

TECHNOLOGY, [2]KAWASAKI HEAVY INDUSTRIES LTD.. — THE CRITICAL CURRENT AND N-VALUE OF A HIGH-T_C SUPERCONDUCTING TAPE WIRE DECREASE UNDER A MAGNETIC FIELD, DEPENDING BOTH ON ITS AMPLITUDE AND DIRECTION. WE ARE CURRENTLY UNDER PROGRESS OF A MW-CLASS HTS SHIP PROPULSION MOTOR, FOR WHICH THE ROTOR HTS COIL MADE OF BI-2223 TAPE WIRE HAS ALREADY BEEN SUCCESSFULLY COOLED DOWN TO 30 K. YET, THE QUALIFICATION OF THE ELECTRIC LOSS IN THE TAPE WIRE WAS TO BE DONE BY USING A CURRENT-VOLTAGE CHARACTERISTIC UNDER PRACTICAL OPERATION CONDITIONS. THUS, WE MEASURED THE CURRENT-VOLTAGE CHARACTERISTIC UNDER DIFFERENT MAGNETIC FIELDS AT 40 K. THE CRITICAL CURRENT AND N-VALUE OF THE BI-2223 HIGH-T_C SUPERCONDUCTING TAPE WIRE WERE OBTAINED FOR MAGNETIC FIELDS OF VARIOUS AMPLITUDES AND DIRECTIONS. AS A SECOND STEP, THE DESIGN OF THE RACE-TRACK TYPE FIELD POLE COIL WAS ACHIEVED. THE EXPECTED ELECTRIC LOSS WAS CALCULATED BY INTEGRATION OF THE GENERATED VOLTAGE DROP WITH AN ELECTROMAGNETIC ANALYSIS OF THE WHOLE RACE-TRACK COIL BODY WHEN INSIDE THE FIELD-POLE ARMATURE STRUCTURE. AS A RESULT, THE CALCULATED LOSS WAS COMPARABLE TO THE ACTUAL LOSS OBSERVED IN THE TEST COIL UNDER AN OPERATION CURRENT OF UP TO 200 A.

A PART OF THE PRESENT STUDY WAS SUPPORTED BY NEDO.

1LPF-03

RESEARCH ON DISTRIBUTION OF MAGNETIC FIELD AROUND THE SUPERCONDUCTING COILS IN FERROMAGNETIC ENVIRONMENT ***L. LI****, J. CAO, S. YANG, B. KOU;* HARBIN INSTITUTE OF TECHNOLOGY. — THIS PAPER RESEARCHES THE DISTRIBUTION OF THE SUPERCONDUCTING COIL IN THE STATOR TOOTH-SLOT ENVIRONMENT WHICH IS COMPOSED OF FERROMAGNETIC MATERIAL. THE ELECTROMAGNETIC FIELD DISTRIBUTION IN THE INFLUENCE OF THE ROTATE MAGNETIC FIELD AND FERROMAGNETIC MATERIAL WILL BE PRESENTED, AND COUPLING LAW OF THE AC CURRENT THAT FLOW IN THE SUPERCONDUCTING COILS AND THE DISTRIBUTION OF MAGNETIC FIELD AROUND THE SUPERCONDUCTING COILS WILL ALSO BE PRESENTED IN THIS PAPER. FINALLY, IN CONSIDERATION OF THE DECREASING THE PERPENDICULAR MAGNETIC FIELD IN THE SUPERCONDUCTING COILS, THE FERROMAGNETIC MATERIAL IS ADDED AROUND THE SUPERCONDUCTING COILS. THE SIMULATION RESULT SHOWS THAT THIS METHOD CAN GET BETTER EFFORT.

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1LPF-04

IMPROVED DESIGN TO REDUCE EDDY-CURRENT LOSS IN RETAIN-RING IN SUPERCONDUCTING MACHINES ***S. LEE****[1], J. HONG[1], Y. KWON[2], H. PARK[3], Y. KIM[3];* [1]HANYANG UNIVERSITY, [2]KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE, [3]DOOSAN HEAVY INDUSTRIES AND CONSTRUCTION CO., LTD.. — IN ORDER TO FIX MAGNETIC SHIELD OF LAMINATION STRUCTURE USING SILICON STEEL IN AXIAL DIRECTION IN SUPERCONDUCTING MACHINE HAVING HIGH-CAPACITY, RETAIN RING USED TO MAGNETIC OR NON-MAGNETIC SUBSTANCE. BECAUSE LEAKAGE FLUX WHICH IS GENERATED FROM END-WINDING OF FILED WINDING IN SUPERCONDUCTING MACHINE HAVING HIGH-CAPACITY, IS HIGHER THAN THAT OF GENERAL ELECTRIC MACHINE, IT HAS A EFFECT ON RETAIN RING. ALTHOUGH FIELD CURRENT IS DIRECT CURRENT, FIELD WINDING IN ROTOR IS ROTATED IN OPERATION CONDITION. CONSEQUENTLY, FLUX DISTRIBUTION AND LINKAGE FLUX AT THE RETAIN RING VERSUS ROTOR POSITION IS CHANGED AND THEN, THIS PHENOMENON GENERATES EDDY-CURRENT LOSS IN RETAIN RING. AS THE RESULT OF THIS EDDY-CURRENT LOSS IN RETAIN RING, PERFORMANCE OF SUPERCONDUCTING MACHINE IS DOWNED AND THERMAL PROBLEM IS GENERATED. IN ADDITION, ADDITIONAL COOLING SYSTEM IS REQUIRED. THEREFORE, THIS PAPER DEALS WITH IMPROVED DESIGN TO REDUCE THE EDDY-CURRENT LOSS IN RETAIN RING. FIRSTLY, 3-DIMENSIONAL TRANSIENT ANALYSIS VERSUS SUBSTANCE UNDER THE SAME RETAIN RING SHAPE IS FIRSTLY PERFORMED. SECONDLY, DISTRIBUTION AND QUANTITY OF EDDY-CURRENT ARE COMPARED AND SELECTION METHOD OF RETAIN RING SUBSTANCE IS SUGGESTED. FINALLY, SHAPE OF RETAIN RING TO REDUCE THE EDDY CURRENT LOSS IS SUGGESTED. THIS STUDY WILL BE USEFULLY USED TO DECIDE THE SUBSTANCE AND SHAPE OF RETAIN RING.

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1LPF-05

CHARACTERISTIC COMPARISON ACCORDING TO THE CHANGE OF END-WINDING SHAPE IN FIELD COIL FOR SUPERCONDUCTING MACHINES ***S. LEE****[1], J. HONG[1], Y. KWON[2], H. KIM[2], Y. JO[2], Y. KIM[3];* [1]HANYANG UNIVERSITY, [2]KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE, [3]DOOSAN HEAVY INDUSTRIES AND CONSTRUCTION CO., LTD.. — IN ORDER TO CONSIDER MECHANICAL AND ELECTROMAGNETIC CHARACTERISTICS OF SUPERCONDUCTOR, THE END-WINDING OF FIELD COIL FOR SUPERCONDUCTING MACHINES GENERALLY HAS CIRCLE SHAPE. HOWEVER, THE CIRCLE SHAPE OF END-WINDING INCREASES THE DEMANDED QUANTITY OF SUPERCONDUCTOR AND IT GENERATES A LOT OF LEAKAGE FLUX COMPONENT WHICH DOES NOT CONTRIBUTE THE MECHANICAL OUTPUT OF SUPERCONDUCTING MACHINES. IN ADDITION, VOLUME OF MECHANICAL BLOCK STRUCTURE ,WHICH IS TO WIND SUPERCONDUCTOR, IS ALSO INCREASED. THEREFORE, THIS PAPER DEALS WITH A STUDY ON END-WINDING WHICH HAS PARTIALLY STRAIGHT SHAPE FOR FIELD COIL.IN ORDER TO COMPARE THE ELECTROMAGNETIC AND MECHANICAL CHARACTERISTICS VERSUS SHAPE OF END-WINDING, TWO MODELS, WHICH HAVE CIRCLE OR PARTIALLY STRAIGHT SHAPE IN END-WINDING FOR FIELD COIL, ARE RESPECTIVELY DESIGNED UNDER THE SAME MECHANICAL OUTPUT CONDITION. AND THEN, AMPLITUDE AND

DISTRIBUTION OF PERPENDICULAR FLUX DENSITY FOR SUPERCONDUCTOR ARE COMPARED UNDER LOAD CONDITION. IN ADDITION, THE REDUCTION DEGREE FOR VOLUME AND WEIGHT OF SUPERCONDUCTING MACHINE AND THE QUANTITY OF SUPERCONDUCTOR IS ALSO COMPARED.

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1LPF-06

COIL OPTIMIZATION FOR HTS MACHINES ***N. MIJATOVIC***[1]*, B. B. JENSEN*[1]*, V. M. R. ZERMENO*[2]*, C. TRÆHOLT*[1]*, A. B. ABRAHAMSEN*[3]*, M. P. SØRENSEN*[2]*, N. F. PEDERSEN*[1]*;* [1]TECHNICAL UNIVERSITY OF DENMARK - DEPARTMENT OF ELECTRICAL ENGINEERING, [2]TECHNICAL UNIVERSITY OF DENMARK - DEPARTMENT OF MATHEMATICS, [3]RISØ NATIONAL LABORATORY FOR SUSTAINABLE ENERGY - MATERIALS RESEARCH DIVISION. — A NEW APPROACH TO OPTIMIZING HTS COILS IN HTS SYNCHRONOUS MACHINES (SM) IS PRESENTED. THE OPTIMIZATION IS AIMED AT HIGH POWER SM SUITABLE FOR DIRECT DRIVEN WIND TURBINES. THE OPTIMIZATION PROCESS WAS APPLIED TO A GENERAL RADIAL FLUX MACHINE WITH A PEAK AIR GAP FLUX DENSITY HIGHER THAN 1T. THE PROPOSED COIL DESIGN IS OPTIMIZED WITH RESPECT TO MINIMIZING THE PERPENDICULAR FIELD WHILE STILL MAXIMIZING THE AMPLITUDE OF FUNDAMENTAL SPACE HARMONIC. THIS GUARANTEES THE LOWEST HTS LOSS DENSITY AND BEST UTILIZATION OF EXPENSIVE HTS MATERIAL IN THE FIELD WINDING OF THE SM. ADDITIONALLY, ACCOUNTING FOR DIFFERENT TAPE PARAMETERS AS CRITICAL CURRENT, *N*-VALUE AND PRICE, FURTHER IMPROVEMENT IN THE HTS COST VS. LOSSES WAS OBTAINED. ALLOWING FOR DIFFERENT TYPES OF HTS TAPES IN THE COILS, AN INDICATION OF WHICH TAPE IS OPTIMAL FOR WHAT COIL SEGMENT IS DEMONSTRATED. THE PRESENT STUDY THUS PROVIDES VALUABLE INPUT FOR FUTURE COIL DESIGN OF HTS MACHINES ENSURING OPTIMAL USAGE OF HTS TAPES.

1LPF-07

RESEARCH AND DEVELOPMENT OF ALTERNATIVE CONCEPTS IN HTS MACHINES ***J. M. PINA***[1]*, D. P. INÁCIO*[1]*, G. F. LUÍS*[2]*, J. M. CEBALLOS*[3]*, P. R. PEREIRA*[1]*, J. F. MARTINS*[1]*, M. VENTIM NEVES*[1]*, A. ÁLVAREZ*[3]*, A. L. RODRIGUES*[1]*;* [1]CENTRE OF TECHNOLOGY AND SYSTEMS, [2]FACULDADE DE CIÊNCIAS E TECNOLOGIA, [3]"BENITO MAHEDERO" GROUP OF ELECTRICAL APPLICATIONS OF SUPERCONDUCTORS. — HIGH TEMPERATURE SUPERCONDUCTING (HTS) MACHINES ARE RECOGNIZED TO OFFER SEVERAL ADVANTAGEOUS FEATURES WHEN COMPARING TO CONVENTIONAL ONES. AMONGST THESE, HIGHLIGHTS THE DECREASE IN MACHINES' WEIGHT AND VOLUME, DUE TO INCREASED CURRENT DENSITY IN CONDUCTORS OR THE ABSENCE OF IRON SLOTS' TEETH; OR THE DECREASE IN AC LOSSES AND CONSEQUENT MACHINES' HIGHER EFFICIENCY, EVEN ACCOUNTING FOR CRYOGENICS. THESE CONCEPTS HAVE BEEN ALREADY DEMONSTRATED AND SOME MACHINES HAVE EVEN ACHIEVED COMMERCIAL STAGE. IN THIS PAPER, SEVERAL ALTERNATIVE APPROACHES ARE APPLIED TO ELECTRICAL MOTORS EMPLOYING HTS MATERIALS. THE FIRST ONE IS AN ALL SUPERCONDUCTING LINEAR MOTOR, WHERE COPPER CONDUCTORS AND PERMANENT MAGNETS ARE REPLACED BY BI-2223 WINDINGS AND TRAPPED FLUX MAGNETS, TAKING ADVANTAGE OF STABLE LEVITATION DUE TO FLUX PINNING, HIGHER CURRENT DENSITIES AND HIGHER EXCITATION FIELD. THE SECOND IS AN INDUCTION DISC MOTOR WITH BI-2223 ARMATURE, WHERE IRON, IRONLESS AND HYBRID APPROACHES ARE COMPARED. FINALLY, AN INNOVATIVE COMMAND STRATEGY, CONSISTING OF AN ELECTRONICALLY VARIABLE POLE PAIRS' NUMBER APPROACH, IS APPLIED TO A SUPERCONDUCTING HYSTERESIS DISC MOTOR. ALL THESE CONCEPTS ARE BEING INVESTIGATED AND SIMULATION AND EXPERIMENTAL RESULTS ARE PRESENTED.

SOME OF THE AUTHORS WOULD LIKE TO THANK TO CTS (CENTRE OF TECHNOLOGY AND SYSTEMS) FROM UNINOVA (INSTITUTO DE DESENVOLVIMENTO DE NOVAS TECNOLOGIAS) AND TO FUNDAÇÃO PARA A CIÊNCIA E A TECNOLOGIA FOR ITS FINANCIAL SUPPORT.

1LPF-08

EXPERIMENTAL CHARACTERIZATION OF A CONVENTIONAL (ALUMINUM) AND A SUPERCONDUCTING (YBCO) AXIAL FLUX DISC MOTOR ***D. P. INÁCIO***[1]*, J. M. PINA*[1]*, J. F. MARTINS*[1]*, M. F. VENTIM-NEVES*[1]*, A. ÁLVAREZ*[2]*;G. LUIS*[3] [1]CTS - UNINOVA (FCT-UNL), [2]" BENITO MAHEDERO" GROUP OF ELECTRICAL APPLICATIONS OF SUPERCONDUCTORS′
[3]FACULDADE DE CIÊNCIAS E TECNOLOGIA, UNIVERSIDADE NOVA DE LISBOA— WITH THE DISCOVERY OF THE SUPERCONDUCTIVITY PHENOMENON SEVERAL SUPERCONDUCTING MACHINES HAVE BEEN DEVELOPED BASED ON HIGH TEMPERATURE SUPERCONDUCTING (HTS) MATERIALS. THE INTEGRATION OF HTS SUPERCONDUCTING MATERIALS IN ELECTRICAL MACHINES PROVIDES ADVANTAGEOUS WHEN COMPARING TO CONVENTIONAL ONES. REPLACING THE ALUMINUM DISC ROTOR OF AN AXIAL FLUX MOTOR BY A SUPERCONDUCTIVE DISC ROTOR, NCREASED POWER DENSITY AND REDUCED LOSSES ARE OBTAINED, PROVIDING A SMALL AND LIGHT MACHINE. ALSO, WHILE THE ALUMINUM ROTOR MOTOR IS AN ASYNCHRONOUS MOTOR, WITH THE SUPERCONDUCTOR ROTOR THE MOTOR MAY SHOW BOTH ASYNCHRONOUS AND SYNCHRONOUS BEHAVIOR. AT ASYNCHRONOUS PERMANENT REGIMES, BOTH MOTORS CAN BE DESCRIBED BY STEINMETZ-TYPE MODELS. THE PAPER DESCRIBES TESTS CONDUCTED ON AN AXIAL FLUX MOTOR, BOTH WITH AN ALUMINUM DISC ROTOR AND AN YBCO HIGH TEMPERATURE SUPERCONDUCTOR (HTS) DISC ROTOR AT LIQUID NITROGEN TEMPERATURE (77 K); THE ROTATING MAGNETIC FIELD WAS PRODUCED BY A FOUR-POLE, THREE-PHASE STATOR WINDING, AT 50HZ. A VARIABLE LOAD FROM A DC MACHINE WAS APPLIED TO THE MOTOR ALLOWING OBTAINING VARIOUS CHARACTERISTICS, FOR BOTH CONVENTIONAL AND HTS MOTOR. FROM THE TESTS, THE

PARAMETERS OF BOTH MOTORS' MODELS WERE DEDUCED. THE CHARACTERISTICS OF BOTH MOTORS ARE COMPARED.

1LPG-01

HIGH TEMPERATURE SUPERCONDUCTOR ARMATURE WINDING DESIGN OF A SYNCHRONOUS MOTOR ***F. XU****, A. CHEN, X. LIU, J. CAO, L. LI;* HARBIN INSTITUTE OF TECHNOLOGY. — THIS PAPER GIVES A CONCEPTUAL DESIGN OF HTS ARMATURE WINDING FOR A SYNCHRONOUS MOTOR, WHICH HAS A SPECIAL PERMANENT MAGNET ROTOR STRUCTURE AND A STATOR STRUCTURE WITH IRON CORE, ITS DESIGNED OUTPUT IS 400 KW AT THE RATED SPEED OF 250 RPM. THE ARMATURE WINDINGS ARE MADE OF THE BSCCO HTS TAPES AND COOLED WITH SUB-COOLED LIQUID NITROGEN. THE PRELIMINARY RESEARCH RESULTS SHOW THAT, WHEN THE INTERNAL MAGNETIC FIELD LESS THAN 0.2T AND THE OPERATING TEMPERATURE IS KEPT BELOW 70K, ARMATURE WINDINGS COULD OBTAIN A REASONABLE VALUE OF WORKING CURRENT AND AC LOSS. TO MAKE THE WINDINGS CAPABLE OF CARRYING A LARGE ALTERNATING CURRENT, ROEBEL TRANSPOSED CONDUCTOR IS ADOPTED. TO REDUCE THE INTERNAL MAGNETIC FIELD WITHIN THE WINDINGS, CONSIDERING CRYOGENIC COOLING REQUIREMENTS A SPECIAL MAGNETIC CIRCUIT STRUCTURE INSIDE CRYOSTAT IS DESIGNED. TO ANALYZE AC LOSS OF THE WINDINGS, A COMPLEX 3D MAGNETIC FIELD FE MODEL IS CREATED. THE RESULTS SHOW THAT THE USE OF HTS MATERIAL IN THE ARMATURE WINDING IS FEASIBLE FOR THIS KIND OF SYNCHRONOUS MOTOR.

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1LPG-02

STUDY OF LARGE SCALE WIND TURBINE SYNCHRONOUS GENERATORS WITH HTS FIELD WINDINGS ***S. FUKUI****[1], J. OGAWA[1], T. SATO[1], O. TSUKAMOTO[2], N. KASHIMA[3], S. NAGAYA[3];* [1]NIIGATA UNIVERSITY, [2]YOKOHAMA NATIONAL UNIVERSITY, [3]CHUBU ELECTRIC POWER CO. INC.. — SINCE, IN WIND GENERATION, IT IS SAID THAT THE ELECTRIC POWER THAT CAN BE GENERATED PER UNIT AREA OF GENERATION SITE INCREASES WITH INCREASING NOMINAL POWER CAPACITY PER WIND TURBINE, THE DEVELOPMENT OF LARGE SCALE WIND TURBINE GENERATORS MORE THAN 10MVA IS EXPECTED. GENERALLY, THE ROTATION SPEED OF THE 10MVA-CLASS WIND TURBINE IS ABOUT 10 RPM. DUE TO EXTREMELY LARGE INPUT TORQUE, IT IS DIFFICULT TO USE SPEED-UP TRANS-GEAR BY THE MECHANICAL REASONS. ON THE OTHER HAND, IN THE CASE OF THE DIRECT DRIVE WITH THE LOW ROTATION SPEED, THE CONVENTIONAL GENERATOR MUST BE USED EXTREMELY LARGE DIAMETER AND HEAVY WEIGHT. THEREFORE, IT IS NECESSARY TO DEVELOP THE COMPACT/LIGHT WEIGHT GENERATOR IN THE LOW ROTATION SPEED. WE PROPOSE TO APPLY HIGH TEMPERATURE SUPERCONDUCTIVITY (HTS) FOR THE LARGE SCALE WIND TURBINE GENERATORS. IN THIS STUDY, THE ELECTROMAGNETIC DESIGN OF 10MVA-CLASS WIND TURBINE SYNCHRONOUS GENERATOR WITH HTS FIELD WINDINGS IS STUDIED.

1LPG-03

DESIGN AND MODEL TEST OF A HIGH TEMPERATURE SUPERCONDUCTING GENERATOR FOR WIND POWER APPLICATIONS ***X. LI****, L. HAN, D. ZHANG, J. ZHANG, S. DAI, D. XIA, L. LIN, L. XIAO;* INSTITUTE OF ELECTRICAL ENGINEERING, CHINESE ACADEMY OF SCIENCES. — HIGH TEMPERATURE SUPERCONDUCTING (HTS) GENERATORS ARE PROMISING IN THE WIND POWER APPLICATIONS FOR ITS ADVANTAGES IN SIZE, WEIGHT AND THERMAL STABILITY AGAINST LOAD FLUCTUATIONS, ESPECIALLY IN THE "DIRECT-DRIVEN" DESIGN. A 100 KW MODEL GENERATOR IS PROPOSED FOR THE DEMONSTRATION OF THE FEASIBILITY OF USING HTS IN 10 MW WIND TURBINE GENERATORS. THE ELECTROMAGNETIC DESIGN AND THE OPTIMIZATION OF THE ROTOR WERE DONE USING A FINITE ELEMENT METHOD (FEM). THE EXCITATION COIL OF THE ROTOR WAS DEVELOPED AND TESTED CONSIDERING VARIABLE WORKING CONDITIONS AND LOAD FLUCTUATIONS. ACCORDING TO THE OBTAINED RESULTS, A NUMBER OF SUGGESTIONS IN THE DESIGN AND WIND TECHNIQUES OF THE SUPERCONDUCTING ROTOR ARE PROPOSED.INDEX TERMS: HTS GENERATOR; HTS TAPE; EXCITATION COIL; WIND TURBINE; STABILITY.

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1LPG-04

TESTING OF A LIGHTWEIGHT CORELESS HTS SYNCHRONOUS GENERATOR COOLED BY SUBCOOLED LIQUID NITROGEN. ***W. O. BAILEY****;* UNIVERSITY OF SOUTHAMPTON. — *ABSTRACT*_A LIGHTWEIGHT (100KW) HTS, 2-POLE ROTOR, DESIGNED AND BUILT AT THE UNIVERSITY OF SOUTHAMPTON HAS BEEN COMPLETED AND IS READY FOR TESTING. THE NEW ROTOR HAS BEEN DESIGNED TO SLIDE INTO THE CONVENTIONAL 2-POLE, 3-PHASE STATOR, INHERITED FROM THE FIRST GENERATION 100KW HTS 'IRON CORED' ROTOR PROJECT IN (2005). THE 'COLD' COMPONENTS OF THE ROTOR ASSEMBLY ARE NOW 3 TIMES LIGHTER THAN IN ITS PREDECESSOR WITH THE SAME POWER RATING. SIGNIFICANT TIME AND COST SAVINGS IN THE COOLDOWN PROCESS OWE MUCH TO THE DOUGHNUT SHAPED CRYOSTAT DESIGN. IT HOUSES THE HTS WINDING, WHICH IS SUB-ASSEMBLED FROM 14 DOUBLE PANCAKE BSCCO COILS, ALL FULLY WETTED BY THE CIRCULATING LIQUID CRYOGEN IN THE ANNULAR SPACE BETWEEN THE WALLS OF THE DOUGHNUT CRYOSTAT. THE PRACTICAL TESTING OF THE GENERATOR BEGAN WITH TESTS TO CONFIRM THE CRITICAL CURRENT (IC) OF THE HTS WINDING AND TO MEASURE THE WAVEFORM AND HARMONIC CHARACTERISTICS OF GENERATED VOLTAGE OF THE MACHINE, AT VARIOUS SPEEDS AND FIELD CURRENTS IN THE TEMPERATURE RANGE OF (65 K - 77 K). THESE RESULTS ARE COMPARED TO OUR FINITE MODELING PREDICTIONS, BEFORE THE MACHINE WAS TESTED MORE INTENSIVELY IN A SERIES OF STANDARD OPEN AND CLOSE CIRCUIT

CONFIGURATIONS TO OBTAIN THE REAL VALUE OF THE SYNCHRONOUS REACTANCE.

1LPG-05

FURTHER TESTING OF AN IRON-CORED HTS SYNCHRONOUS GENERATOR COOLED BY LIQUID AIR. ***W. O. S. BAILEY;*** UNIVERSITY OF SOUTHAMPTON. — *ABSTRACT*_INVESTIGATING THE PERFORMANCE OF A (100KW) HTS SYNCHRONOUS GENERATOR WITH A MAGNETIC CORE BEGAN IN 2008 AT THE UNIVERSITY OF SOUTHAMPTON. MEASUREMENTS OF THE WAVEFORMS AND HARMONIC CHARACTERISTICS OF THE GENERATED VOLTAGES AT DIFFERENT IRON SATURATIONS WERE PRESENTED. THESE MEASUREMENTS WERE CONDUCTED AT LIQUID NITROGEN TEMPERATURES (77K) AND SUBCOOLING NITROGEN CLOSE TO ITS TRIPLE POINT (65K). NEW MEASUREMENTS AT THESE OPERATING TEMPERATURES FOR BOTH OPEN AND CLOSED CIRCUIT CONFIGURATIONS HAVE ENABLED US TO CONFIRM THE MACHINES SYNCHRONOUS REACTANCE. IN ORDER TO REINFORCE OUR INITIAL MEASUREMENTS FOR THE STATIONARY 'LOCK TEST' AND OBTAIN GREATER PERFORMANCE FROM OUR HTS WINDING, NEW TESTS HAVE BEEN TRIED USING LIQUID AIR. CIRCULATING LIQUID AIR THROUGH THE CLOSED LOOP COOLING SYSTEM ENABLED US TO ACHIEVE A ROTOR TEMPERATURE OF 61K AND BOOST THE (IC) OF THE HTS WINDING TO 140A. A SERIES OF ADDITIONAL TESTS WITH THE MOTOR RUNNING WITH A LOAD SIMULATED MORE REALISTIC CONDITIONS AS IF THIS MACHINE WERE TYPICALLY INSTALLED FOR POWER GENERATION. FINALLY, SOME TRANSIENT TESTS INVESTIGATED THE POTENTIAL RISKS OF OVER-CURRENTS DURING SUDDEN SHORT CIRCUITING OF THE STATOR.

1LPG-06

DEVELOPMENT OF AN HTS ROTOR FOR A HIGH-SPEED GENERATOR ***M. G. FEE***[1]*, M. P. STAINES*[2]*, R. G. BUCKLEY*[2]*, L. LONG*[3]*;* [1]HTS-110 LTD, [2]INDUSTRIAL RESEARCH LTD, [3]LONG ELECTROMAGNETICS INC. — HTS TECHNOLOGY IS UNIQUE IN THE HIGH CURRENT DENSITY IT CAN PROVIDE IN COMPACT APPLICATIONS. COMBINING THIS WITH A HIGH ROTATIONAL SPEED ROTOR CAN RESULT IN A COMPACT LIGHTWEIGHT GENERATOR, WITH A VERY HIGH POWER-TO-WEIGHT RATIO, SUITABLE FOR AIRBORNE APPLICATIONS OR EMERGENCY DEPLOYMENT. TO GAIN THESE ADVANTAGES AT ROTATIONAL SPEEDS UP TO 15,000 RPM A NUMBER OF TECHNICAL CHALLENGES NEED TO BE MET. IN PARTICULAR THERE IS A NEED TO DEVELOP AN UNDERSTANDING OF THE MECHANICAL PERFORMANCE OF HTS WIRE UNDER THE HIGH INERTIAL FORCES TO BE EXPERIENCED IN SUCH A GENERATOR. IN THIS PRESENTATION WE WILL DISCUSS RESULTS OF LOADING 1G AND 2G HTS COILS TO FAILURE AT 77K THAT DEMONSTRATE THE VIABILITY OF A CRITICAL TECHNOLOGY REQUIRED FOR HIGH-SPEED HTS GENERATORS.

1LPH-01

PERFORMANCE CHARACTERISTICS OF POWER SAVING TYPE HTS POWER SUPPLY UTILIZED SOLAR ENERGY SYSTEM ***Y. CHUNG***[1]*, H. JO*[2]*, D. BAE*[3]*, H. KANG*[3]*, M. AHN*[4]*, Y. YOON*[5]*, T. KO*[2]*;* [1]THE UNIVERSITY OF SUWON, [2]YONSEI UNIVERSITY, [3]CHUNGJU NATIONAL UNIVERSITY, [4]KUNSAN NATIONAL UNIVERSITY, [5]ANSAN COLLEGE OF TECHNOLOGY. — THE REQUIREMENTS OF IMPROVED SUPERCONDUCTING POWER SUPPLIES HAVE BEEN SIGNIFICANTLY CONSIDERED IN THE HIGH FIELD SUPERCONDUCTING MAGNETS.THE DEVELOPED SUPERCONDUCTING POWER SUPPLIES KEPT MEAGERLY EFFICIENT OPERATION IN POWER ASSUMPTION AS WELL AS IT IS DIFFICULT TO MAINTAIN THE SELF-SUSTAINING OPERATION WHERE UTILITY POWER IS NOT INSTALLED. THAT IS, IN THE CASE OF ALL-YEAR-ROUND SYSTEM IN REMOTE LOCATIONS WHERE UTILITY POWER IS NOT AVAILABLE, SELF-MAINTAINING AND SAVING ELECTRICITY POWER SUPPLY SHOULD BE CONSIDERED. ENERGY FROM THE SUN ETERNALLY ARRIVES IN THE FORM OF HEAT AND LIGHT PHOTONS. NOWADAYS, THE WORLD IS CONSUMING FOSSIL-FUEL SOURCES AT A DEVASTATING RATE WHILE ONLY LACKLUSTER IMPETUS IS GIVEN TO THE USE OF THE VAST QUANTITY OF NONPOLLUTING ENERGY FROM RENEWABLE ENERGY SUCH AS SOLAR ENERGY. FROM THESE POINTS OF VIEW, WE ATTEMPTED TO CONFLATION BETWEEN SUPERCONDUCTING POWER APPLICATIONS AND SOLAR ENERGY SYSTEM TO UTILIZE SOLAR ENERGY AS A SOURCE OF ELECTRIC POWER.IN THIS PAPER, AS A PRACTICAL OPTION TO REALIZE THE TECHNICAL FUSION, WE DESCRIBE THE FABRICATION OF THE POWER SAVING TYPE HTS POWER SUPPLY WITH PV (PHOTOVOLTAIC) ENERGY TO PROMPT POWER SAVING AND SELF-SUSTAINING OPERATION. AS A FIRST STEP OF THIS RESEARCH, WE PRESENT THE FUNDAMENTAL PERFORMANCE OF CURRENT CHARGING ACTIONS WITH THE SUPERCONDUCTING POWER SUPPLY COMBINED SOLAR ENERGY SYSTEM.

1LPH-02

APPLICATION OF MGB_2 TO A SWITCH FOR EXTRACTION OF STORED MAGNETIC ENERGY ***T. TAYLOR***[1]*, Y. YANG*[2]*;* [1]CERN, [2]SOUTHAMPTON UNIVERSITY, U.K.. — SUPERCONDUCTING SWITCHES CAN BE CONSIDERED FOR USE TO REPLACE WARM CIRCUIT BREAKERS IN CIRCUITS TO EXTRACT THE ENERGY FROM MAGNET SYSTEMS. IN PRINCIPLE CONVENTIONAL NB-TI IN A CUPRO-NICKEL MATRIX WOULD BE AN APPROPRIATE CONDUCTOR FOR THIS PURPOSE, BUT EXPERIENCE HAS SHOWN IT TO BE PRONE TO SPONTANEOUS QUENCHING WHEN USED FOR LONG PERIODS IN THE CONDUCTIVE STATE. DUE TO THE POOR STABILITY MARGIN MICROSCOPIC MOVEMENTS CAN RELEASE SUFFICIENT ENERGY FOR SUCH EVENTS TO OCCUR. MGB_2 IS MUCH BETTER BEHAVED IN THIS RESPECT THANKS TO ITS HIGHER CRITICAL TEMPERATURE. MOREOVER, THIS MATERIAL IS BOTH ECONOMICAL AND CAN BE PROCESSED IN A RELATIVELY RESISTIVE MATRIX, WHICH MAKES IT AN INTERESTING CANDIDATE FOR SUCH AN APPLICATION FOR SYSTEMS WORKING AT BELOW 20 K. A DESIGN CONCEPT IS PRESENTED OF A SWITCH FOR USE WITH A MAGNETIC CIRCUIT HAVING UP TO 1 MJ OF STORED ENERGY, WITH A DETAILED ANALYSIS OF THE SWITCHING PROCESS.

1LPH-03

PROTOTYPE OF SC INVERTER ***K. OSAMURA***[1]*, A. SAKAI*[2]*, T. NAKAMURA*[2]*, T. OKA*[3]*;* [1]RESEARCH INSTITUTE FOR APPLIED SCIENCES, [2]KYOTO UNIVERSITY, [3]NIIGATA UNIVERSITY. — FIRSTLY A FUNCTION OF PHYSICAL UNIT "HALF PAIR" INCLUDING SUPERCONDUCTING (SC) ELEMENTS IS DESCRIBED. BY COMBINING THEIR PLURAL UNITS, A CIRCUIT IS CONSTRUCTED, WHICH HAS ESSENTIAL ABILITY FOR THE INVERTER ACTION. IN PRACTICE, THE YBCO THIN FILMS WERE USED FOR ELEMENTS OF TWO HALF-PAIRS, WHICH CONNECTED WITH THE METALLIC LOAD Z OF R_Z=50 MΩ. AC MAGNETIC FIELD BETWEEN 0.1 AND 100 HZ WAS APPLIED IN ORDER TO TRANSFER MUTUAL ELEMENTS FROM SC STATE TO RESISTIVE ONE. THE AC CURRENT OF 50HZ WAS OBSERVED ON THE LOAD Z AND ITS AMPLITUDE WAS $I_{Z,MAX}$=1.0A WHEN THE SOURCE DC CURRENT OF I_O = 36 A WAS APPLIED. THUS THE EFFICIENCY BECAME 2.8% IN THIS CASE. WHEN THE FREQUENCY WAS 0.2 HZ, THE EFFICIENCY BECAME 14%. THE MAIN REASON OF THE PRESENT LOW EFFICIENCY IS OWING TO THE RESISTANCE OF SC ELEMENTS WHEN THEY TRANSFER TO RESISTIVE STATE, WHICH WAS 3.2 MΩ, SUGGESTING THE STAGE OF VISCOUS FLUX MOTION. $I_{Z,MAX}$ INCREASED REMARKABLY WHEN THE I_O INCREASED BEYOND THE CRITICAL CURRENT OF SC ELEMENTS. FURTHER $I_{Z,MAX}$ REACHED MAXIMUM AND THEN DECREASED. THIS DROP IS ATTRIBUTED TO AN OVER-SHIFT CONDITION, IN WHICH SC ELEMENTS TRANSFER GRADUALLY TO RESISTIVE STATE. THUS THE PRESENT RESULT GAVE CLEAR EVIDENCE OF SC INVERTER ACTION, EVEN THOUGH THE PRESENT CIRCUIT HAS IMPERFECT INVERTER ACTION BECAUSE OF POOR PERFORMANCE OF PRESENTLY AVAILABLE SC ELEMENTS AND LACK OF OPTIMIZED SWITCHING MECHANISM.

1LPH-04

SIMULATION OF MAGNETICALLY TRIGGERED MGB2 SWITCHES ***S. A. ISHMAEL***[1]*, P. J. MASSON*[2]*, S. MEZANI*[3]*, R. MEINKE*[2]*;* [1]FLORIDA INSTITUTE OF TECHNOLOGY & ADVANCED MAGNET LAB. INC., [2]ADVANCED MAGNET LAB. INC., [3]UNIVERSITÉ NANCY. — SUPERCONDUCTING SYNCHRONOUS MACHINES REQUIRE DC CURRENT EXCITATION FOR THEIR FIELD WINDINGS WHICH CAN BE ACHIEVED VIA BRUSHLESS EXCITERS OR BY DIRECT CONNECTION TO CURRENT LEADS. THE INTRODUCTION OF HIGH HEAT LOADS THROUGH USE OF THE CURRENT LEADS AND THE CURRENT LIMITING SOLID STATE COMPONENTS OF BRUSHLESS EXCITERS ARE DISADVANTAGEOUS ISSUES CONCERNING THEIR USE WITH HTS MACHINES. ANOTHER POSSIBLE EXCITATION SYSTEM CONSISTING OF A HTS FULL WAVE RECTIFIED FLUX PUMP, SEEKS TO ADDRESS THESE MAIN LIMITING ISSUES OF EXISTING EXCITATION METHODS. RECTIFICATION IN THE FLUX PUMP IS ACHIEVED THROUGH MAGNETIC SWITCHES, WHICH ALSO ALLOW CLOSE TO PERSISTENT CURRENT OPERATION. INITIAL EXPERIMENTAL RESULTS DEMONSTRATED THAT MAGNETIC SWITCHING CAUSED ALMOST NO TEMPERATURE INCREASE LEADING TO FAST RECOVERY OF THE SWITCHES TO THE SUPERCONDUCTING STATE. SWITCHING DYNAMICS AND LOSSES ARE OBTAINED THROUGH NUMERICAL SIMULATIONS AND COMPARED TO EXPERIMENTAL DATA. THE EXPECTED PERFORMANCE OF A HIGH CURRENT MAGNETIC SWITCH IS DETERMINED AND USED TO ESTIMATE THE CONTRIBUTION TO THE DYNAMICS OF A ROTATING MACHINE EXCITATION SYSTEM.

1LPH-05

DEVELOPMENT OF A TOROIDAL COIL USING YBCO COATED CONDUCTOR FOR DC REACTOR ***N. HARADA***[1]*, M. YAMAMOTO*[1]*, K. UEDA*[1]*, M. TSUDA*[2]*, T. HAMAJIMA*[2]*, M. FURUSE*[3]*, S. FUCHINO*[3]*;* [1]YAMAGUCHI UNIVERSITY, [2]TOHOKU UNIVERSITY, [3]NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY. — FOR EFFECTIVE UTILIZATION OF ELECTRIC ENERGY, THE DC INTERCONNECTION SYSTEM OF FACTORIES IN AN INDUSTRIAL COMPLEX HAS BEEN INVESTIGATED. A TOROIDAL COIL WITH INDUCTANCE OF 1/10 OF DC REACTOR REQUIRED IN THIS SYSTEM HAS BEEN DEVELOPED. THIS TOROIDAL COIL CONSISTS OF 8 DOUBLE-PANCAKE COILS WOUND BY A COMMERCIALLY AVAILABLE YBCO COATED CONDUCTOR. THE MAJOR RADIUS IN THE TOROIDAL COIL IS 130 MM AND ITS INDUCTANCE IS 100 MH. ONE DOUBLE-PANCAKE COIL IS WOUND BY YBCO CONDUCTOR OF WIDTH 4.1 MM, THICKNESS 0.093 MM AND LENGTH 100 M, AND TWO PANCAKE COILS ARE CONNECTED BY SOLDER. MINIMUM CRITICAL CURRENT OF THE USED YBCO CONDUCTOR IS 81-99 A IN SELF FIELD AT 77 K, BUT CRITICAL CURRENT IN EACH COIL IS 31-36 A FROM I-V CURVES AFTER AN IMPREGNATION BY EPOXY RESIN. IT IS INVESTIGATED THAT THE CRITICAL CURRENT OF EACH DOUBLE-PANCAKE COIL WIDELY DECREASES AS COMPARED TO IT OF A SHORT YBCO CONDUCTOR, AND THE EFFECT OF IMPREGNATION IS DISCUSSED.

1LPJ-01

PROTECTIVE COOPERATION BETWEEN A SUPERCONDUCTING FAULT CURRENT LIMITER AND A RECLOSING SYSTEM ***H. S. CHOI***[1]*, Y. S. CHO*[1]*, B. I. JUNG*[1]*, D. C. CHUNG*[2]*;* [1]CHOSUN UNIVERSITY, [2]WOOSUK UNIVERSITY. — MOST OF POWER GRID HAS A RECLOSING SYSTEM, WHICH CONTROLS THE CIRCUIT BREAKER BY SEQUENTIAL PROCEDURE, TO COPE WITH VARIOUS FAULTS. WHEN THE FAULT WAS OCCURRED IN POWER GRID, THE CIRCUIT BREAKER WAS OPENED AND CLOSED AGAIN AFTER DETERMINED TIME IF THE FAULT WAS REMOVED BY ITSELF. AT THAT TIME, IF THE SUPERCONDUCTING FAULT CURRENT LIMITER (SFCL) WAS NOT RECOVERED, THE CIRCUIT BREAKER COULD NOT BE OPERATED PROPERLY ANY MORE. THEREFORE, FAST RECOVERY OF THE SFCL WAS VERY IMPORTANT FOR STABLE OPERATION BETWEEN THE PROTECTIVE SYSTEM AND THE SFCL. IN ORDER TO REDUCE THE RECOVERY TIME OF A FLUX-COUPLING TYPE SFCL, WINDING NUMBER OF SECONDARY COIL IN THE SFCL WAS CONTROLLED. THE RECOVERY TIME WAS REDUCED ACCORDING TO THE REDUCTION OF WINDING NUMBER OF SECONDARY COIL. ON THE CONTRARY, INTERNAL FLUX FLOWED INTO IRON CORE WAS INCREASED. WE COULD FIND THE OPTIMAL CONDITION FROM GOVERNING EQUATIONS BETWEEN ABOVE TWO PARAMETERS. IT MEANS THE RELIABILITY AND STABILITY OF POWER GRID CAN IMPROVE BY GOOD COOPERATION BETWEEN A FLUX-COUPLING TYPE SFCL AND A RECLOSING SYSTEM.

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1LPJ-02

POWER BURDEN OF FLUX-COUPLING TYPE SUPERCONDUCTING FAULT CURRENT LIMITER IN THE THREE-PHASE POWER SYSTEM ***B. I. JUNG***[1]*, Y. S. CHO*[1]*, H. S. CHOI*[1]*, D. C. CHUNG*[2]*;* [1]CHOSUN UNIVERSITY, [2]WOOSUK UNIVERSITY. — MOST OF TRANSMISSION SYSTEM HAS LOOP STRUCTURE TO IMPROVE THE RELIABILITY AND STABILITY OF POWER SYSTEM. FAULT CURRENT IS CONTINUOUSLY EXPECTED TO INCREASE BY INCREASE OF POWER DEMAND. IF FAULT CURRENT EXCEEDS THE CUTOFF CAPACITY OF A CIRCUIT BREAKER, THE CIRCUIT BREAKER IS BROKEN AND THE DAMAGE BY FAULT CURRENT IS EXPANDED THROUGHOUT THE POWER SYSTEM. SUPERCONDUCTING FAULT CURRENT LIMITER (SFCL) WAS DESIGNED TO SOLVE THIS PROBLEM IN POWER SYSTEMIN THIS PAPER, WE INVESTIGATED THE CURRENT LIMITING AND RECOVERY CHARACTERISTICS OF FLUX-COUPLING TYPE SFCL IN THREE-PHASE POWER SYSTEM. FLUX-COUPLING TYPE SFCL IS ONE OF THE RESISTIVE TYPE SFCLS. THE FLUX-COUPLING TYPE SFCL WAS MADE BY USING THE TRANSFORMER. REACTORS CONNECTED IN THE EACH PHASE SHARED THE IRON CORE. WHEN THE SUPERCONDUCTING ELEMENTS WERE QUENCHED IN FAULT PHASE, THE FAULT CURRENT FLOWED IN THE PRIMARY COIL AND SECONDARY COIL SIMULTANEOUSLY. THUS, THE CURRENT FLOWED IN PRIMARY AND SECONDARY COILS OF SOUND PHASE BY THE MAGNETIC COUPLING FLUX. MEANWHILE, WHEN THE CURRENT OF SOUND PHASE EXCEEDED THE CRITICAL CURRENT OF THE SFCL, SUPERCONDUCTING ELEMENTS CONNECTED IN THE SOUND PHASE WERE QUENCHED. WE FOUND THAT FLUX-COUPLING TYPE SFCL LIMITED THE CURRENT IN WHOLE THREE-PHASE. AS A RESULT, THE FLUX-COUPLING TYPE SFCL HAD GOOD COOPERATION WITH RECLOSING SYSTEM BECAUSE OF AN EQUAL POWER BURDEN BETWEEN THE SUPERCONDUCTING ELEMENTS.

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1LPJ-03

CONDITION BASED MONITORING OF SUPERCONDUCTING FAULT CURRENT LIMITER USING FUZZY SUPPORT VECTOR REGRESSION ***I. SEO****, B. HA, S. LEE, C. SHIN, S. YIM, H. KIM, O. HYUN;* KOREA ELECTRIC POWER RESEARCH INSTITUTE. — THE SUPERCONDUCTOR-TRIGGERED TYPE FAULT CURRENT LIMITER (STFCL), WHICH WAS DEVELOPED BY KOREA ELECTRIC POWER CORPORATION (KEPCO) AND LS INDUSTRIAL SYSTEMS (LSIS), IS UNDER OPERATION FOR THE VERIFICATION TEST AT KEPCO'S POWER TESTING CENTER. THE STFCL IS COMPOSED OF SUPERCONDUCTOR, FAST SWITCH AND CURRENT LIMITING RESISTOR. THE FAULT CURRENT IS SUPPRESSED AFTER A HALF CYCLE BY THE METHOD OF A LINE COMMUTATION.IN THIS PAPER, WE INVESTIGATED THE EMPIRICAL MODELING OF STFCL USING FUZZY SUPPORT VECTOR REGRESSION (FSVR) FOR THE PREDICTION AND FAULT DETECTION OF THE STFCL. SIGNALS FOR THE MODEL ARE CURRENTS AND VOLTAGES ACQUIRED FROM HIGH-TEMPERATURE SUPERCONDUCTOR (HTS), DRIVING COIL (DC) AND CURRENT LIMITING RESISTOR (CLR). AFTER DEVELOPING THE EMPIRICAL MODEL WE ANALYZED THE ACCURACY OF THE MODEL. THE RESULTS WERE COMPARED WITH THOSE OF PRINCIPAL COMPONENTS BASED AUTO-ASSOCIATIVE SUPPORT VECTOR REGRESSION (PCSVR) PRESENTED IN MT21. FSVR SHOWED BETTER PERFORMANCE IN ACCURACY ASPECT. MOREOVER, SENSITIVITY OF THE MODEL WAS EXPLORED USING ARTIFICIALLY DEGRADED SIGNAL. THIS MODEL CAN BE USED FOR CONDITION BASED MONITORING OF STFCL SYSTEM TO PREDICT ANY FAULT SYMPTOMS OF THE SYSTEM BY THE BENEFIT OF AUTO-CORRECTION FUNCTION OF THE MODEL.

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1LPJ-04

ANALYTICAL DESIGN METHOD AND EXPERIMENTAL TEST OF 1KV/2KA CLASS NON-INDUCTIVE HIGH-TC SUPERCONDUCTING FAULT CURRENT LIMITER ***Y. KIM***[1]*, D. PARK*[2]*, K. CHANG*[1]*, Y. YOON*[3]*, T. KO*[1]*;* [1]YONSEI UNIVERSITY, [2]MESSACHUSETTS INSTITUTE OF TECHNOLOGY, [3]ANSAN COLLEGE OF TECHNOLOGY. — THIS PAPER IS ABOUT DESIGN AND TEST OF 1KV/2KA CLASS NON-INDUCTIVE WINDING SUPERCONDUCTING FAULT CURRENT LIMITER (SFCL) WHICH IS ONE OF THE TARGETS OF THIRD YEAR IN PHASE III OF 21ST CENTURY FRONTIER R&D PROGRAM IN KOREA. THIS RESISTIVE TYPE SFCL IS MADE OF 2G HIGH TEMPERATURE SUPERCONDUCTING (HTS) WIRE WHICH HAS HIGH RESISTIVITY AT ROOM TEMPERATURE. THE SFCL HAS FOUR NON-INDUCTIVELY WOUND SOLENOID COILS IN SERIES AND EACH COIL HAS EIGHT COPPER TERMINALS IN PARALLEL. THE SFCL HAS SIXTEEN WIRES IN PARALLEL TO INCREASE TOTAL CRITICAL CURRENT OF THE SFCL BY STACKING A PAIR OF WIRES. FAULT CURRENT TEST WAS PERFORMED AND AC LOSS OF THE SFCL WAS ALSO MEASURED. THE TESTS WERE PERFORMED IN SUB-COOLED NITROGEN OF 65 K, 1 ATM. A NUMERICAL DESIGN METHOD WAS ALSO INTRODUCED IN THIS PAPER. THE METHOD WAS COMBINATION OF ELECTRICAL, THERMAL, AND MECHANICAL MODEL TO PREDICT ITS TRANSIENT BEHAVIOR WHEN A FAULT CURRENT OCCURS. THE ANALYTICAL PREDICTION FROM THE NUMERICAL DESIGN METHOD WAS ALSO IN THIS PAPER AND IT WAS COMPARED WITH THE EXPERIMENTAL RESULTS TO EVALUATE THE VALIDITY OF THE DESIGN METHOD

THIS RESEARCH WAS SUPPORTED BY A GRANT FROM CENTER FOR APPLIED SUPERCONDUCTIVITY TECHNOLOGY OF THE 21ST CENTURY FRONTIER R&D PROGRAM FUNDED BY THE MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY, REPUBLIC OF KOREA

1LPJ-06

TEMPERATURE SPATIAL DISTRIBUTION OF HIGH-TC COATED CONDUCTOR BY NUMERICAL METHOD WHEN A FAULT CURRENT FLOWS ***S. CHOI**, Y. KIM, K. CHANG, J. JANG, T. KO;* YONSEI UNIVERSITY. — THE SUPERCONDUCTING FAULT CURRENT LIMITER (SFCL) IS A PROTECTION DEVICE FOR AN ELECTRIC POWER SYSTEM. IN OTHER TO DESIGN A HIGH TEMPERATURE SUPERCONDUCTING (HTS) WINDING FOR THE SFCL, THE TEMPERATURE OF THE WINDING SHOULD BE CALCULATED UNDER THE OVER-CURRENT CAUSED BY FAULT CONDITION. THE STRUCTURE AND PROPERTY OF HTS TAPE WILL AFFECT TO THE TEMPERATURE.IN THIS PAPER, FINITE ELEMENT METHOD IS PERFORMED TO ESTIMATE THE TEMPERATURE RISE OF HTS COATED CONDUCTOR UNDER OVER-CURRENT. WE EXPERIMENT WITH THE SHORT SAMPLE TO MEASURE THE TEMPERATURE. IN ORDER TO PROVE THE RELIANCE OF THE SIMULATION METHOD, THE RESULTS FROM THE ELECTRICAL AND THERMAL ANALYSIS ARE COMPARED WITH THE EXPERIMENTAL DATA. ON THE BASIS OF RESULTS, THE PROPOSED RESULTS IN THIS STUDY CAN BE UTILIZED TO DESIGN HTS TAPE FOR THE SFCL.

THIS WORK WAS SUPPORTED BY MANPOWER DEVELOPMENT PROGRAM FOR ENERGY & RESOURCES OF MKE WITH YONSEI ELECTRIC POWER RESEARCH CENTER (YEPRC) AT YONSEI UNIVERSITY, SEOUL, KOREA

1LPJ-07

SIMULATION OF A TRANSFORMER TYPE HTS SUPERCONDUCTING FAULT CURRENT LIMITER PERFORMANCE IN AN ELECTRICAL POWER DISTRIBUTION FEEDER *E. RUPPERT[1], **A. E. J.**[1], C. A. BALDAN[2], C. Y. SHIGUE[2], J. S. LAMAS[2];* [1]UNICAMP, [2]USP. — THE TRANSFORMER OF THE TRANSFORMER TYPE SUPERCONDUCTING FAULT CURRENT LIMITER MUST MAKE THE SUPERCONDUCTOR EQUIVALENT ELECTRICAL RESISTANCE HIGH SO THAT IT MUST HAVE HIGH TURNS RATIO IN ORDER TO REDUCE THE AMOUNT OF THE SUPERCONDUCTING MATERIAL AND ALSO THE CRYOSTAT SIZE.HOWEVER HIGH TURNS RATIO CAN LEAD TO LARGE TRANSFORMER SIZE SO THAT IT IS NECESSARY TO DESIGN IT ADEQUATELY TO OPERATE CONTINUOUSLY IN SHORT-CIRCUIT. THE SET COMPOSED BY THE TRANSFORMER AND THE SUPERCONDUCTING MATERIAL MUST OFFER A VERY SMALL IMPEDANCE TO THE DISTRIBUTION FEEDER DURING NORMAL OPERATION BECAUSE THE FEEDER VOLTAGE DROP CAN´T BE HIGHER THAN PREVIOUSLY SPECIFIED VALUES, THIS WAY THE LEAKAGE REACTANCE OF THE PRIMARY AND THE SECONDARY WINDINGS MUST BE MINIMIZED. THE TRANSFORMER ALSO MUST BE CAREFULLY DESIGNED AND A SECOND GENERATION SUPERCONDUCTING MATERIAL MUST BE USED SO THAT THE AMOUNT OF THIS MATERIAL BE MINIMIZED TO REDUCE THE COST OF THE CURRENT LIMITER AND TO GUARANTEE THE NECESSARY ELECTRICAL RESISTANCE TO LIMIT THE FAULT CURRENT TO THE SPECIFIED VALUE.A DEEP DISCUSSION OF THE ABOVE MENTIONED POINTS THROUGH SIMULATION RESULTS USING MATLAB/SIMULINK/ SIMPOWERSYSTEMS WILL BE PRESENTED.

THE AUTHORS WOULD LIKE TO THANK VERY MUCH CPFL ENERGIA AND CAPES FOR THE FINANCIAL SUPPORT.

1LPK-01

STUDY ON CURRENT LIMITING CHARACTERISTICS WITH FAULT TYPE AND FAULT ANGLE DURING CONNECTION BETWEEN THE WIRES FOR CURRENT LIMITER AND CABLE USING YBCO THIN FILM TYPE WIRE ***H. DU**[1], D. LEE[1], B. HAN[1], S. SONG[1], J. LEE[1], Y. KIM[1], S. HAN[2];* [1]CHONBUK NATIONAL UNIVERSITY, [2]KEPRI. — THE FIRST ADVANTAGE OF APPLYING YBCO THIN FILM TYPE WIRE TO SUPERCONDUCTING POWER EQUIPMENT IS THAT IT CAN EFFECTIVELY ADDRESSES THE NORMAL AND FAULT CURRENTS USING LESS QUANTITY OF WIRE THAN WHEN USING BI WIRE DUE TO ITS HIGH CRITICAL CURRENT DENSITY. SECOND, THE TYPE OF STABILIZATION LAYER THAT SURROUNDS THE YBCO SUPERCONDUCTOR IS SELECTABLE AND THE MAGNITUDE OF THE RESISTANCE THAT IS PRODUCED FROM QUENCHING CAN BE ADJUSTED. IN THIS STUDY, THE WIRES FOR CURRENT LIMITER AND CABLE WERE SELECTED VIA THE OVER-CURRENT TRANSPORT TEST CONSIDERING THE CHARACTERISTICS OF THE YBCO THIN FILM TYPE WIRE, AND THE CURRENT LIMITING CHARACTERISTICS OF THE WIRES FOR CURRENT LIMITER AND CABLE ACCORDING TO THE FAULT TYPE AND FAULT ANGLE WERE EXAMINED. THE TESTS WERE CONDUCTED WITH THREE PHASES, AND THE FAULT TYPE AND FAULT ANGLE WERE EXAMINED FOR SINGLE LINE GROUND FAULT, TWO-LINE GROUND FAULT AND THREE-LINE GROUND FAULT AT 0 °. THE YBCO THIN FILM TYPE WIRE FOR CURRENT LIMITER WITH A CRITICAL CURRENT OF 80 A_{RMS}, CRITICAL TEMPERATURE OF 90 K AND VOLTAGE LEVEL OF 1.2 V_{RMS}/CM HAD NO STABILIZATION LAYER, AND THE YBCO THIN FILM TYPE WIRE FOR CABLE WITH A CRITICAL CURRENT OF 80 A_{RMS}, CRITICAL TEMPERATURE OF 90 K AND VOLTAGE LEVEL OF 1.5 V_{RMS}/CM HAD COPPER STABILIZATION LAYER. THE REQUIRED LENGTHS WERE DETERMINED CONSIDERING THE VOLTAGE LEVELS OF WIRES, AND THE WIRES WERE WOUND ON A STRAIGHT FORMER AND A SPIRAL FORMER.

1LPK-02

DESIGN AND TEST RESULTS OF A 0.9 MVA RESISTIVE TYPE HTS FAULT CURRENT LIMITER *V. E. KEILIN, **V. V. LOBYNTSEV**, M. S. NOVIKOV, S. J. NOVIKOV, V. I. SHCHERBAKOV;* KURCHATOV INSTITUTE. — A SMALL RESISTIVE TYPE SINGLE PHASE AC FAULT CURRENT LIMITER (FCL) WAS BUILD AND SUCCESSFULLY TESTED. ITS RATED VOLTAGE IS 3,5 KV, CURRENT 250 ARMS. IN THE FCL TYPE SF12100 HTS TAPE PRODUCED BY SUPEPOWER (USA) WERE USED. THE FCL CONSISTS OF 8 BIFILAR COILS WOUNDED ONTO GLASS-FIBER TUBES AND CONNECTED IN SERIES. THE TAPES WERE ADDITIONALLY STABILIZED WITH CU LAMINATED HIGHLY RESISTIVE FOIL. DURING THE TESTS AT VOLTAGES UP TO 3,5 KV AN EXCELLENT LIMITING PERFORMANCE WAS OBSERVED. THE FCL WAS SWITCHED OFF AFTER 60 MS, THE MAXIMUM TEMPERATURE AT THE HTS TAPE WAS LESS THEN 200 K.

THE WORK WAS SUPPORTED BY STATE ATOMIC ENERGY CORPORATION “ROSATOM” AND “RUSSIAN SUPERCONDUCTOR” COMPANY

1LPK-03

TEST OF A MODULAR FAULT CURRENT LIMITER FOR 220V LINE USING YBCO COATED CONDUCTOR TAPES WITH SHUNT PROTECTION ***C. A. BALDAN***[1]*, J. S. LAMAS*[2]*, C. Y. SHUGUE*[3]*, E. RUPPERT*[4]*;* [1]EEL/USP AND DEE/UNESP - BRAZIL, [2]GHENT UNIVERSITY - BELGIUM, [3]EEL/USP - BRAZIL, [4]FEEC/UNICAMP-BRAZIL. — A MODULAR FAULT CURRENT LIMITER (FCL) CONSISTING OF 16 ELEMENTS WERE CONSTRUCTED AND TESTED IN A 220V LINE FOR A FAULT CURRENT BETWEEN 1 KA TO 7.4 KA (RMS). THE ELEMENTS ARE MADE UP OF SECOND GENERATION (2G) YBCO COATED CONDUCTOR TAPES WITH STAINLESS STEEL REINFORCEMENT. FOR EACH ELEMENT FOUR TAPES WERE ELECTRICALLY CONNECTED IN PARALLEL WITH EFFECTIVE LENGTH OF 0.4 M PER ELEMENT, TOTALING 16 ELEMENTS CONNECTED IN SERIES. THE EVALUATION OF FCL PERFORMANCE WAS CARRIED OUT BY DC AND AC TESTS. THE DC TEST WAS PERFORMED THROUGH PULSED CURRENT TESTS AND ITS RECOVERY CHARACTERISTICS UNDER LOAD CURRENT WERE ANALYZED BY OPTIMIZING THE VALUE OF THE SHUNT RESISTOR. THE AC TEST USING A 3 MVA/220 V/60 HZ TRANSFORMER SHOWED THE CURRENT LIMITING RATIO ACHIEVED A FACTOR HIGHER THAN 10 DURING FAULT OF UP TO FIVE CYCLES WITHOUT DEGRADATION. THE MEASUREMENT OF THE VOLTAGE FOR EACH ELEMENT DURING THE AC TEST SHOWED THAT IN THIS MODULAR FCL THE QUENCH IS HOMOGENEOUS AND THE TRANSITION OCCURS SIMILARLY IN ALL OF ELEMENTS. THE CONSTRUCTION DETAILS AND FURTHER TEST RESULTS WILL BE SHOWN IN THE PAPER.

THIS RESEARCH WAS SUPPORTED BY CPFL PAULISTA - CAMPINAS- SP- BRAZIL

1LPK-05

OPERATING CHARACTERISTICS OF OVAL-SHAPED RESISTIVE SUPERCONDUCTING FAULT CURRENT LIMITER ***H. JO***[1]*, K. CHANG*[1]*, Y. KIM*[1]*, H. KIM*[1]*, S. CHU*[1]*, H. KIM*[2]*, Y. YOON*[3]*, J. SONG*[4]*, H. LEE*[4]*, T. KO*[1]*;* [1]YONSEI UNIVERSITY, [2]THE KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE, [3]ASAN COLLEGE OF TECHNLOLGY, [4]KOREA UNIVERSITY. — IN ORDER TO LIMIT FAULT CURRENT WHICH GOES BEYOND CAPABILITY OF CIRCUIT BREAKERS IN POWER GRID, MANY RESEARCH GROUPS HAVE DEVELOPED RESISTIVE SUPERCONDUCTING FAULT CURRENT LIMITERS (SFCLS) WITH BIFILAR SOLENOID AND BIFILAR PANCAKE TYPES. COMPARING WITH A BIFILAR SOLENOID TYPE, A BIFILAR PANCAKE TYPE HAS THE ADVANTAGE OF ITS VOLUME, BUT IT HAS PROBLEMS SUCH AS RECOVERY AND INSULATION OF SFCLS. THEREFORE IT IS IMPORTANT FOR THE SFCLS TO IMPROVE DRAWBACK OF THESE TWO TYPES. IN THIS PAPER, A NEW TYPE OF COIL WHICH IS OVAL-SHAPED SFCL WAS PROPOSED. THIS SFCL CONSISTS OF INNER AND OUTER LAYERS WHICH ARE CONNECTED IN PARALLEL. TO VERIFY THE PROPRIETY AND THE EFFECTIVENESS AS A SFCL, THERMAL AND MAGNETIC FIELD ANALYSIS USING FINITE ELEMENT METHOD (FEM) WERE CARRIED OUT. A SMALL-SCALE SAMPLE COIL WAS FABRICATED AND EXPERIMENTS FOR BOTH SHORT CIRCUIT AND RECOVERY CHARACTERISTICS ARE PERFORMED IN LIQUID NITROGEN. EXPERIMENTAL RESULTS WERE COMPARED WITH TWO TYPES OF COILS; BIFILAR SOLENOID AND BIFILAR PANCAKE COIL.

THIS STUDY WAS SUPPORTED BY THE KOREA SCIENCE AND ENGINEERING FOUNDATION (KOSEF) GRANT FUNDED BY THE KOREA GOVERNMENT (MEST 2009 - 0085369)

1LPK-06

NOVEL DESIGN OF THE STRUCTURE OF A NON-INDUCTIVE SUPERCONDUCTING COIL ***M. AHN***[1]*, H. LEE*[2]*, T. KO*[3]*;* [1]KUNSAN NATIONAL UNIVERSITY, [2]KOREA UNIVERSITY, [3]YONSEI UNIVERSITY. — A NON-INDUCTIVE COIL IS AN ESSENTIAL OF A RESISTIVE SUPERCONDUCTING FAULT CURRENT LIMITER (FCL). BIFILAR PANCAKE TYPE NON-INDUCTIVE COIL, WHICH IS MOST COMMON TYPE, HAS TWO DRAWBACKS; DIFFICULTY OF PARALLELING TAPES AND HIGH RISK OF ELECTRICAL BREAKDOWN AT THE TERMINAL PARTS. ALTHOUGH THE BIFILAR TYPE IS SIMPLE AS AN ELEMENT, LARGE-SCALE FCL NEEDS QUITE A NUMBER OF SERIAL AND PARALLEL CONNECTIONS BETWEEN ELEMENTS. TO MAKE A NON-INDUCTIVE COIL USING CONVENTIONAL INDUCTIVE ELEMENTARY COILS, WE PROPOSE A NOVEL STRUCTURE OF THE COIL. IT LOOKS LIKE A TOROID BUT ENTIRE INDUCTANCE IS NEAR ZERO. THIS COIL CAN OVERCOME THE DRAWBACKS OF CONVENTIONAL BIFILAR COIL. IN THIS PAPER, WE CONFIRM THE NEW CONCEPT BY NUMERICAL ANALYSES. SMALL-SCALE MODEL COIL BASED ON THE CONCEPT WAS MANUFACTURED AND COMPARED WITH THE ANALYSIS. THIS NEW STRUCTURE COIL CAN HELP IMPLEMENT THE HYBRID FCL WHICH IS TO GENERATE THE MAGNETIC FIELD AT ONLY FAULT.

THIS STUDY WAS SUPPORTED BY THE KOREA SCIENCE AND ENGINEERING FOUNDATION (KOSEF) GRANT FUNDED BY THE KOREA GOVERNMENT (MEST 2009-0085369).

1LPK-07

STUDY ON INITIAL OPERATING PROPERTIES OF RESISTIVE TYPE SFCLS USING YBCO THIN-FILM WIRE WITH ELECTRICAL COUPLING CONDITION ***H. DU***[1]*, D. LEE*[1]*, Y. KIM*[1]*, B. HAN*[1]*, S. SONG*[1]*, J. LEE*[1]*, S. HAN*[2]*;* [1]CHONBUK NATIONAL UNIVERSITY, [2]KEPRI. — EXCELLENT SUPERCONDUCTING CURRENT-LIMITING ELEMENTS MUST BE MANUFACTURED TO IMPROVE THE SFCL PERFORMANCE. THE FACTORS THAT ARE USED TO EVALUATE THE SFCL ELEMENTS ARE V_{MAX}*(VOLTAGE PEAK)*, T_R*(RESPONSE TIME)*, I_{MAX}*(MAXIMUM LIMITED CURRENT)*, AND I_Q*(QUENCH CURRENT OF THE SFCL ELEMENT)*, WHICH ARE MEASURED AFTER THE QUENCHING IN THE SUPERCONDUCTING CURRENT-LIMITING ELEMENTS. IT CAN BE EXPECTED THAT THE PERFORMANCE OF V_{MAX}, T_R, I_{MAX}, AND I_Q WILL IMPROVE IF THE ELECTRICAL CHARACTERISTIC WILL BE COMBINED WITH THE SFCL ELEMENT. THEREFORE, IN THIS STUDY, THE YBCO THIN-FILM WIRE WITH A STAINLESS STABILIZER LAYER AS A SUPERCONDUCTING ELEMENT WAS COMBINED WITH AN SFCL WHEREIN A CORE AND COILS WERE USED, WHOSE PERFORMANCE HAD BEEN VERIFIED BY THE PREVIOUS STUDY RESULTS, AND V_{MAX}, T_R, I_{MAX}, AND I_Q WERE MEASURED. THE MEASUREMENT RESULTS WERE COMPARED WITH THOSE OF

THE RESISTIVE SFCL, WHEREIN THE YBCO THIN-FILM WIRE WAS USED AS A SUPERCONDUCTING ELEMENT, AND THEY CAN BE SEEN AS DATA THAT VERIFY THE PERFORMANCE IMPROVEMENT OF THE SFCL. THE YBCO THIN-FILM WIRE, WHICH WAS USED AS AN SFCL ELEMENT, HAD A CRITICAL CURRENT OF 70 A_{RMS} AND A CRITICAL TEMPERATURE OF 90 K.

1LPL-02

EXPERIMENTAL INVESTIGATION OF AN ACTIVE SUPERCONDUCTING SURRENT SONTROLLER ***J. WANG****, L. ZHOU, J. SHI;* HUAZHONG UNIVERSITY OF SCIENCE & TECHNOLOGY. — A LABORATORY PROTOTYPE OF 800V/30A ACTIVE SUPERCONDUCTING CURRENT CONTROLLER (SCC) IS DEVELOPED. THE SCC IS COMPOSED OF AN AIR-CORE SUPERCONDUCTING TRANSFORMER AND A COMPENSATION VOLTAGE SOURCE. BASED ON THE PRINCIPLE OF SERIES VOLTAGE COMPENSATION, THE SCC CAN LIMIT THE FAULT CURRENTS EFFECTIVELY DURING FAULT CONDITIONS. BESIDES, IT CAN ACTIVELY CONTROL THE POWER FLOW OF THE TRANSMISSION LINES WITHIN A CERTAIN EXTENT. DUE TO THE CHARACTERISTIC OF HIGHER ENERGY DENSITY AND HIGH POWER DENSITY, THE SUPERCAPACITOR MODULE IS ADOPTED TO COMPENSATE THE DYNAMIC POWER DURING CONTROLLING THE SYSTEM CURRENT. TO EVALUATE THE DYNAMIC CHARACTERISTIC OF THE SCC, A SERIES OF EXPERIMENTS ARE CARRIED OUT IN THE LABORATORY. THIS PAPER PRESENTS PARTS OF THE IMPORTANT TEST RESULTS, INCLUDING THE CAPABILITY OF VOLTAGE REGULATION OF THE COMPENSATION VOLTAGE SOURCE, CHARGING AND DISCHARGING TEST OF THE SUPERCAPACITOR MODULE, AND THE CHARACTERISTIC OF SYSTEM CURRENT CONTROL IN A SIMULATED POWER SYSTEM.

THIS WORK WAS SUPPORTED BY NATIONAL BASIC RESEARCH PROGRAM OF CHINA-973 PROGRAM UNDER GRANT 2010CB227206, NATIONAL BASIC RESEARCH PROGRAM OF CHINA-973 PROGRAM UNDER GRANT 2009CB219702.

1LPL-03

FAULT CURRENT LIMITATION BY A TRANSFORMER TYPE FCL BASED ON THE SECOND GENERATION HTS WIRES ***L. S. FLEISHMAN****[1], E. P. VOLKOV[1], V. A. MALGINOV[2], A. V. MALGINOV[2], A. Y. KUNTSEVICH[2], A. S. SHEYNSHTEYN[3];* [1]KRZHIZHANOVSKY POWER ENGINEERING INSTITUTE, [2]P.N. LEBEDEV PHYSICAL INSTITUTE, [3]EL CAMINO COLLEGE. — A TRANSFORMER TYPE FAULT CURRENT LIMITER (FCL) COMPRISES AN IN SERIES TRANSFORMER AND A NONLINEAR RESISTOR CONNECTED ACROSS ITS SECONDARY TERMINALS. A SMALL-SCALE PROTOTYPE FCL FOR AC POWER GRIDS WAS DESIGNED AND MANUFACTURED USING A NONLINEAR RESISTOR MADE OF THE SECOND GENERATION HTS WIRE (YBCO COATED CONDUCTOR). APPLICATION OF THE SECOND GENERATION HTS WIRE INSTEAD OF THE FIRST ONE WAS FOUND TO REDUCE BY AN ORDER THE REQUIRED AMOUNT OF SUPERCONDUCTING MATERIALS. AN EXPERIMENTAL STUDY WAS MADE OF FAULT CURRENT LIMITATION AND TRANSIENTS IN AN ELECTRIC CIRCUIT WITH THE FCL. THE FCL DEMONSTRATES HIGH PERFORMANCE CHARACTERISTICS IN LIMITATION OF THE PEAK AND STEADY STATE FAULT CURRENT. THE RESPONSE TIME IS LESS THAN 2 MS AND THE RECOVERY-UNDER-LOAD TIME IS LESS THAN 0.5 S. THE PROTOTYPE FCL WITHSTANDS FAULT OF ANY DURATION AND IS NOT DAMAGED WHEN THE FAULT CLEARANCE DOES NOT TAKE PLACE. THE PHYSICAL BASIS OF THE FCL OPERATION USING THE SECOND GENERATION HTS WIRES WAS INVESTIGATED. A STUDY WAS MADE OF MECHANICAL, THERMAL AND ELECTROMAGNETIC PROCESSES DURING THE DESTRUCTION OF SUPERCONDUCTING STATE IN THE SECOND GENERATION HTS WIRES. THE NORMAL PHASE PROPAGATION VELOCITY AND ITS DEPENDENCE ON THE APPLIED VOLTAGE WERE MEASURED. BOTH THE EXPERIMENTAL DATA AND COMPUTER SIMULATIONS OF THE FCL OPERATION ARE PRESENTED.

THIS WORK IS SUPPORTED BY THE RFBR, PROJECT NO. 10-08-00678.

1LPL-04

RECOVERY TIME AND BOILING HEAT CHARACTERISTICS OF SUPERCONDUCTING TAPES SUITABLE FOR SFCL APPLICATIONS *M. K. AL-MOSAWI,* ***W. BAILEY****, C. BEDUZ, Y. YANG;* ENERGY TECHNOLOGY RESEARCH GROUP, INSTITUTE OF CRYOGENICS. — AFTER A QUENCH BY HEAT PULSES OR OVER CURRENT, THE SURFACE TEMPERATURE OF A SUPERCONDUCTOR INCREASES BEYOND THE CRITICAL HEAT FLUX. THE RECOVERY TIME TO THE SUPERCONDUCTING STATE IS DETERMINED BY FILM BOILING FOLLOWED BY NUCLEATE BOILING AFTER THE WETTING OF THE SURFACE BY THE CRYOGEN. THESE TWO DISTINCT REGIMES OF HEAT TRANSFER DEPEND ON THE SURFACE AND LIQUID PROPERTIES.WE HAVE MONITORED AND SIMULATED THE RECOVERY TIME AFTER QUENCH IN A WAY SIMILAR TO THAT EXPECTED IN A FAULT CURRENT LIMITERS OR OTHER SUPERCONDUCTING DEVICES WHERE MOST OF THE SUPERCONDUCTING ELEMENTS ARE IN CONTACT WITH CRYOGEN. THE SAMPLE WAS FABRICATED USING AGAU4% BI2223 TAPES WITH A NOMINAL CRITICAL CURRENT OF 150A AT 77K AND SELF FIELD. THERECOVERY AFTER HEATING THE SUPERCONDUCTING TAPE TO ABOUT 150K WAS STUDIED IN TWO CONFIGURATIONS; IN AS SUPPLIED TAPE AND WITH LOW THERMAL CONDUCTIVITY THIN COATING APPLIED TO THE SURFACE. THE RESULTS SHOW THAT THE RECOVERY TIME CAN BE REDUCED TO ABOUT HALF WITH THE INTRODUCTION OF A THIN COATING. WITH THE COATING, THE ONSET OF THE NUCLEATE BOILING REGIME CAN BE SEEN TO START MUCH EARLIER RESULTING IN A REDUCED TOTALRECOVERY TIME TO WITHIN FEW PERCENT OF THE BATH SATURATION TEMPERATURE (THE SUPERCONDUCTOR IS BEING FULLY RECOVERED, HENCE IMPLYING A READY STATE FOR RECONNECTION OF THE FAULT CURRENT LIMITER OR DEVICE).

1LPL-05

LOSS AND TRANSITION STUDIES OF SHUNTED FREE-STABILIZED YBCO TAPE FOR SFCL APPLICATIONS ***P. SUÁREZ****, A. ALVAREZ, J. M. CEBALLOS, B. PÉREZ;* UNIV. OF EXTREMADURA. — SUPERCONDUCTING FAULT CURRENT

LIMITERS (SFCL) USE THE TRANSITION OF SUPERCONDUCTING MATERIALS AS THE MECHANISM TO INTRODUCE HIGH IMPEDANCE IN THE LINE TO BE PROTECTED WHEN THE CURRENT IN THE LINE SURPASSES THE FIXED MAXIMUM VALUE. WHEN THE NORMAL WORKING CURRENT PASSES THROUGH THE LINE, THE DEVICE EXHIBITS ALMOST ZERO IMPEDANCE. THE TRANSITION OF THE SUPERCONDUCTOR MAY BE DUE TO THE CURRENT CROSSING THE MATERIAL OR THE MAGNETIC FIELD SURROUNDING THE MATERIAL. THESE FORMS OF DESTROYING THE SUPERCONDUCTIVITY LEAD TO THE MAIN SFCL TYPES: RESISTIVE AND INDUCTIVE. IN ORDER TO EVALUATE THE POTENTIAL APPLICATION OF NON-STABILIZED YBCO TAPE FOR THE DESIGN OF SFCL (REGARDLESS OF TYPE), A STUDY OF THIS TAPE WAS MADE. FIRST, THE AC LOSS WAS DETERMINED AS A FUNCTION OF THE *RMS* VALUE OF THE TRANSPORT CURRENT. THIS PERMITS US TO KNOW WHAT COOLING POWER IS REQUIRED IN THE NORMAL STATE AND THE VALUE OF THE CRITICAL CURRENT THAT MAKES THE MATERIAL TRANSIT. SECOND, WE STUDIED THE TAPE STABILIZED BY EXTERNAL RESISTANCES, TO GET INFORMATION ABOUT THE BEHAVIOUR OF THE TAPE CARRYING CURRENT GREATER THAN THE CRITICAL CURRENT. FINALLY, THE VARIATION OF THE CRITICAL CURRENT AND AC LOSS IN THE PRESENCE OF MAGNETIC FIELDS WAS STUDIED. SOME COMMENTS ABOUT THE RELATION BETWEEN ALL THESE PARAMETERS AND THE POSSIBILITY OF DESIGNING SFCL USING THIS TAPE ARE INCLUDED AS CONCLUSIONS.

AUTHORS WISH TO ACKNOWLEDGE FINANCIAL SUPPORT FROM THE “MINISTERIO DE CIENCIA E INNOVACIÓN” OF THE GOVERNMENT OF SPAIN, BY MEANS OF THE PROJECT: ENE2007-67426.

1LPL-06

MULTIPLE CRITERIA DECISION MAKING METHODS FOR OPTIMIZATION DESIGN AND LOCATION OF FAULT CURRENT LIMITERS ***H. HEYDARI,*** *R. SHARIFI;* IRAN UNIVERSITY OF SCIENCE AND TECHNOLOGY. — IN THE PAST TWO DECADES, SEVERAL TYPES OF SUPERCONDUCTING FAULT CURRENT LIMITERS (SFCL): NORMAL AND FLUX FLOW RESISTIVE, INDUCTIVE, AND DIODE BRIDGE TYPE, HAVE BEEN PRESENTED. THE SUPERCONDUCTING STATE DEPENDS ON INTERACTION OF THE SUPERCONDUCTOR PROPERTY AND ELECTRICAL BEHAVIOR OF SYSTEM. SINCE, ANY CHANGE IN SFCL PARAMETERS AND LOCATION MAY LEAD TO CHANGE THE LIMITING PERFORMANCE; THERE IS A COMPROMISE FOR AN OPTIMAL DESIGN. THIS PAPER INVESTIGATES THE EFFECT OF CHANGING THE PARAMETERS ON THE PERFORMANCE FOR AN OPTIMAL SFCL DESIGN, USING MULTIPLE CRITERIA DECISION MAKING (MCDM) TECHNIQUES. THIS REQUIRES SIMULATION OF ELECTRICAL AND THERMAL BEHAVIOR OF RESISTIVE, INDUCTIVE AND BRIDGE TYPE SFCLS. FOLLOWING THE IDENTIFICATION OF THE MUTUAL RELATION BETWEEN THE CRITERIA, A MAIN CONCERN IS THE COMPARISON OF DECISION CRITERIA WHICH ARE GROUPED INTO TWO OPPOSITE CATEGORIES: THE BENEFIT (REWARD) AND THE COST (REGRET OR LOSS) CRITERIA.AS A CASE STUDY, THE PROPOSED MCDM APPROACHES IN DESIGN OF SFCL ARE EVALUATED BY PROVIDING A MODEL IN WHICH AN OPTIMIZED SFCL IS ASSIGNED IN AN OPTIMAL LOCATION WITHIN A STANDARD IEEE SYSTEM.

1LPM-01

OPTIMISATION OF 2G YBCO WIRES FOR RESISTIVE FAULT CURRENT LIMITER ***A. KUDYMOW***[1]*, S. ELSCHNER*[2]*, O. MAEDER*[1]*, W. GOLDACKER*[1]*;* [1]KARLSRUHE INSTITUTE OF TECHNOLOGY, INSTITUTE FOR TECHNICAL PHYSICS, [2]UNIVERSITY OF APPLIED SCIENCE, MANNHEIM. — RECENT PROGRESS INCREASING THE CRITICAL CURRENT DENSITY OF SECOND GENERATION (2G) HIGH TEMPERATURE SUPERCONDUCTOR (HTS) SEEMS ALSO TO INCREASE THE SWITCHING CAPACITY PER EFFECTIVE SURFACE AREA. AN OPTIMIZED STABILISATION CAP LAYER (AS THIN AS POSSIBLE, AS THICK AS NECESSARY) ALLOWS TO MAXIMISE THE SWITCHING CAPACITY OF TAPES AT ACCEPTABLE TEMPERATURE RISE UND TO MINIMISE THE OVERALL TAPE LENGTH.WE PRESENT THE ARCHITECTURE OF AVAILABLE 2G HTS TAPES DESIGNED FOR FCL, ADDRESS AN APPROXIMATE AND A PRECISE HTS MODEL COMPUTATION UNDER FULL FAULT AND MODERATE OVERLOAD CONDITIONS AND REPORT ON THE SET OF EXPERIMENTS ON SHORT TAPE SAMPLES FOR IDENTIFYING THE OPTIMAL STABILISED COATED CONDUCTOR ACCORDING TO THE REQUIRED SPECIFICATION OF AN FCL WITH LARGE INRUSH CURRENT (ENSYSTROB). AS A RESULT WE PRESENT A TOOL TO OPTIMISE THE AG CAP LAYER IN DEPENDENCE OF CRITICAL CURRENT DENSITY AND LIMITATION TIME.

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1LPM-02

RECOVERY CHARACTERISTIC OF COATED CONDUCTORS FOR SUPERCONDUCTING FAULT CURRENT LIMITERS ***A. BERGER,*** *M. NOE, W. GOLDACKER, A. KUDYMOW;* KARLSRUHE INISTITUTE OF TECHNOLOGY (KIT). — SUPERCONDUCTING FAULT CURRENT LIMITERS (SFCL) OFFER THE POSSIBILITY TO REDUCE THE LEVEL OF SHORT CIRCUIT CURRENTS IN ELECTRICAL POWER DISTRIBUTION NETWORKS. DURING THE CURRENT LIMITATION, THE TEMPERATURE OF THE SUPERCONDUCTOR INCREASES BECAUSE OF THE RESISTIVE LOSSES UNTIL THE SHORT CIRCUIT IS SWITCHED OFF. AFTER THE CURRENT LIMITATION, THE SUPERCONDUCTOR HAS TO COOL DOWN TO BECOME SUPERCONDUCTING AGAIN. IF RECOVERY UNDER LOAD IS REQUIRED, THE SUPERCONDUCTOR HAS TO COOL DOWN UNDER REGULAR LOAD CONDITIONS. THIS PAPER PRESENTS EXPERIMENTAL RECOVERY UNDER LOAD TESTS OF COATED CONDUCTORS FOR THE USE IN FAULT CURRENT LIMITERS OR COMBINED APPLICATIONS, LIKE FAULT CURRENT LIMITING TRANSFORMERS. THE RESULTS SHOW THE LIMITS OF THE RECOVERY TIME, DEPENDING ON THE RESIDUAL CURRENT FOR DIFFERENT COATED CONDUCTORS IN BOILING LIQUID NITROGEN.

1LPM-03

ESTIMATION OF OVER-CURRENT PERFORMANCE IN YBCO SUPERCONDUCTING THIN FILMS FOR FAULT CURRENT LIMITER ***M. YASUDA****, T. KAWAHARA, Y. YOKOMIZU, T. MATSUMURA;* NAGOYA UNIVERSITY. — IN RECENT YEARS, DEVELOPMENT OF FAULT CURRENT LIMITER(FCL) IS EXPECTED FOR ONE OF COUNTERMEASURES AGAINST INCREASE IN FAULT CURRENT DUE TO DISPERSED POWER SYSTEM. IN THIS PAPER, WE FOCUS ON RESISTANCE TYPE FCL WITH YBCO SUPERCONDUCTING THIN FILMS MADE BY MOD METHOD, AND PROPOSE A COMPUTATIONAL APPROACH TO CALCULATE RESISTANCE AND TEMPERATURE DISTRIBUTION IN THESE ELEMENTS ON OVER-CURRENT PERFORMANCE.WE APPLIED THE OVERCURRENT TO YBCO SUPERCONDUCTING THIN FILMS WITH PROTECTIVE METAL COAT(AU-AG) WHICH IS 210 MM LONG, 30 MM WIDE AND 0.15 MU M THICK. FROM THE RESULTS, RESISTANCE AND HEAT GENERATION CHARACTERISTICS OF INDIVIDUAL ELEMENTS WERE BROUGHT OUT. WITH THESE RESULTS, WE DEVELOPED APPROXIMATE CALCULATION METHOD OF OVERCURRENT CHARACTERISTICS OF FCL. IN ADDITION, IT IS POINTED OUT THAT SITUATIONS OF CURRENT SHARING IN PARALLEL AND VOLTAGE DISTRIBUTING IN SERIES CONNECTED YBCO THIN FILMS CAN BE CALCLATED BY APPLING THIS METHOD.

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1LPM-04

ANALYSIS OF ELECTRICAL AND THERMAL TRANSITION OF YBCO COATED CONDUCTOR TAPES SUBJECTED TO PULSED AND AC CURRENT TESTS ***C. Y. SHIGUE****[1], R. P. FERREIRA[1], J. S. LAMAS[1], M. MARTINI[1], C. A. BALDAN[1], E. RUPPERT-FILHO[2];* [1]EEL USP, [2]UNICAMP. — YBCO COATED CONDUCTOR TAPES ARE OF GREAT INTEREST FOR POWER ELECTRICAL DEVICES PARTICULARLY FOR RESISTIVE FAULT CURRENT LIMITERS (RFCL). BECAUSE OF THEIR FLEXIBLE TAPE ARCHITECTURE, A HIGH RESISTIVITY SUBSTRATE CAN PROVIDE PROPER ELECTRICAL RESISTANCE FOR RFCL DESIGN USING LIMITED CONDUCTOR LENGTH. HOWEVER AS THE OVERCURRENT CAPACITY FOR SHORT TIME PERIODS CAN BE HIGHER THAN 10 TIMES THE CRITICAL CURRENT, THE PREDICTION OF THE TRANSIENT DISSIPATION OF THERMAL ENERGY IS IMPORTANT FOR AVOIDING THE TAPE DEGRADATION CAUSED BY JOULE HEATING. IN ADDITION THE EVALUATION OF RECOVERY TIME IS ALSO OF INTEREST FOR RFCL OPERATION. IN THIS WORK WE HAVE STUDIED THE ELECTRICAL AND THERMAL TRANSITION OF SHORT-LENGTH YBCO TAPES WITH DIFFERENT ARCHITECTURES SUBJECTED TO PULSED AND AC OVERCURRENT TESTS. FOR THE PULSED OVERCURRENT TESTS THE TIME PERIOD AND THE ENERGY REQUIRED TO QUENCH THE SUPERCONDUCTOR ARE MEASURED. THE AC OVERCURRENT TESTS AT 60 HZ FREQUENCY MIMIC THE FAULT CURRENT CONDITION. THE TEST RESULTS ARE ANALYZED BY SIMULATING THE TRANSIENT BEHAVIOR AND COMPARING TO EXPERIMENTAL DATA FOR VALIDATING THE NUMERICAL MODEL.

FINANCIAL SUPPORT FROM COMPANHIA PAULISTA DE FORÇA E LUZ (CPFL) IS ACKNOWLEDGED.

1LPM-05

IMPACT OF SHUNT RESISTORS ON SIMULTANEOUS QUENCHES IN SERIES-CONNECTED 2G YBCO COILS OF DC REACTOR TYPE SFCL ***E. LEE****[1], T. KO[1], M. AHN[2], Y. YOON[3], J. JANG[1];* [1]YONSEI UNIVERSITY, [2]KUNSAN NATIONAL UNIVERSITY, [3]ANSAN COLLEGE OF TECHNOLOY. — A SIMULTANEOUS QUENCH HAS BEEN ONE OF CHALLENGING ISSUES IN THE DEVELOPMENT OF THE SUPERCONDUCTING FAULT CURRENT LIMITERS (SFCLS) AS LONG AS SERIES-CONNECTED SUPERCONDUCTING MATERIALS ARE NOT IDENTICAL EACH OTHER. THE EXTREMELY RAPID SUPERCONDUCTOR NORMAL TRANSITION AND INHOMOGENEOUS SUPERCONDUCTING MATERIAL CAUSE THE UNEVEN QUENCHES IN SERIES-CONNECTED 2G YBCO COILS. THIS PAPER DEALS WITH AN IMPACT OF SHUNT RESISTORS ON SIMULTANEOUS QUENCHES IN SERIES-CONNECTED 2G YBCO COILS OF DC REACTOR TYPE SFCL, AS A PRELIMINARY STEP TO DEVELOP ITS FACULTIES FOR HIGH VOLTAGE CC APPLICATIONS. FOR THIS EXPERIMENT, TWO 2G YBCO COILS MADE FROM A BATCH OF AMSC 344S HAD BEEN CONNECTED IN SERIES TO INVESTIGATE THE CHARACTERISTICS OF QUENCHES AND VOLTAGE DISTRIBUTION IN EACH COIL. AND THE OVER-CURRENT TEST IN DIRECT CURRENT WAS PERFORMED IN THE CASE OF HAVING SHUNT RESISTORS IN PARALLEL WITH EACH COIL AND NOT, RESPECTIVELY. IN ORDER TO INVESTIGATE THE IMPACT OF SHUNT RESISTOR, AN ELECTRICAL ANALYSIS BASED ON THE FINITE ELEMENT METHOD (FEM) HAD BEEN PERFORMED.

INDEX TERMS— 2G YBCO, SIMULTANEOUS QUENCH, SHUNT RESISTOR, DC REACTOR, SUPER- CONDUCTING FAULT CURRENT LIMITER.

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1LPM-07

HTS TAPES COOLED BY LIQUID NITROGEN AT CURRENT OVERLOADS ***S. FETISOV****, V. ZUBKO, V. VYSOTSKY;* RUSSIAN SCIENTIFIC R&D CABLE INSTITUTE. — KNOWLEDGE OF HTS MATERIALS AND DEVICES BEHAVIOR AT OVERLOAD CURRENTS IS IMPORTANT FOR DESIGNING OF HTS POWER DEVICES, ESPECIALLY FOR FAULT CURRENT LIMITERS. THIS BEHAVIOR IS DETERMINED IN A VERY HIGH LEVEL BY COOLING, PARTICULARLY, BY THE TRANSIENT HEAT TRANSFER FROM HTS DEVICE TO LIQUID NITROGEN. IN THIS PAPER WE CONTINUE OUR STUDY OF OVERLOAD BEHAVIOR OF DIFFERENT HTS TAPES COOLED BY LIQUID NITROGEN [1,2]. IN THESE WORKS WE OBSERVED SHARP PEAKS IN THE VOLTAGE DURING

RECTANGULAR CURRENT PULSE. IN THE PRESENT PAPER WE EXPLAIN THESE PEAKS BY ANALYSIS OF TRANSIENT REGIMES IN LIQUID NITROGEN. EVEN INHOMOGENEOUS NITROGEN CAN WITHSTAND A CERTAIN OVERHEATING BEFORE SWITCH TO NUCLEATE BOILING. THE SHARP PEAK IN THE VOLTAGE IS OCCURRING AFTER TEMPERATURE EXCEEDS CERTAIN LEVEL BEFORE NUCLEATE BOILING STARTS. BASING ON MEASUREMENTS OF THE VOLTAGE AND TEMPERATURE OF HTS TAPES DURING CURRENT OVERLOAD AND NUMERICAL ANALYSIS OF THE PROCESS WE ESTIMATED OVERHEAT TEMPERATURES OF NITROGEN IN TRANSIENT REGIMES. INFLUENCE OF COVERS OF HTS TAPES ON OVERHEAT TEMPERATURE OF NITROGEN IS DISCUSSED. EXPERIMENTAL DATA AND THEORETICAL CALCULATIONS' ARE COMPARED[1] S.S. FETISOV ET AL, IEEE TRANSACTIONS ON APPLIED SUPERCONDUCTIVITY, VOL.19, N3, 2009 PP. 2411-2414[2] V.VYSOTSKY ET AL, «INFLUENCE OF COVERS ON HTS TAPES BEHAVIOR AT OVERLOADS», PAPER 121 PRESENTED AT EUCAS-2009, DRESDEN, GERMANY, SEPTEMBER, 2009

1LPM-08

ELECTRICAL AND SUPERCONDUCTING CHARACTERISTICS IN LAP JOINTS FOR YBCO TAPES *C. A. BALDAN[1], U. R. OLIVEIRA[1], V. P. OLIVEIRA[1], M. MARTINI[1], E. RUPPERT-FILHO[2],* ***C. Y. SHIGUE[1];*** [1]EEL USP, [2]UNICAMP. — THE JOINT PROCESS BETWEEN TAPES OF COATED CONDUCTORS IS A CRITICAL ISSUE FOR THE MOST OF THE POWER APPLICATIONS OF HIGH TEMPERATURE SUPERCONDUCTORS (HTS). SEVERAL LAP JOINTS USING DIFFERENT TECHNIQUES WERE PREPARED FOR THREE DIFFERENT TYPES OF COMMERCIALLY AVAILABLE YBCO COATED CONDUCTOR TAPES, WITH AND WITHOUT STABILIZER OR REINFORCEMENT LAYERS. THE LAP JOINTS WITH EFFECTIVE LENGTH IN THE RANGE OF 3 TO 20 CM WERE PREPARED USING LOW MELTING POINT IN-SN AND SN-PB ALLOYS AS SOLDERING MATERIALS. THE SPLICE RESISTANCE, THE CRITICAL CURRENT AND THE N-INDEX OF THE JOINTS WERE CALCULATED FROM *I X V* CURVES DURING DC OVERCURRENT TEST AND FURTHER EVALUATED THROUGH AC FAULT CURRENT TEST USING A 3 MVA/220 V/60 HZ TRANSFORMER TO EVALUATE THE DEGREE OF DEGRADATION. THE RESULTS OBTAINED USING SEVERAL ARRANGEMENTS, DIFFERENT SURFACE PREPARATION PROCESS AND DIFFERENT SOLDERING MATERIALS WILL BE PRESENTED AND ANALYZED IN COMPARISON WITH OTHER JOINT PROCESS REPORTED IN THE LITERATURE.

FINANCIAL SUPPORT FROM THE COMPANHIA PAULISTA DE FORÇA E LUZ (CPFL) IS ACKNOWLEDGED

1LPN-01

OPERATIONAL LOSS CHARACTERISTIC ANALYSIS OF 10KJ CLASS TOROIDAL-TYPE SMES ***K. KIM[1]****, A. KIM[1], M. PARK[1], I. YU[1], B. EOM[2], K. SIM[2], H. KIM[2], J. BAE[2], K. SEONG[2];* [1]CHANGWON NATIONAL UNIVERSITY, [2]KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE. — SUPERCONDUCTING MAGNETIC ENERGY STORAGE (SMES) SYSTEM IS AN OUTSTANDING DEVICE FOR POWER QUALITY ENHANCEMENT DUE TO THE FAST RESPONSE TIME AND THE HIGH ENERGY STORAGE EFFICIENCY. THE SMES SYSTEM IS OPERATED BY A DC ENERGY SOURCE IN GENERAL, HOWEVER, THE EDDY CURRENT AND MAGNETIZATION LOSSES MAY OCCUR IN THE SMES SYSTEM DUE TO THE OPERATING CURRENT AND MAGNETIC FIELD VARIATION ACCORDING TO THE ENERGY CHARGING OR DISCHARGING BEHAVIORS. THE EDDY CURRENT AND MAGNETIZATION LOSSES CAUSE THE HEAT GENERATION OF THE SMES MAGNET.THERE ARE THREE DIFFERENT TYPE OF SMES ACCORDING TO THE MAGNET SHAPE; SOLENOID, PANCAKE AND TOROIDAL. THE TOROIDAL-TYPE SMES IS EXPECTED TO CAUSE LOWER AC LOSSES DUE TO SMALLER MAGNETIC FLUX VARIATION COMPARED TO OTHER TYPES OF MAGNET. TO INVESTIGATE THE OPERATIONAL LOSSE OF A TOROIDAL-TYPE SMES, THE AUTHORS DESIGNED AND MANUFACTURED 10KJ CLASS CONDUCTION COOLING TOROIDAL-TYPE SMES. WE HAVE STUDIED NOT ONLY THE CONDUCTION HEAT AND RADIATION HEAT INVASIONS UNDER NO-LOAD CONDITION BUT ALSO THE AC LOSSES INCLUDING JOULE HEAT DURING THE OPERATING CONDITIONS. THE EDDY CURRENT LOSS AND MAGNETIZATION LOSS BY CHARGING AND DISCHARGING RATE OF THE SMES WERE ANALYZED USING FINITE ELEMENT METHOD (FEM) PROGRAM. BOTH THE SOFTWARE-BASED ANALYSIS AND THE OPERATING EXPERIMENT RESULTS OF THE TOROIDAL-TYPE SMES ARE COMPARED AND DISCUSSED IN DETAIL.

THIS WORK HAS BEEN SUPPORTED BY GRANT NO. RTI04-01-03 FROM THE REGIONAL TECHNOLOGY INNOVATION PROGRAM OF THE MINISTRY OF KNOWLEDGE ECONOMY (MKE).

1LPN-02

TEST RESULTS OF 30 KVA / 10 KJ SMES FOR VOLTAGE SAG COMPENSATION *T. JANOWSKI[1],* ***S. KOZAK[2]****, J. KOZAK[2], G. WOJTASIEWICZ[2], B. KONDRATOWICZ-KUCEWICZ[2], M. MAJKA[2];* [1]LUBLIN UNIVERSITY OF TECHNOLOGY, [2]ELECTROTECHNICAL INSTITUTE IN WARSAW. — THE 30 KVA / 10 KJ SMES SYSTEM WITH 1H SUPERCONDUCTING MAGNET IS CONDUCTING COOLED BY SRDK-408 CRYOCOOLER. IN THE PAPER WE REPORT DETAILS OF THE MAGNET DESIGN, PERFORMANCE OF THE SYSTEM, THE MAGNET TEMPERATURE PROFILE DURING EXCITATION, THE VOLTAGE SAG COMPENSATION CHARACTERISTICS AND THE RESYNCHRONIZATION PROCESS AFTER MAINS SUPPLY VOLTAGE DIP. THE THERMAL STABILITY OF CONDUCTION COOLED HTS SMES MAGNET IS DISCUSSED.

THIS WORK WAS SUPPORTED BY THE POLISH MINISTRY OF SCIENCE AND HIGHER EDUCATION UNDER GRANT NR N N510 0855 331LPN-03THE ELECTROMAGNETIC ANALYSIS AND STRUCTURE DESIGN OF A 1 MJ MAGNET FOR SMES *J. ZHANG, S. DAI;* INSTITUTE OF ELECTRICAL ENGINEERING, CHINESE ACADEMY OF SCIENCES. — THE ELECTROMAGNETIC ANALYSIS AND STRUCTURE DESIGN OF A 1 MJ MAGNET FOR SMESJINGYE ZHANG, SHAOTAO DAI, LIYE XIAO, ZIKAI WANG, DONG ZHANG, NAIHAO SONG,ZHIYUAN GAO, FENGYUAN ZHANG, GUOMIN ZHANG AND LIANGZHEN LIN*KEY LABORATORY OF APPLIED SUPERCONDUCTIVITY, CHINESE ACADEMY OF SCIENCES,INSTITUTE OF ELECTRICAL ENGINEERING, CHINESE ACADEMY OF SCIENCES, BEIJING 100190ABSTRACT_*A 1 MJ HTS MAGNET WAS DESIGNED AND FABRICATED FOR THE 1 MJ/0.5

MVA SMES. IT CONSISTED OF 44 PANCAKES WITH THE INDUCTANCE OF 6.38 H, AND THE RATED OPERATION CURRENT IS 560 A. IN THIS PAPER, THE ELECTROMAGNETIC ANALYSIS AND THE STRUCTURE DESIGN OF THE MAGNET WERE PRESENTED. BECAUSE OF THE STRONG ANISOTROPY OF BI2223/AG TAPE, THE FIELD DISTRIBUTIONS CAN SERIOUSLY AFFECT THE PERFORMANCES OF THE MAGNET. CONSEQUENTLY, THE MAGNETIC FIELD DISTRIBUTIONS OF THE 1 MJ MAGNET WERE ANALYZED BY MEANS OF FEM. IN THE SAME WAY, THE CRITICAL CURRENTS DISTRIBUTIONS OF EACH TURNS OF THE MAGNET WERE CALCULATED. BASED ON THE ANALYSIS AND CALCULATIONS, THE STRUCTURE DESIGN OF THE MAGNET WAS FINISHED. IN ORDER TO OBTAIN A UNIFORM CURRENT DISTRIBUTION BETWEEN CO-WIND TAPES IN THE SAME DOUBLE PANCAKE AND AMONG THE PARALLEL CONNECTED DOUBLE PANCAKES, SPECIAL METHODS HAVE BEEN USED IN THE DESIGN OF THE MAGNET.*INDEX TERMS*_ BI2223/AG TAPE, DOUBLE-PANCAKE, ELECTROMAGNETIC ANALYSIS, HTS MAGNET, SMES.

1LPN-04

UNIT COIL DEVELOPMENT FOR Y-SMES ***K. SHIKIMACHI****, T. TAMADA, M. NARUSE, N. HIRANO, S. NAGAYA;* CHUBU ELECTRIC POWER CO., INC.. — A SUPERCONDUCTING MAGNETIC ENERGY STORAGE (SMES) SYSTEM HAS BEEN DEVELOPED FOR ELECTRIC POWER SYSTEM CONTROL. WE HAVE BEEN DEVELOPING THE SMES COIL USING YTTRIUM-BASED COATED CONDUCTOR OF HIGH PERFORMANCE IN I_C AND MECHANICAL PROPERTIES, IN ORDER TO FULFILL THE REQUIREMENTS FOR LARGE CAPACITY AND COST REDUCTION OF THE SMES.THE TARGET STORED ENERGY OF THE COIL REQUIRED FOR THE SMES SYSTEM OF 100 MVA OUTPUT POWER IS 2 GJ CLASS, AND THE SYSTEM WAS COORDINATED IN THE LAST STUDY. THE CONCEPTUAL DESIGNED COIL OF TOROID TYPE CONSISTS OF ONE HUNDRED EIGHTY UNIT COILS OF □ 2.8 M AND EACH UNIT COIL IS CONNECTED TO EACH CONVERTER OF A MULTI-CELL TYPE. DUE TO THIS DESIGN CONCEPT, THE MAIN SPECIFICATIONS OF 2 KA CURRENT, 2 KV VOLTAGE, 600 MPA HOOP STRESS TOLERANCE AND 3 W/M^2 HEAT FLUX AROUND 20 K CAN REALIZE THE UNIT COILS OF THE SMES SYSTEM.THE VERIFICATION MODEL UNIT COIL OF □ 0.7 M CLASS WAS DESIGNED AND MANUFACTURED USING FOUR COATED CONDUCTOR TAPES. CURRENT STATUS OF THE MAJOR CHALLENGES SUCH AS CURRENT CAPACITY AND MECHANICAL STRENGTH ENHANCEMENTS IN THE UNIT COIL DEVELOPMENT ARE REPORTED.

THIS WORK WAS SUPPORTED BY THE NEW ENERGY AND INDUSTRIAL TECHNOLOGY DEVELOPMENT ORGANIZATION (NEDO) AS THE TECHNOLOGICAL DEVELOPMENT OF YTTRIUM-BASED SUPERCONDUCTING POWER EQUIPMENT.

1LPN-05

ANALYSIS OF EDDY CURRENT LOSSES AND MAGNETIZATION LOSSES IN TOROIDAL MAGNETS FOR A 2.5 MJ HTS SMES ***S. LEE****[1], S. H. PARK[1], J. K. LEE[2], W. S. KIM[3], S. J. LEE[4], J. H. BAE[5], K. C. SEONG[5], S. H. KIM[5], C. PARK[6], K. CHOI[1], S. HAHN[7];* [1]KOREA POLYTECHNIC UNIVERSITY, [2]WOOSUK UNIVERSITY, [3]KOREA ELECTRIC POWER RESEARCH INSTITUTE, [4]UIDUK UNIVERSITY, [5]KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE, [6]SEOUL NATIONAL UNIVERSITY, [7]ELECTRICAL ENGINEERING AND SCIENCE RESEARCH INSTITUTE. — A SMES MAGNET MAY BE IN THREE DIFFERENT MODES - CHARGING, STORING, AND DISCHARGING. THE EDDY CURRENT LOSSES AND MAGNETIZATION LOSSES ARE GENERATED DURING CHARGING AND DISCHARGING IN SMES SYSTEM. EDDY CURRENT LOSS PER CYCLE IS GENERATED LARGELY DURING DISCHARGING PERIOD BECAUSE THE DISCHARGING PERIOD IS GENERALLY SHORTER THAN THE CHARGING PERIOD. MAGNETIZATION LOSS PER CYCLE IS GENERATED LARGELY DURING CHARGING PERIOD THAN THE OTHER PERIOD. IN THIS PAPER, WE INVESTIGATED DECREASING EFFECTS OF EDDY CURRENT LOSSES ACCORDING TO A SHAPES OF CONDUCTION COOLING PLATES. THE COOLING PLATE HAVING LESS EDDY CURRENT LOSSES IS DESIGNED BY DIVIDING AND SLITTING. ALSO, THE MAGNETIZATION LOSSES IN THE TOROIDAL COIL CONSTRUCTED WITH MANY PANCAKE COILS ARE ANALYZED BY USING 3D FINITE ELEMENT METHOD DURING THE INITIAL CHARGING PERIOD AND SOME DISCHARGING PERIODS IN A OPERATING SCENARIO FOR THE 2.5 MJ SMES.

THIS WORK WAS SUPPORTED BY ELECTRIC POWER INDUSTRY TECHNOLOGY EVALUATION AND PLANNING.

1LPN-06

SIMULTANEOUS OPTIMIZATION OF SMES COIL SIZE AND CONTROL PARAMETERS FOR ROBUST POWER SYSTEM STABILIZATION ***I. NGAMROO****;* KING MONGKUT'S INSTITUTE OF TECHNOLOGY LADKRABANG. — AS THE COIL SIZE IS THE HEART OF SUPERCONDUCTING MAGNETIC ENERGY STORAGE (SMES), THE SIMULTANEOUS OPTIMIZATION OF COIL SIZE AND CONTROL PARAMETERS OF SMES FOR ROBUST POWER SYSTEM STABILIZATION IS PROPOSED. THE STRUCTURE OF ACTIVE AND REACTIVE POWER CONTROLLERS OF SMES IS THE PRACTICAL FIRST-ORDER LEAD/LAG COMPENSATOR. TO HANDLE SYSTEM UNCERTAINTIES SUCH AS VARIOUS GENERATING AND LOADING CONDITIONS, SYSTEM NONLINEARITIES ETC., THE MULTIPLICATIVE UNCERTAINTY MODEL IS EMBEDDED IN THE SYSTEM MODELING. AS A RESULT, THE OPTIMIZATION PROBLEM OF COIL SIZE AND CONTROLLER PARAMETERS BASED ON THE ENHANCEMENT OF SYSTEM DAMPING AND ROBUST STABILITY MARGIN AGAINST SYSTEM UNCERTAINTIES CAN BE FORMULATED. SOLVING THE PROBLEM BY A METAHEURISTIC METHOD, THE OPTIMAL COIL SIZE AND CONTROLLER PARAMETERS ARE OBTAINED SIMULTANEOUSLY. SIMULATION STUDY IN THE WEST JAPAN SIX-AREA INTERCONNECTED POWER SYSTEM WITH TWO SMES UNITS CONFIRMS THE SUPERIOR ROBUSTNESS AND DAMPING PERFORMANCE OF THE PROPOSED SMES CONTROLLER UNDER VARIOUS SITUATIONS IN COMPARISON TO THE CONVENTIONAL SMES CONTROLLER.

THIS WORK WAS SUPPORTED BY THE KING MONGKUT'S INSTITUE OF TECHNOLOGY LADKRABANG RESEARCH FUND.

1LPN-07

ANALYSIS OF STRESS DISTRIBUTION IN HELICAL COILS WITH GEODESIC WINDINGS BASED ON VIRIAL THEOREM ***H. TSUTSUI****, S. NOMURA, S. TSUJI-IIO, R. SHIMADA;* TOKYO INSTITUTE OF TECHNOLOGY. — DISTRIBUTIONS OF STRESS IN HELICAL COILS WITH THE GEODESIC WINDING BASED ON VIRIAL THEOREM ARE ANALYZED THEORETICALLY AND NUMERICALLY. A FORCE-BALANCED COIL (FBC) IS A MULTI-POLE HELICAL HYBRID COIL COMBINING TOROIDAL FIELD (TF) COILS AND A SOLENOID HELICALLY WOUND ON A TORUS. THE COMBINATION REDUCES THE NET ELECTROMAGNETIC FORCE IN THE DIRECTION OF MAJOR RADIUS BY CANCELING THE CENTERING FORCE DUE TO THE TF COIL CURRENT AND THE HOOP FORCE DUE TO THE SOLENOID CURRENT. THE FBC CONCEPT WAS EXTENDED USING THE VIRIAL THEOREM WHICH SHOWS THAT STRENGTH OF MAGNETIC FIELD IS RESTRICTED BY WORKING STRESS IN THE COILS AND THEIR SUPPORTING STRUCTURE. HIGH-FIELD COILS SHOULD ACCORDINGLY HAVE SAME AVERAGED PRINCIPAL STRESSES IN ALL DIRECTIONS WHICH IS NAMED THE VIRIAL-LIMIT CONDITION. RECENTLY, WE MADE A MODEL FBC WHICH WERE NEITHER IMPREGNATED WITH EPOXY RESIN NOR REINFORCED WITH STAINLESS STEEL WIRES. USING ACOUSTIC EMISSION MEASUREMENTS, WE FOUND THAT THE WIRES VIBRATED IN RESPONSE TO ELECTROMAGNETIC FORCE CHANGES. SINCE FBC WINDING IS MODULATED TO REDUCE THE TILTING FORCE, THE WINDING IS FAR FROM THE SHORTEST GEODESIC TRAJECTORY AND HAS NO TENSILE LOAD. IN ORDER TO REDUCE THE VIBRATION, THE GEODESIC WINDING IS EXPECTED TO BE EFFECTIVE. IN THIS WORK, WE ANALYZE THE EFFECT OF THE WINDING MODULATIONS INCLUDING THE GEODESIC MODULATION FOR THE STRESS DISTRIBUTION OF HELICAL WINDINGS.

1LPN-08

A DUAL MODE CONTROL STRATEGY OF SMES FOR MULTIFUNCTIONAL APPLICATION ***W. GUO****, L. XIAO, S. DAI, Z. ZHANG, L. LIN;* INSTITUTE OF ELECTRICAL ENGINEERING, CHINESE ACADEMY OF SCIENCES. — **A DUAL MODE CONTROL STRATEGY OF SMES FOR MULTIFUNCTIONAL APPLICATION**WENYONG GUO, LIYE XIAO, SHAOTAO DAI, ZHIFENG ZHANG, LIANGZHEN LIN*1. APPLIED SUPERCONDUCTIVITY KEY LAB, CHINESE ACADEMY OF SCIENCES, BEIJING, 100190, CHINA2. INSTITUTE OF ELECTRICAL ENGINEERING, CHINESE ACADEMY OF SCIENCES , BEIJING, 100190, CHINA*THE SUPERCONDUCTING MAGNETIC ENERGY STORAGE SYSTEM (SMES) HAS GOOD CHARACTERISTICS SUCH AS HIGH EFFICIENCY, QUICK RESPONSE, NO DETERIORATIONS AND SO ON. HOWEVER IT IS STILL FAR FROM WIDE APPLICATION. THE MAIN OBSTACLE IS DUE TO ITS HIGH COST. ONE OF THE MOST EFFECTIVE WAY TO REDUCE THE COST OF SMES IS TO MAKE IT MULTIFUNCTIONAL. IN THIS PAPER, A DUAL MODE CONTROL STRATEGY IS PROPOSED. WITH THE PROPOSED CONTROL STRATEGY, SMES CAN COMPENSATE VOLTAGE DIP, CURRENT HARMONICS, REACTIVE POWER, AND ACTIVE POWER FLUCTUATION WITH A SIMPLE TOPOLOGY. THE EFFICACY OF THE PROPOSED CONTROL STRATEGY IS VERIFIED BY SIMULATION RESULTS.

1LX-01

(INVITED) **FIRST FULL-SYSTEM TEST OF THE ATLAS DETECTOR MAGNET SYSTEM** ***H. H. J. TEN KATE****[1], A. DUDAREV[1], N. DELRUELLE[1], K. BARTH[1], R. PENGO[2], R. RUBER[1], J. BUSKOP[3], E. BAYNHAM[4], C. BERRIAUD[5], P. VEDRINE[5], G. VOLPINI[6], F. BROGGI[6], A. YAMAMOTO[7];* [1]CERN, [2]CERN/INFN, [3]NIKHEF, [4]CCLRC, [5]CEA-SACLAY, [6]INFN-LASA, [7]KEK. — THE TOROIDS AND SOLENOID OF THE ATLAS DETECTOR AT THE LHC PROVIDE THE MAGNETIC FIELD FOR THE MUON- AND INNER DETECTOR TRACKERS, RESPECTIVELY. THE SYSTEM WITH AN ENVELOPE OF 25 M LENGTH AND 20 M DIAMETER COMPRISES A BARREL TOROID, TWO END CAP TOROIDS AND THE CENTRAL SOLENOID. THE COILS ARE WOUND WITH AN ALUMINUM STABILIZED NBTI CONDUCTOR AND OPERATE AT 20.4 KA AND 4.1 T PEAK MAGNETIC FIELD OF THE TOROIDS AND 2.6 T AT 7.7 KA IN THE SOLENOID. THE COILS ARE CONDUCTION COOLED AT 4.8 K BY FORCED FLOW HELIUM IN COOLING TUBES ATTACHED TO THE COLD MASS. THE STORED ENERGY IS 1.6 GJ. AFTER THEIR INSTALLATION IN THE ATLAS CAVERN 100 M UNDERGROUND, THE INDIVIDUAL 3 TOROIDS AND THE SOLENOID WERE SUCCESSFULLY CHARGED TO NOMINAL MAGNETIC FIELD. THE LAST AND CRUCIAL STEP WAS THE TEST OF THE ENTIRE SYSTEM WITH ALL MAGNETS SWITCHED ON BY WHICH THE MAXIMUM LORENTZ FORCES ARE EXERTED. AFTER A FEW TRAINING STEPS IN THE END CAP TOROIDS, THE SYSTEM ARRIVED SUCCESSFULLY AT NOMINAL MAGNETIC FIELD AT 20.4 KA CURRENT. THE FIRST TEST RESULTS AND OPERATING EXPERIENCE OF THIS COMPLEX AND UNIQUE MAGNET SYSTEM GAINED IN 2008 AND 2009 DURING THE FIRST-BEAM AND FIRST COLLISIONS OPERATION OF THE LHC ARE PRESENTED. THE SUCCESSFUL CHARGE TO NOMINAL MAGNETIC FIELD AND THE SAFE QUENCH AND FAST DUMP OPERATIONS DEMONSTRATE THE FEASIBILITY OF THIS HUGE AND COMPLEX MAGNET SYSTEM AND OPENS THE PATH TO EVEN LARGER SYSTEMS IN THE FUTURE.

THIS PROJECT IS FUNDED BY THE ATLAS COLLABORATION, PRESENTLY ABOUT 2200 SCIENTIFIC AUTHORS FROM 164 INSTITUTES IN 35 COUNTRIES AND SUPPORTED IN PART BY CERN.

1LX-02

DESIGN AND TEST STATUS OF THE FAST RAMPED SUPERCONDUCTING SIS100 DIPOLE MAGNET FOR FAIR ***E. FISCHER****[1], P. AKISHIN[2], A. MIERAU[1], B. SCHNIZER[3], P. SCHNIZER[1], C. SCHROEDER[1], P. SHCHERBAKOV[4], P. SPILLER[1], S. WILFERT[1];* [1]GSI HELMHOLTZZENTRUM FÜR SCHWERIONENFORSCHUNG MBH, [2]JOINT INSTITUTE FOR NUCLEAR RESEARCH, [3]TECHNISCHE UNIVERITÄT GRAZ, [4]INSITUTE FOR HIGH ENERGY PHYSICS. — THE SIS 100 WILL BE THE WORLD'S SECOND FAST RAMPED SYNCHROTRON FOR HEAVY ION RESEARCH USING SUPERCONDUCTING MAGNETS. WE SUMMARISE THE EXPERIMENTAL RESULTS OBTAINED ON TWO FULL SIZE MODEL MAGNETS AND PRESENT THE DESIGN CHOICES MADE FOR THE SIS100 DIPOLE. THE MAIN DESIGN COMPONENTS OF THE MAGNET ARE OUTLINED. SPECIAL ATTENTION IS GIVEN TO AN OPTIMAL ADJUSTMENT OF THE FOLLOWING TOPICS CRUCIAL FOR RELIABLE AND EFFECTIVE OPERATION OF THE MAGNETS: MECHANICAL STABILITY OF

THE COIL WINDINGS, MAGNETIC STEEL, FIELD DESIGN, TEMPERATURE FIELD, AC LOSSES AND THE VACUUM CHAMBER. WE CONCLUDE THAT THE PRESENT DIPOLE DESIGN IS CONSOLIDATED AND CLOSE TO SERIES PRODUCTION.

1LX-03

PERFORMANCE OF A NB3SN QUADRUPOLE UNDER HIGH STRESS ***H. FELICE***[1]*, M. BAJKO*[2]*, B. BINGHAM*[1]*, B. BORDINI*[2]*, L. BOTTURA*[2]*, S. CASPI*[1]*, D. R. DIETDERICH*[1]*, P. FERRACIN*[1]*, J. FEUVRIER*[2]*, C. GILOUX*[2]*, A. GODEKE*[1]*, R. HAFALIA*[1]*, C. R. HANNAFORD*[1]*, A. MILANESE*[2]*, J. C. PEREZ*[2]*, G. DE RIJK*[2]*, G. SABBI*[1]*;* [1]LBNL, [2]CERN. — FUTURE UPGRADES OF THE LARGE HADRON COLLIDER (LHC) WILL REQUIRE LARGE APERTURE AND HIGH GRADIENT QUADRUPOLES. NB3SN IS THE MOST VIABLE OPTION FOR THIS APPLICATION BUT IS ALSO KNOWN FOR ITS STRAIN SENSITIVITY. IN HIGH FIELD MAGNETS, WITH MAGNETIC FIELDS FROM 12 TO 16 T ON THE CONDUCTOR AND LORENTZ FORCES RISING ACCORDINGLY, THE MECHANICAL STRESSES MAY EXCEED 200 MPA IN THE WINDINGS. THE EXISTING MEASUREMENTS OF CRITICAL CURRENT VERSUS STRAIN ON NB3SN STRANDS OR CABLES ARE NOT EASILY TRANSPOSABLE TO MAGNETS. IN ORDER TO INVESTIGATE THE IMPACT OF HIGH MECHANICAL STRESSES ON THE QUENCH PERFORMANCE, A SERIES OF TESTS WAS CARRIED OUT WITHIN A LBNL/CERN COLLABORATION USING TQS03, A LHC ACCELERATOR RESEARCH PROGRAM (LARP) 1-METER LONG, 90-MM APERTURE NB3SN QUADRUPOLE. THE MAGNET WAS TESTED FOUR TIMES AT CERN WITH VARIOUS PRE-STRESS CONDITIONS. THE AVERAGE MECHANICAL STRESSES AT 4.2 K RANGED FROM 120 MPA TO 200 MPA. THIS PAPER REPORTS ON THE MAGNET PERFORMANCE DURING THE FOUR TESTS FOCUSING ON QUENCH TRAINING AND STRAIN GAUGE DATA.SUPPORTED BY THE U.S.DEPARTMENT OF ENERGY UNDER CONTRACT NO. DE-AC02-05CH11231.

1LX-04

TEST RESULTS OF HQ01A - A 120 MM 15 T NB3SN QUADRUPOLE FOR THE LHC UPGRADE* ***S. CASPI***[1]*, G. AMBROSIO*[2]*, M. ANERELLA*[3]*, E. BARZI*[2]*, B. BINGHAM*[1]*, R. BOSSERT*[2]*, D. W. CHENG*[1]*, G. CHLACHIDZE*[2]*, D. DIETDERICH*[1]*, H. FELICE*[1]*, P. FERRACIN*[1]*, A. GHOSH*[3]*, A. R. HAFALIA*[1]*, C. R. HANNAFORD*[1]*, J. JOSEPH*[1]*, V. V. KASHIKHIN*[2]*, G. L. SABBI*[1]*, J. SCHMALZLE*[3]*, P. WANDERER*[3]*, W. XIAORONG*[1]*, A. V. ZLOBIN*[2]*;* [1]LBNL, [2]FNAL, [3]BNL. — IN SUPPORT OF THE PHASE II LARGE HADRON COLLIDER (LHC) UPGRADE, THE US LHC ACCELERATOR RESEARCH PROGRAM (LARP) HAS BEEN DEVELOPING A 1-METER LONG, 120 MM BORE NB3SN IR QUADRUPOLE MAGNET (HQ). WITH A SHORT SAMPLE GRADIENT OF 219 T/M AT 1.9 K AND A CONDUCTOR PEAK FIELD OF 15 T, THE MAGNET WILL OPERATE UNDER HIGHER FORCES AND STORED-ENERGY LEVELS THAN THAT OF ANY PREVIOUS LARP MODELS. IN ADDITION, HQ HAS BEEN DESIGNED TO INCORPORATE ACCELERATOR QUALITY FEATURES SUCH AS PRECISE COIL ALIGNMENT AND ADEQUATE COOLING. THE FIRST 4 COILS (OUT OF THE 8 FABRICATED SO FAR) HAVE BEEN ASSEMBLED AND TESTED IN HQ01A. THIS PAPER PRESENTS THE COILS FABRICATION STATUS, THE MECHANICAL BEHAVIOR AS WELL AS THE QUENCH PERFORMANCE OF HQ01A.

THIS WORK WAS SUPPORTED IN PART BY THE DIRECTOR, OFFICE OF SCIENCE, HIGH ENERGY PHYSICS, U.S. DEPARTMENT OF ENERGY UNDER CONTRACT NO. DE-AC02-05CH11231 AND PARTIALLY SUPPORTED BY THE DOE THROUGH THE US LHC ACCELERATOR RESEARCH PROGRAM (LARP).

1LX-05

TEST RESULTS OF THE FIRST 3.7 M LONG NB3SN QUADRUPOLE BY LARP AND FUTURE PLANS ***G. AMBROSIO***[1]*, N. ANDREEV*[1]*, M. ANERELLA*[2]*, E. BARZI*[1]*, D. BOCIAN*[1]*, R. BOSSERT*[1]*, S. CASPI*[3]*, G. CHLACHIDIZE*[1]*, D. DIETDERICH*[3]*, H. FELICE*[3]*, P. FERRACIN*[3]*, A. GHOSH*[2]*, A. GODEKE*[3]*, R. HAFALIA*[3]*, V. V. KASHIKHIN*[1]*, M. LAMM*[1]*, P. KOVACH*[2]*, F. NOBREGA*[1]*, I. NOVITSKY*[1]*, D. ORRIS*[1]*, E. PREBYS*[1]*, G. L. SABBI*[3]*, J. SCHMALZLE*[2]*, P. WANDERER*[2]*, A. ZLOBIN*[1]*;* [1]FERMILAB, [2]BROOKHAVEN NATIONAL LABORATORY, [3]LAWRENCE BERKELEY NATIONAL LABORATORY. — IN DECEMBER 2009 DURING ITS FIRST COLD TEST, LQS01, THE FIRST LONG NB3SN QUADRUPOLE MADE BY LARP (LHC ACCELERATOR RESEARCH PROGRAM, A COLLABORATION OF BNL, FNAL, LBNL AND SLAC), REACHED ITS TARGET GRADIENT OF 200 T/M. THIS TARGET WAS SET IN 2005 BY THE US DEPARTMENT OF ENERGY, CERN AND LARP, AS A SIGNIFICANT MILESTONE TOWARD THE DEVELOPMENT OF NB3SN QUADRUPOLES FOR POSSIBLE USE IN LHC LUMINOSITY UPGRADES.LQS01 IS A 90 MM APERTURE, 3.7 M LONG QUADRUPOLE USING NB3SN COILS. THE 10-MM WIDE CABLE IS MADE OF 27 STRANDS WITH 0.7 MM DIAMETER. THE STRANDS, MANUFACTURED BY OXFORD SUPERCONDUCTING TECHNOLOGY USING THE RESTACK-ROD-PROCESS (RRP), HAVE 54 NB3SN SUBELEMENTS. THE COIL LAYOUT IS EQUAL TO THE LAYOUT USED IN THE LARP TECHNOLOGICAL QUADRUPOLES (TQC AND TQS MODELS). PRE-STRESS AND SUPPORT ARE PROVIDED BY A SEGMENTED ALUMINUM SHELL PRE-LOADED USING BLADDERS AND KEYS, SIMILARLY TO THE TQS MODELS. AFTER THE FIRST TEST THE MAGNET WAS DISASSEMBLED AND REASSEMBLED WITH AN OPTIMIZED PRE-STRESS. IN THIS PAPER WE PRESENT THE RESULTS OF BOTH TESTS AND DISCUSS THEIR SIGNIFICANCE FOR FUTURE NB3SN ACCELERATOR MAGNETS. THE NEXT STEPS OF THE LONG QUADRUPOLE R&D ARE ALSO PRESENTED.

WORK SUPPORTED BY THE U.S. DEPARTMENT OF ENERGY

1LX-06

PERFORMANCE OF NB3SN RUTHERFORD CABLES FOR THE LARP LONG-QUADRUPOLE MAGNETS* ***A. K. GHOSH***[1]*, D. R. DIETDERICH*[2]*;* [1]BROOKHAVEN NATIONAL LABORATORY, [2]LAWRENCE BERKELEY NATIONAL LABORATORY. — OVER 3 KILOMETERS OF NB3SN RUTHERFORD KEYSTONE CABLE IN UNIT LENGTHS OF 240 M HAVE BEEN FABRICATED FOR THE LARP 90 MM APERTURE LONG-QUADRUPOLE (LQ) MAGNET DEVELOPMENT. THESE CABLES USED 0.7 MM DIAMETER RRP® WIRE FROM OXFORD SUPERCONDUCTING TECHNOLOGY. THE CABLING PROCEDURE ADOPTED IS A TWO STAGE PROCESS TO CONTROL THE WIDTH, MID-THICKNESS, AND THE STRAND

DEFORMATION AT THE EDGES OF THE CABLE. THE CABLE PARAMETERS IN THE DIFFERENT RUNS ARE COMPARED TO PROVIDE AN UNDERSTANDING OF VARIATION IN THE PRODUCTION. STRANDS WERE EXTRACTED FROM THE FINISHED CABLE, REACTED ON STAINLESS STEEL BARRELS AND ITS CRITICAL CURRENT, IC, MEASURED ON TI-ALLOY BARRELS. BASED ON MEASUREMENTS OF THE ROUND WIRE AND THAT OF THE EXTRACTED STRAND, THE DEGRADATION DUE TO CABLING WAS ESTIMATED. DETAILS OF THE CABLING PARAMETERS AND RESULTS OF LOW TEMPERATURE MEASUREMENTS OF IC AND THE RESIDUAL RESISTANCE RATIO, RRR, OF THE COPPER STABILIZER ARE PRESENTED. THE IMPLICATIONS OF THESE FINDINGS ARE DISCUSSED.

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1LX-07

THE CONSTRUCTION OF THE MODEL OF THE CURVED FAST RAMPED SUPERCONDUCTING DIPOLE FOR FAIR SIS300 SYNCHROTRON ***P. FABBRICATORE***[1]*, F. ALESSANDRIA*[2]*, G. BELLOMO*[2]*, S. FARINON*[1]*, U. GAMBARDELLA*[3]*, R. MARABOTTO*[4]*, R. MUSENICH*[1]*, M. SORBI*[2]*, G. VOLPINI*[2]*;* [1]INFN SEZIONE DI GENOVA, [2]INFN SEZIONE DI MILANO LASA, [3]INFN LABORATORI DI FRASCATI, [4]ASG SUPERCONDUCTORS GENOVA. — THE FAIR FACILITY, UNDER DEVELOPMENT AT GSI, INCLUDES THE SYNCHROTRON SIS300 (300 TM RIGIDITY). IN ORDER TO REACH THE REQUIRED HIGH INTENSITIES OF PROTON AND HEAVY IONS BEAMS, THE BENDING DIPOLE MAGNETS HAVE TO BE PULSED FROM THE INJECTION MAGNETIC FIELD OF 1.5 T UP TO 4.5 T MAXIMUM FIELD AT THE RATE OF 1 T/S. THESE 7.8 M LONG MAGNETS HAVE COSΘ SHAPED COILS, 100 MM BORE WITH THE PARTICULAR CHARACTERISTIC TO BE GEOMETRICALLY CURVED (THE SAGITTA IS 114 MM). ALL THESE ASPECTS DEMANDED FOR A CHALLENGING R&D, AIMED AT THE DEVELOPMENT OF SUITABLE WINDING AND, MORE IN GENERAL, CONSTRUCTION TECHNOLOGIES FOR FAST RAMPED CURVED COILS. THE HEART OF THE R&D PROGRAM IS THE CONSTRUCTION OF A 3.9 M LONG MODEL. THE PAPER DISCUSSES THE MAIN PROBLEMS FACED DURING THE DESIGN AND THE CONSTRUCTION OF THE COLD MASS, MAINLY COVERING THE ASPECTS RELATED TO THE MANUFACTURE

1LX-08

TESTING THE SUPERCONDUCTING MAGNET AND CRYOGENICS FOR THE AMS-02 EXPERIMENT ***P. MCINTYRE****;* TEXAS A&M UNIVERSITY. — THE AMS-02 EXPERIMENT IS A MAGNETIC SPECTROMETER FOR PRECISION MEASUREMENT OF HIGH-ENERGY COSMIC RAYS, TO BE STAGED ON THE INTERNATIONAL SPACE STATION (ISS). A KEY ELEMENT OF THE SPECTROMETER IS A SUPERCONDUCTING MAGNET AND ASSOCIATED SUPERFLUID HE (SFHE) CRYOGENICS, DESIGNED TO SUSTAIN OPERATION OF THE SPECTROMETER FOR A PERIOD OF >2 YEARS.THE AMS MAGNET/CRYOGENICS INCORPORATES A SOPHISTICATED CRYOGENIC DESIGN TO SUSTAIN MULTI-YEAR OPERATION OF SUCH A LARGE SUPERCONDUCTING MAGNET IN SPACE: INDIRECT COOLING OF THE MAGNET USING SFHE, DRIVING SFHE FLOW USING THERMOMECHANICAL PUMPS DURING CHARGING AND RECOVERY, PHASE SEPARATION OF VAPOR FROM SFHE, GATHERING OF SFHE IN ZERO-G WITHIN THE STORAGE TANK, PERSISTENT OPERATION WITH GAS-ACTUATED DISCONNECT LEADS, AND EFFICIENT USE OF VAPOR ENTHALPY THROUGH A SEQUENCE OF SEGMENTED VAPOR-COOLED SHIELDS, CRYOCOOLER INTERCEPTION OF CONDUCTIVE AND RADIATIVE HEAT AT 10K.DURING 2009 THE ENTIRE EXPERIMENT WAS FULLY INTEGRATED AND TESTED IN TEST BEAM AT CERN. SUBSEQUENTLY THE EXPERIMENT WAS TESTED UNDER THERMAL VACUUM TESTS AT ESTEC, WHERE IT WAS OPERATED IN CONDITIONS SIMULATING THOSE THAT WILL PERTAIN IN ORBIT. ALL ELEMENTS OF THE SUPERCONDUCTING MAGNET AND CRYOGENICS PERFORMED AS DESIGNED, AND EQUILIBRIUM OPERATION WAS ATTAINED AT SEVERAL VALUES OF VACUUM CASE TEMPERATURE. DETAILS OF THE TESTS WILL BE PRESENTED. A THERMAL MODEL OF THE OVERALL CRYOGENIC SYSTEM WAS CALIBRATED FROM THOSE MEASUREMENTS. THE MODEL WAS USED TO PREDICT THE CRYOGENIC LIFETIME OF THE EXPERIMENT, AS IT WOULD BE STAGED ON ISS, TO BE (28±6) MONTHS. WHILE THIS PERFORMANCE IS CONSISTENT WITH THE DESIGN, A RECENT DECISION BY NASA TO PROLONG ISS OPERATION FOR AT LEAST A DECADE MOTIVATED THE COLLABORATION TO SUBSTITUTE A PERMANENT MAGNET IN ORDER TO SUSTAIN MAGNETIC FIELD FOR THAT MUCH LONGER DURATION IN SPACE. THIS DECISION NOTWITHSTANDING, THE AMS-02 SUPERCONDUCTING MAGNET AND CRYOGENICS ACHIEVED DESIGN PERFORMANCE IN ALL OPERATING MODES REQUIRED FOR SPACE OPERATION. THIS SUCCESS PROVIDES A VALUABLE BASIS FOR FUTURE APPLICATIONS OF SPACE MAGNETICS.

1LY-01

(INVITED) **NAVAL INTEGRATED CRYOGENIC ENGINEERING PLANT** ***B. FITZPATRICK****, J. KEPHART, N. SPIVEY;* NAVAL SURFACE WARFARE CENTER - CARDEROCK DIVISION. — THE DEVELOPMENT OF A NAVAL INTEGRATED CRYOGENIC ENGINEERING PLANT (NICEP), WHICH IS BASED ON SUPERCONDUCTING TECHNOLOGY, IS A LONG-TERM NAVAL SURFACE WARFARE CENTER CARDEROCK DIVISION VISION THAT REQUIRES A COMMITMENT OVER SEVERAL DECADES TO ACHIEVE THE FULL BENEFITS OF THE TECHNOLOGY. BASED ON CURRENT SHIP BUILD SCHEDULES AND TECHNOLOGY READINESS LEVELS A FULL NICEP IS NOT FEASIBLE UNTIL THE 2025 TIMEFRAME. THIS DOES NOT MEAN FLEET INSERTION OF THIS TECHNOLOGY IS 20 YEARS AWAY. FUTURE SHIP CONSTRUCTION OFFER OPPORTUNITIES FOR SINGLE SYSTEMS USES SUCH AS PROPULSION MOTORS, AUXILIARY OR MAIN GENERATORS, HTS DEGAUSSING, AND HIGH LOAD SINGLE SOURCE POWER CABLES FOR MOTORS OR RADAR SYSTEMS. THE OFFICE OF NAVAL RESEARCH AND NAVSEA CURRENTLY SUPPORT PROGRAMS WHERE SEVERAL COMPONENTS ARE CURRENTLY IN DEVELOPMENT AND ARE NEARING A TRL OF 6. THE HTS DEGAUSSING SYSTEM HAS BEEN SUCCESSFULLY TRANSITIONED TO THE FLEET BY NSWCCD AND HAS BEEN INSTALLED ON THE USS HIGGINS IN JULY 2008. THE NAVY IS CURRENTLY FUNDING 25 CRYOGENIC AND SUPERCONDUCTING DEVELOPMENT PROJECTS THROUGH BOTH SBIR'S AND CORE FUNDING. ALL OF THESE

DEVELOPMENTS HAVE BEEN PURSUED BASED ON THE PROMISE OF WEIGHT REDUCTION, COST REDUCTIONS, HIGHER ELECTRICAL EFFICIENCIES, AND IMPROVED CAPABILITIES. THIS PAPER WILL ATTEMPT TO SUMMARIZE THE ONGOING WORK AND LAY OUT A ROADMAP WITH INSERTION POINTS FOR CONTINUED DEVELOPMENT.

1LY-02

(INVITED) **THE PROGRESS OF HTS POWER TECHNOLOGY IN CHINA** ***L. XIAO****, L. LIN, S. DAI;* INSTITUTE OF ELECTRICAL ENGINEERING, CAS. — THIS PRESENTATION WILL REVIEW THE RECENT PROGRESS OF POWER APPLICATION OF SUPERCONDUCTOR IN CHINA. SINCE 2008, 35KV/2KA FAULT CURRENT LIMITER AND 100KW MOTOR HAVE BEEN DEVELOPED, AND A DC POWER CABLE WITH 380 METER IN LENGTH AND 10KA IN CAPACITY, A FCL WITH VOLTAGE UP TO 220KV AND A SUPERCONDUCTING SUBSTATION ARE BEING DEVELOPED. A 500KJ/150KVA SMES UNIT WAS DEVELOPED AND TESTED, AND 1.0 MJ/0.5MW SMES WILL BE DEMONSTRATED IN A SUBSTATION SOON. AND A 10.5KV SUPERCONDUCTING SUBSTATION WHICH INCLUDES HTS CABLE, TRANSFORMER, FCL AND SMES IS BEING BUILT.

1LY-03

EXPERIMENT RESEARCH ON THE DYNAMIC VOLTAGE SAG COMPENSATION BY USING 2G HIGH TEMPERATURE SMES *J. ZHU,* ***J. ZHU****, Q. CHENG, B. YANG, J. TIAN, Y. GUO;* CHINA ELECTRIC POWER RESEARCH INSTITUTE. — EXPERIMENT RESEARCH ON THE DYNAMIC VOLTAGE SAG COMPENSATION BY USING 2G HIGH TEMPERATURE SMESABSTRACTBASED ON THE DIGITAL SIGNAL PROCESSOR(DSP) TMS320F2812 PRODUCED BY TEXAS INSTRUMENTS(TI), A CLOSED LOOP CONTROL ALGORITHM IS PROPOSED FOR DYNAMIC VOLTAGE SAG COMPENSATION IN POWER SYSTEMS BY USING A 2ND GENERATION HIGH TEMPERATURE SUPERCONDUCTING MAGNETIC ENERGY SYSTEM (SMES). BASED ON THE DYNAMIC VOLTAGE SAG COMPENSATION CONTROL ALGORITHM FOR THE SMES AND BY DESIGNING THE SIGNAL CONDITIONING CIRCUIT, DSP CONTROLLING CIRCUIT AND POWER CONVERSION CIRCUIT IN A SMES CONVERTER, A VOLTAGE SAG COMPENSATION DYNAMIC SIMULATION EXPERIMENT SYSTEM WAS CONSTRUCTED AND A SERIES OF DYNAMIC VOLTAGE SAG COMPENSATION EXPERIMENTS WERE COMPLETED WITH THE SMES CONVERTER. A DYNAMIC SIMULATION EXPERIMENT FOR COMPENSATION OF INSTANTANEOUS VOLTAGE SAG IS PROCESSED. ANALYSIS OF THE VOLTAGE WAVEFORMS BEFORE AND AFTER COMPENSATION OF THE POWER SYSTEM SHOWS THAT THE COMPENSATION SYSTEM COULD COMPENSATE THE VOLTAGE SAG ON THE POWER SYSTEM FAST AND ACCURATELY WITH THE 2G HT-SMES, AND THE EXPERIMENT PROVED THAT THE SMES CHOPPER COULD REALIZE THE FOLLOW CURRENT FUNCTION FOR SMES. THIS SMES MODEL CAN COMPENSATE THE VOLTAGE SAG WELL.

1LY-04

EFFICIENCY IMPROVEMENTS ON THE GRID BY USING SC MEDIUM VOLTAGE CABLES ***X. GRANADOS***[1]*, R. RODRIGUEZ*[2]*, S. CASCANTE*[3]*, J. FRAU*[3]*, R. SOIKA*[4]*, T. PUIG*[1]*, X. OBRADORS*[1]*;* [1]ICMAB-CSIC, [2]LABEIN-TECNALIA, [3]ENDESA, [4]NEXANS. — THE LOW IMPEDANCE AND LOW LOSSES BEHAVIOUR OF THE SUPERCONDUCTING CABLES, ALLOWS THE TRANSPORT OF HIGH POWER LEVELS AT MEDIUM VOLTAGE GIVING NOT ONLY A SIMPLIFICATION AND INCREASING OF THE GRID STABILITY BUT ALSO AN INCREASING OF THE SYSTEM EFFICIENCY COMPARING WITH ITS CONVENTIONAL COUNTERPART. IN THE CONTEXT OF THE NOVARE -ENDESA PROJECT “SUPERCABLE”, FOR THE DEVELOPMENT OF A 3.2KA, 25KV SUPERCONDUCTING CABLE AS A COLLABORATION BETWEEN ICMAB-CSIC, NEXANS, LABEIN, UAB AND ENDESA, AN ANALYSIS OF THE LOSSES AND THE BENEFIT OF INCLUDING SC CABLES IN SOME DISTRIBUTION LINKS BETWEEN SUBSTATIONS AND DISTRIBUTION NODES HAS BEEN PERFORMED. THE RESULTS SHOW THAT, AMONG OTHER ENVIRONMENTAL CONCERNS, THE DIMINISHING OF LOSSES CAN BE CONSIDERED AS A WAY TO CONTRIBUTE TO THE PAYBACK OF THE INSTALLATION. DATA CONCERNING THE TRANSFORMER SAVINGS, THE ENERGY AND THE CO_2 EMISSIONS COSTS ARE REPORTED. CONSIDERATIONS CONCERNING DC GRIDS ARE ALSO DISCUSSED.

1LY-05

LONG TERM OPERATION AND FAULT TESTS OF A 22.9 KV HYBRID SFCL IN THE KEPCO GRID ***O. HYUN***[1]*, S. YIM*[1]*, S. YOO*[1]*, M. KIM*[1]*, H. KIM*[1]*, S. YANG*[1]*, W. KIM*[1]*, J. SIM*[2]*, K. PARK*[2]*;* [1]KOREA ELECTRIC POWER RESEARCH INSTITUTE, [2]LS INDUSTRIAL SYSTEMS. — WE REPORT TEST OPERATION OF A 22.9 KV HYBRID SUPERCONDUCTING FAULT CURRENT LIMITER (SFCL) FOR MORE THAN A YEAR AND SHORT-CIRCUIT-TESTS USING ARTIFICIAL FAULT CURRENTS FOR PROTECTION COORDINATION STUDY IN THE KEPCO TEST GRID. THE SFCL WORKS AT THE RATED VOLTAGE AND CURRENT OF 22.9 KV AND 630 A, RESPECTIVELY. THE SUPERCONDUCTING COMPONENTS ARE IN SUB-COOLED LIQUID NITROGEN AT 76 K PRESSURIZED BY 3 ATM OF HE GAS. THE SFCL HAS BEEN RUN WITH REMOTE WATCH, CONTROL, AND DATA RECORDING VIA HIGH SPEED INTERNET. TO SIMULATE THE LOADED OPERATION 100 ARMS OF CURRENT WAS APPLIED TO THE SFCL DURING NORMAL STATE, ALLOWING ESTIMATION OF OPERATION COST, MOSTLY FROM MAINTENANCE AND OPERATION OF THE CRYOCLOOLER. THE CRYOCOOLER OPERATION COST APPROXIMATELY 7,000$ PER YEAR, WHICH CAN BE LOWERED BY SYSTEM OPTIMIZATION. FOR SUCH EMERGENCY CASES AS BLACKOUTS PROCEDURES WERE PREPARED TO KEEP THE CRYOGENIC TEMPERATURE CONSTANT SO THAT IT CAN BE READY WHEN POWER IS RESTORED. ASSUMING A BLACKOUT FOR MAXIMUM 20 MINUTES, TEMPERATURE WAS KEPT BY GRADUALLY RELEASING THE HE GAS. PERIODICALLY, SHORT CIRCUIT TESTS WERE PERFORMED USING AN ARTIFICIAL FAULT GENERATOR IN THE TEST GRID, WHICH INCLUDES CIRCUIT BREAKERS AND A RECLOSER. THE TESTS ALLOW US TO STUDY COORDINATION BETWEEN PROTECTION DEVICES IN THE GRID. WE WILL DISCUSS DETAILED TEST RESULTS AND SUGGEST TRIALS OF PROTECTION SCHEME INCLUDING A SFCL.

THIS WORK WAS SUPPORTED BY A GRANT FROM THE CENTER FOR APPLIED SUPERCONDUCTIVITY TECHNOLOGY OF THE 21ST CENTURY FRONTIER R&D PROGRAM FUNDED BY THE MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY, REPUBLIC OF KOREA.

1LY-06

APPLICATION OF SFCLS TO A REAL GRID IN KOREA ***H. KIM***[1]*, S. YIM*[1]*, S. YU*[1]*, D. HAN*[1]*, S. YANG*[1]*, W. KIM*[1]*, O. HYUN*[1]*, K. PARK*[2]*, J. SIM*[2]*, Y. KIM*[2]*;* [1]KOREA ELECTRIC POWER RESEARCH INSTITUTE, KEPCO, [2]LS INDUSTRIAL SYSTEMS. — A SUPERCONDUCTING FAULT CURRENT LIMITER (SFCL) PROJECT WAS RECENTLY STARTED IN KOREA. THE GOAL OF THIS PROJECT IS TO OPERATE 22.9KV CLASS SFCLS IN A REAL GRID AND DEMONSTRATE ITS PERFORMANCE. KOREA ELECTRIC POWER CORPORATION PROVIDES THE GRID, INSTALLS AND OPERATES THE SFCL. LS INDUSTRIAL SYSTEMS FABRICATES THE SFCL. SPECIFICATIONS OF THE SFCL, PARTICULARLY THOSE OF SUPERCONDUCTING ELEMENTS WERE DETERMINED, BASED ON GRID REQUIREMENTS, RESULTS OF ANALYSIS ON THE CHOSEN GRID, AND CHARACTERISTICS OF SUPERCONDUCTORS SUCH AS QUENCH, CRITICAL CURRENT AND RECOVERY. THE GRID REQUIREMENTS INCLUDE RECLOSING TIME OF 0.5 SECOND FOR KOREAN DISTRIBUTION SYSTEMS. A HYBRID SFCL MEETING THESE SPECIFICATIONS WILL BE FABRICATED, FACTORY-TESTED. THEN, IT WILL BE INSTALLED AT ICHEON SUBSTATION, WHICH IS LOCATED IN A SEMI-URBAN AREA WITH MODERATE LOADS. AFTER A SERIES OF ON-SITE TESTS, IT IS PLANNED TO BE ENERGIZED AT THE END OF THIS YEAR. THE SFCL WILL BE OPERATED WITH A REMOTE MONITORING AND CONTROL SYSTEM FOR UNMANNED OPERATION.

THIS RESEARCH WAS SUPPORTED BY A GRANT FROM KOREA INSTITUTE OF ENERGY TECHNOLOGY EVALUATION AND PLANNING FUNDED BY THE MINISTRY OF KNOWLEDGE ECONOMICS, REPUBLIC OF KOREA

1MA-01

(INVITED) **PROGRESS IN RESEARCH AND DEVELOPMENT OF IBAD-MOCVD BASED SUPERCONDUCTING WIRES** ***V. SELVAMANICKAM***[1]*, Y. CHEN*[2]*, G. MAJKIC*[1]*, Y. QIAO*[2]*, I. KESGIN*[1]*, T. SHI*[1]*, A. GUEVARA*[1]*, Y. ZHANG*[1]*, Y. ZHANG*[1]*, Y. YAO*[1]*, A. RAR*[2]*, X. XIONG*[2]*, S. SAMBANDAM*[2]*, G. CAROTA*[2]*, Y. XIE*[2]*, J. DACKOW*[2]*;* [1]UNIVERSITY OF HOUSTON, [2]SUPERPOWER. — SECOND-GENERATION (2G) HTS WIRES BASED ON IBAD AND MOCVD HAVE BEEN SUCCESSFULLY SCALED UP BEYOND A KILOMETER WITH A CRITICAL CURRENT PERFORMANCE EXCEEDING 300,000 A-M. IN THIS JOINT PROJECT BETWEEN THE UNIVERSITY OF HOUSTON AND SUPERPOWER, WE ARE EXPLORING AVENUES TO MAKE SIGNIFICANT ADVANCES IN KEY METRICS OF 2G HTS WIRES TO MEET APPLICATION REQUIREMENTS. MAJOR IMPROVEMENTS HAVE BEEN MADE IN IN-FIELD PERFORMANCE BY USE OF ZR-DOPING IN THE MOCVD PROCESS. THE IMPROVEMENTS HAVE BEEN SUCCESSFULLY TRANSITIONED TO LONG LENGTHS AS WELL AS DEMONSTRATED IN COILS EXHIBITING SUPERIOR MAGNETIC FIELD GENERATED AT 65 K. THROUGH INDIVIDUAL TUNING OF SELF-ASSEMBLED BAZRO3 (BZO) NANOCOLUMNS AND ALIGNED RE2O3 PRECIPITATE ARRAYS, THE IN-FIELD CRITICAL CURRENT IS TAILORED IN DIFFERENT FIELD ORIENTATIONS. NEW, SCALABLE TECHNIQUES ARE BEING DEVELOPED TO FABRICATE LONG MULTIFILAMENTARY WIRES FOR APPLICATIONS THAT REQUIRE LOW AC LOSSES. IN AN EFFORT TO REDUCE MATERIALS AND CAPITAL COST, WE ARE DEVELOPING ELECTRODEPOSITION OF SILVER AS AN ALTERNATIVE TO SPUTTERING AND COMPARABLE CRITICAL CURRENTS HAVE BEEN ACHIEVED. SIMILARLY, SUBSTRATE PLANARIZATION INSTEAD OF ELECTROPOLISHING IS BEING PURSUED TO REDUCE THE NUMBER OF PROCESS STEPS AS WELL AS INTRODUCE THE CAPABILITY TO EMPLOY LOWER-COST SUBSTRATES. PROGRESS IN THESE NEW PATHWAYS TO IMPROVE PERFORMANCE AND COST METRICS OF 2G HTS WIRES WILL BE DISCUSSED.

THIS WORK WAS PARTIALLY SUPPORTED BY THE U.S. DEPARTMENT OF ENERGY.

1MA-02

DEVELOPMENT OF HTS FILMS DEPOSITED BY REACTIVE COEVAPORATION ON SIMPLIFIED TEMPLATES FOR LOW-COST COATED CONDUCTORS ***B. MOECKLY***[1]*, V. GLYANTSEV*[1]*, J. HUH*[1]*, C. SHEEHAN*[2]*, Y. COULTER*[2]*, B. MAIOROV*[2]*, V. MATIAS*[2]*;* [1]STI, [2]LOS ALAMOS NATIONAL LABORATORY. — COST REDUCTION OF SECOND GENERATION (2G) HIGH TEMPERATURE SUPERCONDUCTING (HTS) WIRE IS MANDATORY FOR BROAD COMMERCIALIZATION OF THIS TECHNOLOGY. WE BELIEVE THAT HTS FILM GROWTH VIA REACTIVE COEVAPORATION USING CYCLIC DEPOSITION AND REACTION (RCE-CDR) REPRESENTS THE POTENTIALLY LOWEST-COST APPROACH, PARTICULARLY WHEN COMBINED WITH THE SIMPLIFIED BUFFER LAYER TECHNOLOGY DEVELOPED AT LOS ALAMOS NATIONAL LABORATORY. THESE LAYERS CONSIST OF A SOLUTION DEPOSITION PLANARIZATION (SDP) LAYER DEPOSITED DIRECTLY ONTO A METAL SUBSTRATE TAPE FOLLOWED BY MGO LAYERS GROWN BY E-BEAM EVAPORATION AND ION BEAM ASSISTED DEPOSITION. WE WILL DISCUSS THE TRANSPORT AND MATERIALS PROPERTIES OF HTS FILMS GROWN ON THESE TEMPLATES. THE FILMS DISPLAY OUTSTANDING CRYSTALLINITY, AND THEY EXHIBIT CRITICAL CURRENT (IC) DENSITIES OF SEVERAL MA/CM2 AT 77 K IN SELF FIELD FOR THIN FILMS, WHILE THICKER FILMS SUPPORT IC VALUES GREATER THAN 500 A/CM-WIDTH. WE ARE OPTIMIZING THE IN-FIELD PERFORMANCE OF THESE 2G HTS TAPES VIA GROWTH CONDITIONS, COMPOSITION, AND DOPING, AND WE WILL REPORT THE MAGNETIC FIELD AND ANGULAR DEPENDENCE OF IC FOR FILMS GROWN ON 2G TEMPLATES AND ON MGO SINGLE CRYSTALS. IN ADDITION, WE ARE DEVELOPING AN RCE-CDR DEPOSITION SYSTEM FOR PRODUCTION OF LONG LENGTHS OF 2G HTS TAPE, AND WE WILL REPORT ON THE FABRICATION AND PROPERTIES OF MULTI-METER LENGTHS OF HTS COATED CONDUCTORS PRODUCED IN THIS SYSTEM.

1MA-03

ADVANCES IN TFA $YBa_2Cu_3O_7$ THIN FILM GROWTH WITH CONTROLLED MICROSTRUCTURE ***X. OBRADORS****, T. PUIG, K.*

ZALAMOVA, A. LLORDÉS, H. CHEN, A. PALAU, A. CALLEJA, X. GRANADOS, S. RICART, A. POMAR; INSTITUT DE CIÈNCIA DE MATERIALS DE BARCELONA-CSIC. — CHEMICAL SOLUTION DEPOSITION (CSD) HAS EMERGED AS A VERY COMPETITIVE LOW COST TECHNIQUE TO OBTAIN NANOSTRUCTURED COATED CONDUCTORS. THE DEVELOPMENT OF HIGH PERFORMANCE NANOSTRUCTURED SUPERCONDUCTORS WITH ENHANCED VORTEX PINNING PROPERTIES REQUIRES, HOWEVER, A FULL KNOWLEDGE ON THE TFA PROCESS, FROM THE PYROLYSIS STAGE TO THE CRYSTALLINE TRANSFORMATION TO THE SUPERCONDUCTING PHASE, AND STILL MANY QUESTIONS ARE OPENED. IN THIS PRESENTATION WE WILL REPORT ON OUR RECENT ADVANCES CONCERNING PROCESSING OF $YBA_2CU_3O_7$ (YBCO) FILMS BASED ON TFA PRECURSORS. WE HAVE PARTICULARLY INVESTIGATED THE VOLATILE SPECIES BEING RELEASED DURING THE CHEMICAL DECOMPOSITION REACTION AND CONFIRMED THAT NO HF IS RELEASED DURING THE PYROLYSIS STAGE. THE INFLUENCE OF OXYGEN, TOTAL AND WATER PRESSURE AND GAS FLOW ON THE NUCLEATION STAGE OF YBCO FILMS HAS BEEN EXAMINED IN PARALLEL WITH THE MODIFICATION OF THE PYROLYZED STATE AS A SOURCE TO CONTROL THE FILM POROSITY AND THE KINETIC EVOLUTION OF THE INTERMEDIATE PHASES. WE HAVE EVALUATED EXPERIMENTALLY AND THEORETICALLY THE GROWTH RATE DEPENDENCE WITH THE DIFFERENT PROCESS PARAMETERS AND THEIR INFLUENCE ON THE MICROSTRUCTURE AND SUPERCONDUCTING PROPERTIES AND, WE HAVE DEVISED A NEW ROUTE TO DECREASE THE GROWTH TEMPERATURE WHILE KEEPING HIGH SUPERCONDUCTING PERFORMANCES, BY MODIFYING THE TFA SOLUTION.

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1MA-04

TFA-MOD DERIVED COATED CONDUCTORS WITH HIGH IC PROPERTY UNDER MAGNETIC FIELDS ***M. YOSHIZUMI***[1]*, M. MIURA*[1]*, K. NAKAOKA*[1]*, Y. TAKAHASHI*[1]*, Y. TAKAGI*[1]*, T. IZUMI*[1]*, Y. SHIOHARA*[1]*, Y. AOKI*[2]*;* [1]ISTEC-SRL, [2]SWCC SHOWA CABLE SYSTEMS CO., LTD.. — TFA-MOD DERIVED COATED CONDUCTORS ARE THOUGHT TO BE PROMISING FOR FUTURE APPLICATIONS DUE TO HIGH SUPERCONDUCTIVE PROPERTIES AND COST EFFICIENCY. THE PRACTICAL APPLICATIONS SUCH AS SMES, MOTORS, GENERATORS, TRANSFORMERS ARE MOSTLY OPERATED UNDER MAGNETIC FIELDS, THEREFORE, IMPROVEMENT OF THE IC-B PROPERTY IS DESIRED. INTRODUCTION OF ARTIFICIAL PINNING CENTERS WAS INVESTIGATED IN THIS STUDY TO IMPROVE THE IC-B PROPERTY OF TFA-MOD DERIVED COATED CONDUCTORS.ZR SALT WAS ADDED INTO THE STARTING SOLUTION TO FORM BAZRO3 NANO PARTICLES. THE NANO PARTICLES WERE UNIFORMLY DISPERSED INTO A REBCO LAYER AND EFFECTIVELY WORKED AS PINNING CENTERS. IC ANISOTROPY DEPENDENT ON APPLIED MAGNETIC FIELD ANGLE WAS SUPPRESSED, REALIZING IC(MIN.) PROPERTY OF 115A/CM-W UNDER 1T AT 77K. THIS METHOD IS APPLICABLE TO THE LONG WIRE PRODUCTION AND THE IC PROPERTY OF A LONG WIRE WAS IMPROVED AS WELL UNDER MAGNETIC FIELDS.

THIS WORK WAS SUPPORTED BY NEDO.

1MA-05

EXAMINATION OF THROUGH-THICKNESS/THROUGH-TIME PHASE EVOLUTION DURING MOD-TYPE REBCO PRECURSOR CONVERSION USING RAMAN MICROSCOPY ***Z. CHEN***[1]*, V. A. MARONI*[1]*, D. J. MILLER*[1]*, X. LI*[2]*, M. W. RUPICH*[2]*, R. FEENSTRA*[3]*;* [1]ARGONNE NATIONAL LABORATORY, [2]AMERICAN SUPERCONDUCTOR INC., [3]OAK RIDGE NATIONAL LABORATORY. — THROUGH-THICKNESS/THROUGH-TIME COMPOSITION ANALYSES WERE MADE ON $REBA_2CU_3O_{6+X}$ (REBCO) FILMS PREPARED FROM METAL-ORGANIC DEPOSITED (MOD) PRECURSORS ON A RABITS TEMPLATE. $YDY_{0.5}BA_2CU_3O_{6+X}$ FILMS WERE FABRICATED USING BOTH SINGLE AND MULTIPLE PRECURSOR COATING STEPS. SPECIMENS WERE QUENCHED AT SELECTED TIMES ALONG A HEAT TREATMENT PROFILE USED BY AMERICAN SUPERCONDUCTOR, THEN EXAMINED BY RAMAN MICROSCOPY ALONG MECHANICALLY MILLED SLOPES THROUGH THE REBCO FILMS. UPON REACHING THE REACTION TEMPERATURE, T_R, THE PRECURSOR INITIALLY TRANSFORMS INTO A $(Y,DY)_2CU_2O_5$, CUO, CU_2O, AND RE-BA-F-O PHASE MIX, FOLLOWED SHORTLY BY SUBSTRATE-LEVEL REBCO FORMATION THAT PROPAGATES UPWARDS THROUGH TIME. OUR RESULTS INDICATE THAT (1) SINGLE-LAYER (SL) AND DOUBLE-LAYER (DL) FILMS (BOTH ~1.2 MM THICK) REACT TO COMPLETION AT ABOUT THE SAME RATE AND ARRIVE AT A SIMILAR FINAL COMPOSITION AND (2) SOME RESIDUAL BA-CU-O PHASES PERSIST NEAR THE TOP OF THE FULLY REACTED FILMS. THE PERFORMANCE OF THE SL FILM WAS MODERATELY BETTER THAN THAT OF THE DL FILM, SEEMINGLY DUE TO BETTER THROUGH-THICKNESS REBCO TEXTURE AS DETERMINED BY X-RAY DIFFRACTION.

WORK SUPPORTED BY THE U.S. DEPARTMENT OF ENERGY, OFFICE OF ELECTRICITY DELIVERY AND ENERGY RELIABILITY, AND OFFICE OF SCIENCE, OFFICE OF BASIC ENERGY SCIENCES.

1MA-06

ARE $5/KA•M COATED CONDUCTORS POSSIBLE? ***V. MATIAS***[1]*, R. H. HAMMOND*[2]*;* [1]LOS ALAMOS NATIONAL LABORATORY, [2]STANFORD UNIVERSITY. — THE CRITICAL CHALLENGE FOR COATED CONDUCTORS IS TO MAKE THEM AT THE LOW COST THAT IS REQUIRED FOR WIDESPREAD MARKET ACCEPTANCE OF SUPERCONDUCTING POWER DEVICES, INCLUDING SC DC POWER CABLES. IN ORDER FOR THIS TO BE ACHIEVED HIGH TEMPERATURE SUPERCONDUCTING (HTS) LAYERS NEED TO BE DEPOSITED ON LONG LENGTHS BY AN ECONOMICAL AND SCALABLE METHOD THAT SIMULTANEOUSLY PRODUCES HIGH PERFORMING MATERIALS. ECONOMICS DICTATE THAT DEPOSITION METHODS THAT HAVE THE HIGHEST POSSIBLE MATERIALS TRANSFER RATES BE UTILIZED. WE DISCUSS HOW A HIGH-RATE LARGE-AREA CO-DEPOSITION PROCESS CAN BE USED IN TWO DIFFERENT METHODS FOR DEPOSITION OF THE

HTS LAYERS, EITHER BY CYCLIC DEPOSITION-REACTION (CDR) OR BY A TWO-STEP METHOD. THE CDR METHOD DEVELOPED AT LANL UTILIZES QUICKLY ALTERNATING DEPOSITION AND OXYGENATION, AND HAS DEMONSTRATED CRITICAL CURRENT DENSITIES AT 75 K AND SELF-FIELD OF OVER 4 MA/CM2 WITH 1 μM THICKNESS. THE TWO-STEP PROCESS DEMONSTRATED AT STANFORD DEPOSITS AT VERY HIGH RATE (>10 NM/S) IN A GLASSY STATE THAT WHEN REACTED RESULTS IN A JC OF 5 MA/CM2 ON SINGLE CRYSTAL SUBSTRATE, AND OVER 1 MA/CM2 ON ARTIFICIALLY TEXTURED SUBSTRATES. WE DISCUSS SOME PRACTICAL POSSIBILITIES FOR MANUFACTURING SUPERCONDUCTING WIRE AND PRESENT A COST MODEL FOR BOTH PROCESSES. WE MAKE THE CASE THAT THE COST OF HTS DEPOSITION CAN BE LESS THAN $4/KA•M (LN2, SF) AND THE TOTAL COST OF COATED CONDUCTORS CAN APPROACH $5/KA•M.

THE WORK AT LANL IS FUNDED BY THE U.S. DEPARTMENT OF ENERGY OFFICE OF ELECTRICITY DELIVERY AND ENERGY RELIABILITY.

1MA-07

2G HTS CONDUCTOR ENGINEERING - MEETING THE PERFORMANCE REQUIREMENTS FOR LARGE-SCALE APPLICATIONS ***Y. XIE***[1]*, V. SELVAMANICKAM*[2]*, D. HAZELTON*[1]*, J. DACKOW*[1]*;* [1]SUPERPOWER, INC., [2]UNIVERSITY OF HOUSTON & SUPERPOWER, INC.. — SECOND-GENERATION HIGH-TEMPERATURE SUPERCONDUCTING (2G HTS) WIRE HAS BEEN DEMONSTED TO BE A TECHNICAL SOLUTION FOR ENERGY SAVINGS AS IT CAN REPLACE COPPER WIRE AND BE USED IN MANY SUPERCONDUCTING DEVICES FOR REAL WORLD ELECTRICAL APPLICATIONS. ALTHOUGH 2G HTS WIRE IS THE KEY FOR HIGH EFFCIENCY IN ALL SUPERCONDUCTING APPLICATIONS, ITS MAIN FUNCTIONALITY VARIES IN DIFFERENT DEVICES. FOR EXAMPLE, WHILE SOME DEVICES SUCH AS SUPERCONDUCTING POWER CABLE AND RESISTIVE-TYPE FAULT CURRENT LIMITER CALL FOR CURRENT CARRYING CAPABILITY IN LOW OR SELF-FIELD, OTHERS INCLUDING SUPERCONDUCTING MAGNETIC ENERGY STORAGE, MOTOR, GENERATOR AND HIGH-FIELD MAGNETS REQUIRE 2G HTS WIRE TO PERFORM UNDER STRONG MAGNETIC FIELDS AND LORENTZ FORCE INDUCED MECHANICAL STRESSES. IN THIS WORK, WE ASSESS THE TECHNICAL REQUIREMENTS ON 2G HTS WIRE IN DIFFERENT SUPERCONDUCTING DEVICES AND PRESENT OUR WORK IN CONDUCTOR ENGINEERING TO TAILOR DESIGN AND BUILD WIRE PERFORMANCE TO SATISFY THOSE TECHNICAL REQUIREMENTS, INCLUDING IN-FIELD PERFORMANCE, MECHANICAL STRENGTH, STABILIZATION, AC LOSS, AND INSULATION.

1MB-02

CONTROL OF ORIENTATION OF RBCO FILMS ON SUBSTRATES WITH LOW AND HIGH LATTICE MISMATCH VIA SEED LAYER FORMATION ***S. SAMOILENKOV***[1]*, A. MARKELOV*[2]*, M. MOYZYKH*[3]*, A. KAUL*[4]*;* [1]INSTITUTE OF HIGH TEMPERATURE RAS, [2]DEPARTMENT OF MATERIALS SCIENCE, MOSCOW STATE UNIVERTSITY, [3]DEPARTMENT OF MATERIALS SCIENCE, MOSCOW STATE UNIVERSITY, [4]CHEMISTRY DEPARTMENT, MOSCOW STATE UNIVERSITY. — THE ORIENTATION BEHAVIOR OF RBCO FILMS IS CRUCIAL FOR ACHIEVEMENT OF HIGH SUPERCONDUCTING PROPERTIES. THE PROBLEM OF ORIENTATION IS IMPORTANT IN TECHNOLOGY OF COATED CONDUCTORS, ESPECIALLY FOR THE LARGE FILM THICKNESS. IT IS KNOWN THAT PERFECT LATTICE MATCH BETWEEN RBCO FILM AND PEROVSKITE SUBSTRATE PROVIDES FAVORABLE CONDITIONS FOR THE GROWTH OF A-AXIS ORIENTED GRAINS IN RBCO FILMS. TO DESCRIBE THIS BEHAVIOR WE PRESENT HERE THE SIMPLE MODEL BASED ON THE LAYERED NATURE OF RBCO CRYSTAL STRUCTURE. THE MODEL IS SUPPORTED BY OUR EXPERIMENTAL OBSERVATIONS ON ORIENTATION OF RBCO (R=GD,Y,YB) FILMS GROWN BY MOCVD ON TEXTURED METAL SUBSTRATES WITH VARIOUS BUFFERS AND SINGLE CRYSTALLINE SUBSTRATES. IT HAS BEEN SHOWN THAT A-AXIS FORMATION IN RBCO/STO FILMS CAN BE EFFICIENTLY SUPPRESSED BY FEW NANOMETER THICK SEED LAYER OF R_2O_3 OR CEO_2. SUCH SEED LAYER POSSESSES LOW LATTICE MATCH WITH RBCO BUT PROVIDES EXCELLENT TEMPLATE FOR C-AXIS ORIENTATION GROWTH. WE ALSO DEMONSTRATE THE WAYS OF CONTROLLING IN-PLANE ORIENTATION OF RBCO FILMS GROWN DIRECTLY ON HIGHLY MISMATCHED (001)MGO SURFACE OF SINGLE CRYSTAL OR BUFFER LAYER. WE SHOW THAT BY THE PROPER CHOICE OF THE SEED LAYER AND DEPOSITION CONDITIONS, RBCO FILM CAN BE GROWN WITH CUBE-ON-CUBE ORIENTATION OR ROTATED IN PLANE BY 45 DEGREES. THE SUPERCONDUCTING PROPERTIES OF LAYERS WILL BE DISCUSSED IN CONNECTION WITH THE ORIENTATION OBSERVED.

THE FINANCIAL SUPPORT OF SUPEROX COMPANY IS ACKNOWLEDGED.

1MB-03

OPTIMIZATION OF THE TFA-MOD PROCESS FOR INTRODUCTION OF $BAZRO_3$ PINNING CENTERS IN YBCO FILMS ***S. V. GHALSASI***[1]*, G. MAJKIC*[2]*, K. SALAMA*[2]*;* [1]VISITING RESEARCHER AT DEPARTMENT OF MECHANICAL ENGINEERING, UNIVERSITY OF HOUSTON, HOUSTON, TX 77204-4006 AND BECHTEL OGC, [2]DEPARTMENT OF MECHANICAL ENGINEERING, UNIVERSITY OF HOUSTON, HOUSTON, TX 77204-4006. — WE PRESENT RESULTS OF A STUDY AIMED AT UNDERSTANDING THE FORMATION OF $BAZRO_3$ (BZO) PRECIPITATES IN YBCO USING THE TFA-MOD PROCESS, AS WELL AS OPTIMIZING THE BZO CONCENTRATION AND PROCESS CONDITIONS WITH RESPECT TO THE FLUX PINNING PERFORMANCE. A REFERENCE YBCO SAMPLE CONTAINING NO BZO, AS WELL AS THREE SAMPLES CONTAINING 4, 5 AND 6% BZO WERE MADE AND CHARACTERIZED WITH RESPECT TO IN-FIELD I_C PERFORMANCE, ANGULAR FIELD I_C DEPENDENCE AND CRITICAL TEMPERATURE. FURTHERMORE, SAMPLES WERE ANALYZED USING TRANSMISSION ELECTRON MICROSCOPY TO IDENTIFY THE MORPHOLOGY OF PINNING PRECIPITATES AND CORRELATE IT TO THE FLUX PINNING BEHAVIOR. THE INTRODUCTION OF BZO, INTERESTINGLY, DOES NOT RESULT IN FORMATION OF C-AXIS PEAKS IN ANGULAR FIELD I_C DEPENDENCE, BUT RATHER IN CONSIDERABLE WIDENING OF THE AB-PLANE PEAKS IN THE I_C-ANGLE CURVE WITH INCREASING BZO CONTENT, AS WELL

AS DECREASING OF THE RATIO OF MAXIMUM TO MINIMUM I_C WITH RESPECT TO FIELD ANGLE. THIS BEHAVIOR IS ANALYZED IN DETAIL AND CORRELATED TO THE UNDERLYING MICROSTRUCTURE OF PINNING PRECIPITATES.

WE ACKNOWLEDGE THE FINANCIAL SUPPORT OF OAK RIDGE NATIONAL LABORATORY, HIGH TEMPERATURE SUPERCONDUCTIVITY PROGRAM.

1MB-04

CONTROLLING VORTEX MOTION IN MGB2 THIN FILMS *S. TREIBER[1], J. ALBRECHT[2],* ***H. HABERMEIER[3];*** [1]MAX-PLANCK-INSTITUT MF, [2]HOCHSCHULE AALEN, [3]MAX-PLANCK- INSTITUT FKF. — MGB_2 THIN FILMS WOULD BE AN IDEAL CANDIDATE FOR MANY APPLICATIONS SUCH AS CONDUCTORS OR MAGNETIC SENSOR DEVICES DUE TO ITS RELATIVELY HIGH TRANSITION TEMPERATURE, LARGE CRITICAL FIELDS, LARGE COHERENCE LENGTH AND ATTRACTIVE CRITICAL CURRENTS. THE MAIN DRAWBACK HOWEVER ARISES FROM THE DISSIPATIVE VORTEX MOTION IN THIS MATERIAL. AT TEMPERATURES BELOW 10K, A CHAOTIC MOTION OF VORTEX AVALANCHES LEADS TO A HUGE AMOUNT OF MAGNETIC NOISE. PROPAGATION OF AVALANCHES IS CONTROLLED BY THE CRITICAL CURRENT DENSITY, HEAT TRANSFER VIA INTERFACES AND VORTEX PINNING. WE INFLUENCE THE CRUCIAL PARAMETERS FOR AVALANCHE FORMATION BY PREPARATION OF SAMPLES CONTAINING AREAS OF DIFFERENT CURRENT DENSITIES, HEAT TRANSFER COEFFICIENTS AND PINNING, RESPECTIVELY. THIS IS REALIZED IN MGB_2 HYBRID SYSTEMS WITH ADDITIONAL LAYERS SUCH AS NOBLE METALS WITH HIGH THERMAL CONDUCTIVITY (AU) OR METALLIC FERROMAGNETS (CO). COMPARING THE EFFECTS OF AU AND CO OVERLAYERS WE OBSERVE IN BOTH CASES A REDUCTION OF THE AVALANCHE FORMATION TEMPERATURE. IN CASE OF THE MAGNETIC OVERLAYER, HOWEVER, A DRASTIC REDUCTION OF THE FLUX CREEP HAS BEEN OBSERVED. THE IMPACT OF BOTH OBSERVATIONS ON DEVICE PERFORMANCES WILL BE DISCUSSED.

1MB-05

MAGNETO-OPTICAL STUDY OF THE ANISOTROPIC CURRENTS IN TILTED MGB_2 FILMS ***A. A. POLYANSKII[1],*** *A. YAMAMOTO[2], F. KAMETANI[1], D. ABRAIMOV[1], A. GUREVICH[1], D. LARBALESTIER[1], M. PUTTI[3], C. ZHUANG[4], X. XI[4];* [1]FSU, USA, [2]UNIVERSITY OF TOKYO, JAPAN, [3]UNIVERSITY OF GENOVA, ITALY, [4]TEMPLE UNIVERSITY, USA. — IN ORDER TO STUDY THE INFLUENCE OF PI BAND CONDUCTIVITY ON C-AXIS TRANSPORT IN MGB_2, WE PERFORMED MAGNETO-OPTICAL IMAGING TO STUDY THE INFLUENCES OF PINNING AND CRITICAL CURRENT ANISOTROPY IN MGB_2 FILMS GROWN BY HPCVD ON MGO(111) AND MGO(211) SUBSTRATES. FILMS GROWN ON MGO(211) WITH MGB_2 *C*-AXIS 19 DEGREE TILTED AGAINST FILM SURFACE[1] EXHIBIT TILTED GRAIN STRUCTURE, WITH STEPS NORMAL TO THE TILT DIRECTION. THIS STEP STRUCTURE YIELDS TWO ANISOTROPIC CURRENTS ON FILM SURFACE: A LONGITUDINAL CURRENT ALONG THE STEP (J_L) AND A TRANSVERSE CURRENT ACROSS THE STEPS (J_T). WHILE J_L FLOWS ONLY IN *AB*-PLANE, J_T FLOWS BOTH ALONG THE *AB*-PLANE AND PERPENDICULAR ALONG THE *C*-AXIS SO AS TO OVERCOME THE STEP STRUCTURE. CONSIDERING THE RATHER 2D FERMI SURFACE OF THE SIGMA BAND, WE BELIEVE ONLY THE PI-BAND CAN CONTRIBUTE TO J_T WHILES BOTH SIGMA AND PI BANDS CONTRIBUTE TO J_L. WITH INCREASING TEMPERATURE AND FIELD THE ANISOTROPY J_L/J_T INCREASES TO ~2. THIS BEHAVIOUR IS THE OPPOSITE IN RESPECT TO THOSE OBSERVED IN CUPRATES[2] SUGGESTING THAT MULTIBAND EFFECTS CAN PLAY A ROLE IN CURRENT TRANSPORT MECHANISMS OF MGB_2.[1] K. CHEN *ET AL.*, APL **93**, 012502 (2008).[2] A. POLYANSKII *ET AL.*, PRB **53**, 8687 (1996).

1MB-06

MICROWAVE RESONANT ACTIVATION OF MGB_2 THIN FILM JOSEPHSON JUNCTION ***R. C. RAMOS****, J. G. LAMBERT, S. A. CARABELLO, J. T. MLACK, Z. E. THRAILKILL;* DREXEL UNIVERSITY. — IN THE SUPERCONDUCTING STATE, A CURRENT-BIASED JOSEPHSON JUNCTION BEHAVES LIKE A NONLINEAR RESONATOR. ITS ANALOGOUS PHASE PARTICLE OSCILLATES WITHIN THE WELL AT A CLASSICAL PLASMA FREQUENCY. UNDER MICROWAVE RADIATION, THIS PHASE PARTICLE CAN BE RESONANTLY ACTIVATED AND MADE TO THERMALLY ESCAPE OVER ITS POTENTIAL BARRIER. WE WILL REPORT RESULTS OF THE FIRST MICROWAVE RESONANT ACTIVATION OF MGB_2 THIN FILM JOSEPHSON JUNCTIONS AT SUB-KELVIN TEMPERATURES. BY MANIPULATING MICROWAVE FREQUENCY AND POWER, WE DEMONSTRATE CONTROL OF THE STATE OF THE SYSTEM.

WE THANK PROF. X. XI AND K. CHEN (TEMPLE UNIVERSITY) FOR PROVIDING HIGH QUALITY MGB2 SAMPLES.

1MB-07

UNDERSTANDING THE MULTI-BAND EFFECTS ON CURRENT TRANSPORT IN TILTED MGB_2 FILMS ***A. YAMAMOTO[1],*** *M. PUTTI[2], A. POLYANSKII[3], F. KAMETANI[3], D. ABRAIMOV[3], A. GUREVICH[3], D. LARBALESTIER[3], C. ZHUANG[4], X. XI[4];* [1]UNIVERSITY OF TOKYO, [2]CNR-SPIN, UNIVERSITY OF GENOVA, [3]ASC, NATIONAL HIGH MAGNETIC FIELD LABORATORY, FLORIDA STATE UNIVERSITY, [4]TEMPLE UNIVERSITY. — FEW STUDIES ARE REPORTED SO FAR ON MULTI-BAND EFFECTS ON TRANSPORT CRITICAL CURRENT. IT IS CONSIDERED INTERPLAY OF RATHER TWO-DIMENSIONAL SIGMA-BAND AND ISOTROPIC PI-BAND OCCURS AT INTERGRANULAR CURRENT TRANSPORT IN RANDOMLY ORIENTED POLYCRYSTALS, ESPECIALLY UNDER MAGNETIC FIELD, SINCE TWO BANDS HAVE DIFFERENT SENSITIVITIES TO EXTERNAL FIELD. IN THIS PAPER WE REPORT THE CURRENT TRANSPORT STUDY ON THE VICINAL EPITAXIAL MGB_2 THIN FILM GROWN ON MGO (211) SUBSTRATE WITH MGB_2 *C*-AXIS 19 DEGREE TILTED AGAINST FILM SURFACE. DUE TO TILTED GRAIN STRUCTURE, STEPS ARE OBSERVED PERPENDICULAR TO THE TILT DIRECTION. THIS STEP STRUCTURE YIELDS TWO ANISOTROPIC CURRENT FLOWS ON FILM SURFACE, THAT IS, CURRENT ALONG THE STEP (J_L) AND CURRENT ACROSS THE STEPS (J_T) AND CAN PIN VORTICES. SHADOW MASKS AND LASER CUT LITHOGRAPHY HAVE BEEN DEVELOPED TO MEASURE THE CURRENT DIRECTLY ALONG THE

STEPS AND ACROSS THE STEPS. MAGNETIC FIELD WAS TILTED PARALLEL AND PERPENDICULAR TO THE FILM SURFACE TO STUDY THE INFLUENCES OF PINNING AND/OR ANISOTROPY OF TWO BANDS ON CURRENT TRANSPORT AND MICROSCOPIC CURRENT LIMITING MECHANISM THROUGH A COMPARISON OF TWO CURRENTS.

1MB-08

JOSEPHSON AND MULTI-GAP QUASI-PARTICLE TUNNELING IN CRYSTALLINE MGB_2-BASED VERTICAL AND LATERAL JUNCTIONS ***J. LALOË****, J. S. MOODERA;* MIT. — MGB_2 IS A MULTI-GAP SUPERCONDUCTOR WITH A T_C OF 39K AND A HEXAGONAL STRUCTURE. THIS SIMPLE AND STABLE COMPOUND IS VERY ATTRACTIVE FOR DEVICE APPLICATIONS. WE PRESENT TUNNELING CHARACTERISTICS OF *ALL*-MGB_2 DEVICES, BOTH IN THE VERTICAL GEOMETRY WITH A SPUTTERED MGO BARRIER, AND IN THE LATERAL GEOMETRY BY CREATING WEAK-LINK JUNCTIONS USING PROXIMITY WITH FE. IN THE FIRST CASE, WE HAVE DEPOSITED AND PATTERNED MICRON-SIZED SIS TUNNEL JUNCTIONS WITH HIGHLY TEXTURED MGB_2 ELECTRODES GROWN BY MBE CO-EVAPORATION WITH SPUTTER-DEPOSITED MGO TUNNEL BARRIERS, IN AN ENTIRELY IN-SITU PROCESS. THIS METHOD ENABLED US TO OBTAIN LOW RESISTANCE JUNCTIONS WITH VERY GOOD OXIDE COVERAGE. *I-V* AND *DI/DV* DATA DISPLAY JOSEPHSON PAIR TUNNELING AS WELL AS THE QUASI-PARTICLE TUNNELING SIGNATURE OF BOTH THE PI- AND SIGMA-BANDS OF THE MGB_2, WITH GAP VALUES AGREEING WITH PREVIOUS REPORTS. ALTHOUGH OUR MGB_2 FILMS WERE *C*-AXIS ORIENTED, GROWTH-RELATED ROUGHNESS OF THE BOTTOM MGB_2 ENABLE *A/B*-AXIS TUNNELING, GIVING RISE TO SIGMA-BAND FEATURES. THE LAYERS FOR LATERAL JUNCTIONS WERE ALSO DEPOSITED ENTIRELY *IN SITU*, THE FE FILM DIRECTLY IN CONTACT WITH THE MGB_2 FILM. CURRENT TRANSPORT IN THESE $S_1/S_2/S_1$ JUNCTIONS (WITH S_2 BEING THE FE/MGB_2 BILAYER REGION) WAS ALONG THE *A/B*-AXIS. WE OBSERVE SIGNS OF PAIR TUNNELING THOUGH NOT YET IDEAL JOSEPHSON CHARACTERISTICS.

WORK SUPPORTED BY ONR GRANT N00014-06-1-0235

1MC-01

PROPOSED STANDARD FOR DETERMINING THE IRREVERSIBLE STRAIN LIMIT OF NB_3SN WIRES ***L. F. GOODRICH****, N. CHEGGOUR, T. C. STAUFFER, J. D. SPLETT, X. LU, B. J. FILLA;* NIST. — WE PROPOSE A STANDARD METHOD FOR DETERMINING THE IRREVERSIBLE STRAIN LIMIT OF NB_3SN WIRES UNDER TENSION. THE SAMPLE IS SOLDERED TO A CUBE "WALTER'S SPRING" DEVICE THAT IS FULLY ELASTIC OVER A RANGE OF APPLIED STRAIN FROM −1 % TO +1 %. THREE PAIRS OF VOLTAGE TAPS ARE LOCATED ON THE SAMPLE ALONG THE CENTER THREE TURNS OF THE SPRING. THREE PAIRS OF VOLTAGE TAPS ALLOW US TO OBTAIN THREE SEPARATE DETERMINATIONS OF THE IRREVERSIBLE STRAIN LIMIT FROM EACH SPECIMEN. THE CRITICAL CURRENT I_C IS MEASURED AS A FUNCTION OF APPLIED STRAIN AT ONE MAGNETIC FIELD AND 4 K. THE SAMPLE IS LOADED AND (PARTIALLY) UNLOADED SEVERAL TIMES TO DETERMINE THE IRREVERSIBLE STRAIN LIMIT, WHICH IS DEFINED AS THE MAXIMUM LOADED STRAIN WHERE I_C IS REMAINS REVERSIBLE. REVERSIBILITY OF I_C IS DETERMINED BY COMPARING THE UNLOADED I_C TO A PREVIOUS MEASUREMENT OF I_C AT THE SAME LOADED STRAIN. WE INVESTIGATED VARIOUS MEASUREMENT PROTOCOLS TO DETERMINE THE REPEATABILITY AND GENERALITY OF THE METHOD.

THIS WORK WAS SUPPORTED IN PART BY THE U.S. DEPARTMENT OF ENERGY, OFFICE OF HIGH ENERGY PHYSICS.

1MC-02

INFLUENCE OF TI AND TA DOPING ON THE IRREVERSIBLE STRAIN LIMIT OF TERNARY AND QUATERNARY NB_3SN SUPERCONDUCTING WIRES MADE BY THE RESTACKED-ROD PROCESS ***N. CHEGGOUR***[1]*, L. F. GOODRICH*[1]*, T. C. STAUFFER*[1]*, J. D. SPLETT*[1]*, X. LU*[1]*, A. K. GHOSH*[2]*, P. J. LEE*[3]*, P. MUNDAY*[3]*, G. AMBROSIO*[4]*;* [1]NIST, [2]BNL, [3]FSU, [4]FNAL. — NB_3SN SUPERCONDUCTING WIRES MADE BY THE RESTACKED-ROD PROCESS (RRP®) WERE FOUND TO HAVE A DRAMATICALLY IMPROVED RESILIENCE TO AXIAL TENSILE STRAIN WHEN ALLOYED WITH TI AS COMPARED TO TA. WHEREAS TA-ALLOYED NB_3SN IN RRP WIRES SHOWED PERMANENT DAMAGE TO ITS CURRENT-CARRYING CAPACITY (I_C) WHEN TENSIONED BEYOND AN INTRINSIC STRAIN AS SMALL AS 0.04 %, TI-DOPED NB_3SN IN RRP STRANDS EXHIBITS A REMARKABLE REVERSIBILITY UP TO A TENSILE STRAIN OF ABOUT 0.25 %, CONCEIVABLY MAKING TI-DOPED RRP WIRES MORE SUITABLE FOR HIGH-FIELD MAGNETS USED IN PARTICLE ACCELERATORS AND NUCLEAR MAGNETIC RESONANCE APPLICATIONS WHERE MECHANICAL FORCES ARE INTENSE. A STRAIN CYCLING EXPERIMENT AT ROOM TEMPERATURE CAUSED A SIGNIFICANT DROP OF I_C IN TA-ALLOYED WIRES, BUT INDUCED AN INCREASE OF I_C IN THE CASE OF TI-DOPED STRANDS. WHEREAS EITHER TI OR TA DOPING YIELDS A SIMILAR ENHANCEMENT OF THE UPPER CRITICAL FIELD OF NB_3SN, THE MUCH IMPROVED MECHANICAL BEHAVIOR OF TI-ALLOYED WIRES POSSIBLY MAKES TI A BETTER CHOICE OVER TA, AT LEAST FOR THE RRP WIRE PROCESSING TECHNIQUE. THIS IRREVERSIBLE-STRAIN-LIMIT STUDY WAS ALSO EXTENDED TO QUATERNARY NB_3SN RRP WIRES DOPED WITH BOTH TI AND TA, AND AN IN-DEPTH MICROSTRUCTURAL ANALYSIS WAS CONDUCTED TO IMPROVE OUR UNDERSTANDING OF THE EFFECT OF DOPING ON THE ELECTRO-MECHANICAL PROPERTIES OF RRP WIRES.

THIS WORK WAS SUPPORTED IN PART BY THE U.S. DEPT. OF ENERGY, OFFICE OF HIGH ENERGY PHYSICS, AND THE U.S. LHC ACCELERATOR RESEARCH PROGRAM (LARP).

1MC-03

A METALLOGRAPHIC STUDY OF STRAND DEGRADATION IN ITER TFMC CICC ***P. J. LEE***[1]*, C. SANABRIA*[1]*, W. L. STARCH*[1]*, D. C. LARBALESTIER*[1]*, M. C. JEWELL*[2]*, A. DEVRED*[2]*;* [1]1APPLIED SUPERCONDUCTIVITY CENTER, NATIONAL HIGH MAGNETIC FIELD LABORATORY, FLORIDA STATE UNIVERSITY, [2]ITER ORGANIZATION. — TO REMEDY THE PRESENT UNCERTAINTY ABOUT THE REAL STRAND STATE OF LARGE CABLE-IN-CONDUIT (CIC) CONDUCTORS, CAREFUL POLISHING AND IMAGE

ANALYSIS TECHNIQUES HAVE BEEN DEVELOPED WHICH ENABLE A FULL VIEW FROM THE FILAMENT TO THE FULL CABLE SCALE. WE HERE REPORT ON THE CONDITION OF STRANDS IN CIC TFMC-FSJS CONDUCTOR AFTER TESTING IN SULTAN. IN TRANSVERSE CROSS-SECTION THE HEAT TREATED STRANDS SHOW MULTIPLE DEFECTS, NOTABLY AN UNSTABLE DIFFUSION BARRIER AND SUB-ELEMENT LOSS AND CU STABILIZER STRANDS EXHIBITED A LARGE NUMBER OF 3-10 μM DIAMETER VOIDS ALONG GRAIN BOUNDARIES. LONGITUDINAL CROSS-SECTIONS SHOWED LITTLE EVIDENCE OF FILAMENT CRACKING THAT MIGHT EXPLAIN THE SIGNIFICANT PERFORMANCE DEGRADATION FOUND IN SULTAN TESTS, PERHAPS BECAUSE OF THE COMPLEX TWISTING OF THE STRAND AND CABLE. STRANDS WERE EXTRACTED FROM THE CABLE AND POLISHED SEPARATELY SO THAT BOTH STRAIGHT AND BENT SECTIONS OF STRAND (SEVERE BENDING OCCURRING AT STRAND CROSSING POINTS), COULD BE ALIGNED TO THE POLISHING SURFACE. IN OUR PRELIMINARY ANALYSIS OF 12 STRANDS, WE OBSERVED THAT THE CRACK DENSITY INCREASED BY MORE THAN 10 TIMES IN THE BENT PORTIONS OF STRANDS COMPARED TO THE STRAIGHT PORTIONS AND THAT, VERY SURPRISINGLY, THE CRACK DENSITY WAS 4-5 TIMES HIGHER IN THE LOWER-STRAND-DENSITY LOW-PRESSURE CABLE PETAL COMPARED TO THE STRANDS FROM THE HIGHEST-PRESSURE PETAL. ANALYSIS IS ONGOING.

THE AUTHORS WISH TO THANK PATRICK DECOOL FROM CEA CADARACHE FOR SUPPLYING THE CONDUCTOR SECTIONS FOR STUDY. THIS WORK WAS SUPPORTED BY ITER ORGANIZATION CONTRACT CT/08/889 AND THE STATE OF FLORIDA.

1MC-04

COMPARISON OF VARIOUS PARAMETERIZATION APPROACHES FOR THE DESCRIPTION OF CRITICAL CURRENT VS. STRAIN OF A STAINLESS STEEL JACKETED NB_3SN WIRE ***G. DE MARZI***[1]*, V. CORATO*[1]*, L. MUZZI*[1]*, G. MONDONICO*[2]*, B. SEEBER*[2]*, R. FLÜKIGER*[2]*;* [1]ENEA, [2]UNIVERSITY OF GENEVA. — THE CRITICAL CURRENT OF AN INTERNAL TIN NB_3SN MULTI-FILAMENTARY WIRE, EXTERNALLY REINFORCED WITH A STAINLESS STEEL TUBE, HAS BEEN MEASURED AS FUNCTION OF AXIAL STRAIN AT DIFFERENT MAGNETIC FIELDS UP TO 19 T. FOR COMPARISON THE SAME STUDY HAS BEEN PERFORMED ON THE BARE WIRE. DUE TO THE THERMAL PRE-COMPRESSION BY THE STEEL JACKET, NB_3SN FILAMENTS ARE SUBJECT TO 3D STRAIN COMPONENTS ACTING IN BOTH THE AXIAL AND THE RADIAL DIRECTION. WE COMPARE THE EXPERIMENTAL DATA WITH AVAILABLE PARAMETERIZATION FORMULAS: THE UNI-AXIAL POWER LAW FUNCTION PROPOSED BY EKIN, THE DURHAM POLYNOMIAL LAW AND THE TWENTE DEVIATORIC DESCRIPTION AS WELL AS THE 3D MODELS PROPOSED BY LBNL AND MARKIEWICZ, WHICH SHOULD EXPLICITLY INCLUDE THE EFFECT OF THE RADIAL STRAIN COMPONENT. ALTHOUGH ALL MODELS FIT WITH GOOD ACCURACY THE BEHAVIOUR OF BARE STRANDS, THE UNI-AXIAL STRAIN SCALING FUNCTIONS CANNOT REPRODUCE THE I_C VS. STRAIN CURVE OF JACKETED WIRES IN THE ANALYZED RANGE OF FIELD AND STRAIN. IN PARTICULAR, IN THE HIGH TENSILE LOAD REGION, EVEN THE MORE REFINED 3D MODELS OVERESTIMATE THE I_C VALUES OF THE REINFORCED WIRE WITH RESPECT TO THE EXPERIMENTAL DATA. IN ADDITION, THE HIGHER THE MAGNETIC FIELD, THE MORE PRONOUNCED IS THIS DISCREPANCY. IN THIS CONTRIBUTION A THOROUGH DESCRIPTION OF THE FITTING PROCEDURES IS PRESENTED AND THE MAIN ASPECTS AND IMPLICATIONS OF THE RESULTS ARE DISCUSSED.

1MC-05

(INVITED) **UNIFIED SCALING LAW: PARAMETERIZATION TESTING WITH RAW SCALING DATA** ***J. W. EKIN***[1]*, L. F. GOODRICH*[2]*, N. CHEGGOUR*[2]*, J. D. SPLETT*[2]*, B. BORDINI*[3]*, L. BOTTURA*[3]*;* [1]NIST AND UNIV. OF COLORADO, [2]NIST, BOULDER CO, [3]CERN. — GLOBAL FITTING (WHEREIN ALL THE PARAMETERS OF A PINNING-FORCE MODEL ARE SIMULTANEOUSLY ADJUSTED TO MINIMIZE THE MEAN ERROR IN CRITICAL CURRENT) CAN BE ADEQUATE FOR INTERPOLATION WITHIN LIMITED DATA RANGES, BUT IT DOES NOT RESULT IN PINNING-FORCE SCALING. TO OBTAIN SCALING AND UTILIZE ITS POWER TO PREDICT CRITICAL CURRENT OVER A WIDE RANGE OF FIELDS, TEMPERATUES, AND STRAINS, THE INDIVIDUAL PINNING-FORCE VS. MAGNETIC-FIELD CURVES NEED TO BE NORMALIZED, A PROCESS WHICH LEADS IN A NATURAL WAY TO RAW SCALING DATA FOR THE UPPER CRITICAL FIELD AND SCALING LAW PREFACTOR. SCALING DATA OF THIS TYPE, OBTAINED STARTING FROM PUBLISHED AND NEWLY PRODUCED NB_3SN DATA, ARE USED TO TEST PROPOSED PARAMETERIZATIONS OF THE UNIFIED SCALING LAW.

1MC-06

A MODEL TO STUDY PLASTIC DEFORMATION IN NB_3SN DEFORMED STRANDS AND CABLES *E. BARZI*[1]*, M. BOSSERT*[2]*,* ***G. GALLO***[1]*;* [1]FERMILAB, [2]STRAITS COMPANY. — AN IMPORTANT PART OF SUPERCONDUCTING ACCELERATOR MAGNET WORK IS THE CONDUCTOR. TO PRODUCE MAGNETIC FIELDS LARGER THAN 10 T, BRITTLE CONDUCTORS ARE USED. THE ROUND WIRE, IN THE FORM OF A COMPOSITE, IS ASSEMBLED INTO A SO-CALLED RUTHERFORD-TYPE CABLE, WHICH IS USED TO WIND THE MAGNET. THE MAGNET IS THEN SUBJECTED TO A HIGH TEMPERATURE HEAT TREATMENT TO PRODUCE THE CHEMICAL REACTIONS THAT MAKE THE MATERIAL SUPERCONDUCTING. AT THIS STAGE THE SUPERCONDUCTOR IS BRITTLE AND ITS SUPERCONDUCTING PROPERTIES ARE SENSITIVE TO STRAIN. THIS WORK IS BASED ON THE DEVELOPMENT OF A 2D FINITE ELEMENT MODEL, WHICH SIMULATES THE MECHANICAL BEHAVIOR OF NB3SN COMPOSITE WIRES AND CABLES UNDER DEFORMATION. THE ORIGINAL ROUND WIRE IS A COMPOSITE OF COPPER (CU), NIOBIUM (NB) AND TIN (SN). FIRST THE COMPOSITE WAS MODELED IN DETAIL AND ITS BEHAVIOR ANALYZED UNDER FLAT ROLLING USING FINITE ELEMENT ANALYSIS (FEM). THE STRAIN RESULTS OF THE MODEL WERE COMPARED WITH THOSE MEASURED EXPERIMENTALLY ON CROSS SECTIONS OF THE DEFORMED COMPOSITE. THEN A COMPOUND MODEL WAS MADE TO BE USED IN THE SIMULATION OF RUTHERFORD CABLE FABRICATION. EXPERIMENTAL ANALYSIS OF CABLE

CROSS SECTIONS ALLOWED DETERMINING RANGES FOR PLASTIC RESISTANCE LIMITS.

THIS WORK WAS SUPPORTED BY DOE

1MC-07

LOW IC SENSITIVITY OF RAPID QUENCHED NB3AL WIRES UNDER TRANSVERSE COMPRESSIVE STRESS UP TO 300 MPA ***B. SEEBER***[1], *A. FERREIRA*[1], *G. MONDONICO*[1], *C. SENATORE*[1], *R. FLUKIGER*[1], *T. TAKEUCHI*[2]; [1]UNIVERSITY OF GENEVA, [2]NATIONAL INSTITUTE FOR MATERIAL SCIENCE - NIMS. — THE CRITICAL CURRENT OF A NB3AL WIRE (RHQT PROCESS) WITH RECTANGULAR CROSS SECTION OF 1.81 X 0.80 MM2 HAS BEEN MEASURED UNDER TRANSVERSE COMPRESSIVE LOADS AT FIELDS BETWEEN 15 T AND 19 T AT 4.2 K. THE SAME WIRE WAS USED FOR WINDING AN INSERT COIL AT NIMS (HE2432, COIL #B) GENERATING 4.5 T IN A BACKGROUND FIELD OF 15 T AT 4.2 K. IN THIS STUDY THE LOAD IS APPLIED PERPENDICULARLY TO THE SMALL SIDE OF THE CONDUCTOR TRANSMITTING STRESSES UP OF 300 MPA. THE CRITICAL CURRENT STAYS ALMOST CONSTANT UP TO 150 MPA AND SHOWS A FLAT MAXIMUM AROUND 75 MPA. AT 300 MPA THE CRITICAL CURRENT IS REDUCED TO 93%, 90% AND 88% OF ITS STRESS FREE VALUE AT 15 T, 17 T AND 19 T, RESPECTIVELY. THIS INDICATES A RATHER SMALL FIELD DEPENDENCE BEING EFFECTIVE ABOVE 200 MPA ONLY. DEPENDING ON THE FIELD, UNLOADING FROM 300 MPA YIELDS TO AN ALMOST COMPLETE RECOVERY OF IC BETWEEN 94% AND 97% OF ITS INITIAL VALUE. THESE OBSERVATIONS ARE COMPARED TO THE BEHAVIOR OF NB_3SN WIRES MANUFACTURED ACCORDING DIFFERENT PROCESSES (BRONZE, INTERNAL TIN AND POWDER IN TUBE).

1MPA-01

THE OXIDATION BEHAVIOUR AT THE NI-W AND CEO2 INTERFACE WITH AND WITHOUT PD OVER LAYER ***A. MANCINI***[1], *G. CELENTANO*[1], *A. VANNOZZI*[1], *V. GALLUZZI*[1], *A. RUFOLONI*[1], *A. AUGIERI*[1], *A. ANGRISANI ARMENIO*[1], *S. GAUDIO*[1], *I. COLANTONI*[2], *I. DAVOLI*[2]; [1]ENEA, [2]ROMA TOR VERGATA UNIVERSITY. — THE GROWTH OF YBCO FILM ON METALLIC SUBSTRATE, FOR COATED CONDUCTORS DEVELOPMENT, TAKES PLACE IN HIGH-OXIDATIVE CONDITION. THIS CONDITION AFFECTS THE INTERFACE BETWEEN BUFFER LAYER STRUCTURE AND SUBSTRATE, AND COULD EVEN DAMAGE THE ENTIRE COATED CONDUCTORS STRUCTURE. IN THE PAST, WE REPORT YBCO FILM GROWTH ON PD-BUFFERED NI-W CUBE TEXTURED SUBSTRATE WITH CEO2/YSZ/CEO2 BUFFER-LAYER STRUCTURES. ALTHOUGH THE COMPLETE SOLUBILITY BETWEEN PD AND NI CAUSES THE FULL INTERDIFFUSION OF THE PD LAYER IN THE SUBSTRATE, HIGH QUALITY YBCO FILM WITH HIGH CRITICAL CURRENT WERE OBTAINED BOTH VIA PULSED LASER OR METAL-ORGANIC DEPOSITION. IN THESE WORK, THE INTERFACE BETWEEN THE NI-W SUBSTRATE, BOTH BARE AND PD-BUFFERED, AND THE BUFFER LAYER STRUCTURE SUBJECTED TO DIFFERENT OXIDIZING CONDITION WERE INVESTIGATED THROUGH X-RAY DIFFRACTION (XRD), EXTENDED X-RAY ABSORPTION FINE STRUCTURE (EXAFS) AND AUGER ELECTRON SPECTROSCOPY DEPTH PROFILING. PARTICULARLY, THE ROLE OF THE PD FILM IN BARING THE INTERDIFFUSION PROCESS BETWEEN THE NI, WHICH IS COMING FROM THE SUBSTRATE, AND THE CEO2 LAYER WAS IDENTIFIED. THAT ROLE OF THE PD FILM IS STRICTLY DEPENDENT ON THE PD LAYER THICKNESS. THE PRESENCE OF NI IN THE CEO2 FILM INTERFACE CONTRIBUTES TO THE WEAKENING OF THE BUFFER LAYER ADHESION.

1MPA-02

DEPOSITION OF SELF-EPITAXIAL CEO_2 BUFFER LAYER ON MGO SUBSTRATES BY PLD FOR COATED CONDUCTOR ***R. KO***[1], *K. KO*[2], *S. JANG*[1], *S. OH*[1], *C. PARK*[2], *H. HA*[1], *H. KIM*[1], *D. HA*[1], *K. SONG*[3], *S. KANG*[3], *Y. KIM*[4]; [1]KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE, [2]SEOUL NATIONAL UNIVERSITY, [3]CHONBUK NATIONAL UNIVERSITY, [4]PUSAN NATIONAL UNIVERSITY. — WE HAVE DEPOSITED CEO_2 THIN FILM DIRECTLY ON MGO(*00L*) SINGLE CRYSTAL SUBSTRATES AND IBAD_MGO METAL SUBSTRATES BY PULSED LASER DEPOSITION AND SUCCESSFULLY FABRICATED A HIGHLY TEXTURED CEO_2 BUFFER LAYER FOR COATED CONDUCTOR. CEO_2 IS AN ATTRACTIVE BUFFER LAYER MATERIAL AS IT IS CHEMICALLY COMPATIBLE WITH BOTH MGO AND RE123 MATERIALS. THE LARGE LATTICE MISMATCH, 28.5%, BETWEEN CEO_2 AND MGO LEADS TO DEGRADATION OF THE CRYSTALLINITY OF A DEPOSITED FILM. THE CEO_2 BUFFER LAYERS GROWN ON AS RECEIVED MGO SUBSTRATES CONSTITUTED OF (111) OR MIXED (111)(*00L*) ORIENTED CEO_2 FILMS. WE HAVE FOUND THAT PRE-ANNEALING OF MGO SUBSTRATES ENHANCES THE EPITAXIAL GROWTH OF (*00L*) ORIENTED CEO_2 FILMS ON MGO SUBSTRATES AND IN-PLANE GRAIN ALIGNMENT WAS IMPROVED BY INCREASING THE THICKNESS OF CEO_2 FILM. WE REPORT THE EFFECT OF PRE-ANNEALING TREATMENT OF MGO SUBSTRATE AND GROWTH CONDITIONS OF SELF-EPITAXIAL PLD-CEO_2 BUFFER LAYER ON MGO SUBSTRATE IN DETAIL.

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1MPA-03

PREPARATION OF CEO_2 BUFFER LAYER BY ELECTRON BEAM EVAPORATION DEPOSITION ON LMO BUFFERD IBAD-MGO ***J. LEE***[1], *S. PARK*[1], *S. MOON*[2], *H. LEE*[1], *G. HONG*[1]; [1]KOREA POLYTECHNIC UNIVERSITY, [2]SUNAM CO., LTD.. — THE THERMAL AND CHEMICAL STABILITY OF CAP LAYER IS VERY CRITICAL TO THE FINAL PROPERTIES OF COATED CONDUCTOR BECAUSE IT AFFECTS DIRECTLY THE QUALITY OF DEPOSITED REBCO LAYER AS A TEXTURED SUBSTRATE. CEO_2 HAS VERY SUPERIOR PROPERTIES OF GOOD LATTICE PARAMETER MATCH AND CHEMICAL STABILITY. IN THIS STUDY, CEO_2 WAS DEPOSITED BY ELECTRON BEAM DEPOSITION WITH 12~16 Å/SEC OF HIGH DEPOSITION RATE. LMO BUFFERED IBAD-MGO (LMO /IBAD-MGO/Y_2O_3/AL_2O_3/HASTELLOY) WAS USED AS SUBSTRATE, WHICH HAS A $\Delta\phi$ VALUE OF 8.4^O. THE SUBSTRATE TEMPERATURE WAS OPTIMIZED AT 650^OC. THE CHANGE OF

OXYGEN PARTIAL PRESSURE(PO_2) DOES NOT REVEAL SPECIAL EFFECT ON TEXTURE QUALITY OF OBTAINED LAYER. THE Δ□ AND ΔΩ VALUE ARE IMPROVED WITH INCREASING ITS DEPOSITION THICKNESS OF CEO_2, SO FAR THE BEST RESULT OBTAINED IS Δ□ VALUE OF 5.2^O, ΔΩ VALUE OF 2^O AND RA VALUE OF 2.3 NM BY SELF EPITAXY EFFECT. THE DETAILS OF PROCESS PARAMETER AND APPLICATION TO THE LATER PROCESS WILL BE PRESENTED.

1MPA-04

FABRICATION OF THE THICK $CEO_2/LA_2ZR_2O_7$ (LZO) BUFFER LAYERS THROUGH SEED LAYER MODIFICATION USED FOR COATED CONDUCTORS *Y. CHENG,* ***H. SUO****;* BEIJING UNIVERSITY OF TECHNOLOGY. — FABRICATION OF THE THICK $CEO_2/LA_2ZR_2O_7$ (LZO) BUFFER LAYERS THROUGH SEED LAYER MODIFICATION USED FOR COATED CONDUCTORSYANGLING CHENG, HONGLI SUO, RONG WANG, MIN LIU, LIN MA, TENG ZHANGKEY LABORATORY OF ADVANCED FUNCTIONAL MATERIALS, MINISTRY OF EDUCATION, COLLEGE OF MATERIALS SCIENCE AND ENGINEERING, BEIJING UNIVERSITY OF TECHNOLOGY, 100 PINGLEYUAN, CHAOYANG DISTRICT, BEIJING 100124,CHINA***ABSTRACT_*** IN THIS PAPER, THE $CEO_2/LA_2ZR_2O_7$ (LZO) BUFFER LAYERS WERE FABRICATED ON SEED LAYER MODIFIED CUBE-TEXTURED NI5W SUBSTRATES BY THE METAL ORGANIC DEPOSITION (MOD). THE XRD ANALYSIS REVEALED THAT BOTH THE LZO MULTILAYER ON NI5W SUBSTRATE AND CEO_2 FILM ON LZO BUFFER LAYER WERE GROWN EPITAXIALLY. IT WAS FOUND THAT THE SEED LAYER WITH THE UNIFORMLY DISTRIBUTED ISLAND MORPHOLOGY STABILIZED THE IN-PLAN AND OUT-PLAN TEXTURE OF EACH BUFFER LAYERS. THE FULL WIDTH AT HALF MAXIMUM (FWHM) VALUES OF (111) PHI SCANS AND Ω-SCAN ARE AROUND 7° AND 6°, RESPECTIVELY. THE SURFACE RESULT OBSERVED BY AFM INDICATE A VERY SMOOTH CEO_2 SURFACE WITH THE ROOT MEAN SQUARE ROUGHNESS OF 8.54 NM IN AN AREA OF $5\times5MM^2$. AES DEPTH PROFILE RESULTS SHOW THAT THE DEPOSITED 175NM THICK BUFFER LAYER COULD EFFECTIVELY PREVENT THE ELEMENTAL DIFFUSION FROM THE SUBSTRATE MATERIAL.

1MPA-05

SURFACE DECORATION OF $BATIO_3$ ON $LAALO_3$ SUBSTRATE BY CHEMICAL SOLUTION DEPOSITION ***D. SHI****[1], L. WANG[1], Q. LI[1], C. STEVEN[2], T. YAMASHITA[2], J. BARRY[2], S. DOU[1];* [1]INSTITUTE FOR SUPERCONDUCTING & ELECTRONIC MATERIALS, UNIVERSITY OF WOLLONGONG, [2]MESAPLEXX PTY LTD, 7 CLUNIES ROSS COURT, EIGHT MILE PLAINS, QLD 4113, AUSTRALIA. — **SURFACE DECORATION OF $BATIO_3$ ON $LAALO_3$ SUBSTRATE BY CHEMICAL SOLUTION DEPOSITION**D. SHI[1], L. WANG[1], Q. LI[1], C. STEVEN[2], T. YAMASHITA[2], J. BARRY[2],S. X. DOU[11]INSTITUTE FOR SUPERCONDUCTING & ELECTRONIC MATERIALS, UNIVERSITY OF WOLLONGONG, NSW 2519, AUSTRALIA[2] MESAPLEXX PTY LTD, QLD 4113, AUSTRALIA**ABSTRACT**RECENT ADVANCES IN NANOSTRUCTURE ENGINEERING HAVE STIMULATED EFFORTS TO ARTIFICIALLY INTRODUCE NANOSTRUCTURES AS FLUX PINNING DEFECTS IN THE HIGH TEMPERATURE SUPERCONDUCTOR (HTS) FILM IN ORDER TO IMPROVE THE CRITICAL CURRENT DENSITY AND MAGNETIC FIELD DEPENDENCE. AMONG THE APPROACHES THE DECORATION OF THE SUBSTRATE SURFACES IS A SIMPLE TECHNIQUE FOR INDUCED GROWTH DEFECTS IN HTS THAT IS APPLICABLE TO ANY SUBSTRATE TEMPLATE, AND IT ALLOWS CONTROL OF THE GEOMETRY AND NUMBER DENSITY OF THE NANOPARTICLES PRIOR TO HTS FILM GROWTH. BESIDES THE HTS FILMS, THE SURFACE DECORATION OF NANOPARTICLES HAS WIDELY APPLICATIONS IN OTHER FIELDS, SUCH AS SEMICONDUCTOR, FERROELECTRIC ETC. IN THIS PAPER $BATIO_3$ DECORATION HAS BEEN APPLIED TO $LAALO_3$ SUBSTRATE SURFACES BY USING A SCALABLE AND INEXPENSIVE TECHNIQUE OF SOLUTION-BASED SUSPENSION. DIFFERENT HEATING TREATMENT PROCESS WAS USED TO ANNEAL AMORPHOUS FILMS, AND THE EFFECT OF THE ANNEALING CONDITION ON THE SHAPE, SIZE, AND DENSITY OF THE $BATIO_3$ PARTICLES HAS BEEN SYSTEMATICALLY INVESTIGATED.

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1MPA-06

ADVANCED BUFFER LAYER ARCHITECTURES PREPARED BY CHEMICAL SOLUTION DEPOSITION ***M. BAECKER****[1], M. STEFFENS[1], J. KUNERT[1], C. EDNEY[2], D. WESOLOWSKI[2], P. CLEM[2];* [1]ZENERGY POWER GMBH, [2]SANDIA NL. — CHEMICAL SOLUTION DEPOSITION (CSD) IS CONSIDERED TO BE THE PROCESS WITH THE HIGHEST ECONOMIC POTENTIAL BUT ALSO WITH THE HIGHEST TECHNICAL AND SCIENTIFIC CHALLENGES FOR THE CONTINUOUS FABRICATION OF LONG LENGTH COATED CONDUCTORS. IN PARTICULAR THE DEPOSITION OF HIGHEST TEXTURED AND DENSE BUFFER LAYER BY CSD PROCESSES IS STILL A CHALLENGE.THE BUFFER LAYERS MOSTLY USED WORLDWIDE IS LANTHANUMZIRCONATE / CERIUMOXIDE. THIS WELL ESTABLISHED BUFFER ARCHITECTURE ALLOWS GOOD SUPERCONDUCTING PERFORMANCE OF THE SUBSEQUENT DEPOSITED HTS LAYER. NEVERTHELESS THIS COMBINATION IS LIMITED DUE TO REACTION WITH THE HTS MATERIAL AND POROSITY. AS KNOWN FROM SINGLE CRYSTAL EXPERIMENTS TITANATES ARE A PROMISING ALTERNATIVE AS BUFFER LAYERS. THE CHALLENGE HERE IS THE LARGE LATTICE MISMATCH BETWEEN STRONTIUMTITANATE AND NICKEL-TUNGSTEN-SUBSTRATE.IN THIS WORK THE CONTINUOUS PROCESSING OF DOPED TITANATE BUFFER ARCHITECTURES WILL BE PRESENTED. THE INFLUENCE OF DOPANTS, ADDITIVES AND DEPOSITION METHODS LIKE DIP COATING AND INK-JET PRINTING WILL BE DISCUSSED. THEIR CRYSTALLINE PROPERTIES AND THEIR POTENTIAL FOR HTS LAYER PERFORMANCE WILL BE COMPARED WITH STANDARD LANTHANUMZIRCONATE / CERIUMOXIDE BUFFER ARCHITECTURES.

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1MPA-07

OPTIMIZATION OF THE INITIAL STAGE OF MAGNESIUM OXIDE TEMPLATE FILM TEXTURE DEVELOPMENT USING ION ASSIST BEAM DEPOSITION FOR HTS COATED CONDUCTORS ***J. R.***

GROVES[1]*, V. MATIAS*[2]*, L. STAN*[2]*, R. F. DEPAULA*[2]*, R. H. HAMMOND*[1]*, B. M. CLEMENS*[1]*;* [1]STANFORD UNIVERSITY, [2]LOS ALAMOS NATIONAL LABORATORY. — ION BEAM ASSISTED DEPOSITION (IBAD) OF BIAXIALLY TEXTURED THIN FILMS OF MAGNESIUM OXIDE (MGO) TEMPLATE LAYERS REMAINS AN ENABLING TECHNIQUE FOR DEPOSITING HIGH-PERFORMANCE SECOND-GENERATION HIGH-TEMPERATURE SUPERCONDUCTOR WIRES. UNDERSTANDING THE FUNDAMENTAL MECHANISM OF IBAD MGO TEXTURE DEVELOPMENT IS CRITICAL TO OPTIMIZING AND IMPROVING COATED CONDUCTOR PERFORMANCE. WE HAVE FOCUSED OUR EFFORT ON THE INITIAL STAGE OF NUCLEATION AND GROWTH OF IBAD MGO. WE HAVE FOUND THAT THE INITIAL NUCLEATION STAGE OF DEPOSITION IS CRITICAL IN DEFINING THE TEXTURE IN IBAD MGO. THIS STAGE OF GROWTH IS EXAMINED IN DETAIL USING A NOVEL IN-SITU TECHNIQUE AS WELL AS COMPLEMENTARY EX-SITU CHARACTERIZATION METHODS AND A MODEL FOR THE MECHANISM IS PRESENTED. WE HAVE FOUND THAT THE ADDITION OF A THIN (LESS THAN 2 NM) LAYER OF POLYCRYSTALLINE MGO, PRIOR TO IBAD MGO DEPOSITION WETS THE SUBSTRATE SURFACE AND ALLOWS FOR TEXTURE DEVELOPMENT INDEPENDENT OF THE NUCLEATION LAYER. RESULTS OF THIS STUDY ARE PRESENTED ON BARE SILICON SURFACES AND SILCON SURFACES COATED WITH SILICON NITRIDE, YTTRIUM OXIDE AND ALUMINUM OXIDE. OUR OBSERVATIONS SUGGEST THAT THE ROLE OF THE NUCLEATION SURFACE MAY NOT BE AS CRITICAL AS WAS ONCE BELIEVED.

SPONSORED BY DOE OFFICE OF ELECTRICITY DELIVERY AND ENERGY RELIABILITY

1MPA-08

STUDY OF (00L) TILTING OF IBAD MGO AND DEVELOPMENT OF IBAD AND BUFFER PROCESSES ON PLANARIZED SUBSTRATES ***X. XIONG***[1]*, Y. QIAO*[1]*, A. RAR*[1]*, S. KIM*[1]*, M. JONES*[1]*, J. CAO*[2]*, G. SHI*[2]*, V. SELVAMANICKAM*[2]*;* [1]SUPERPOWER INC, [2]UNIVERSITY OF HOUSTON. — TILTING OF THE [00L] DIRECTION OF ION BEAM ASSISTED DEPOSITION (IBAD) MGO FROM THE SUBSTRATE NORMAL HAS BEEN FOUND TO CONTRIBUTE TO SHIFT IN THE PEAK IN THE ANGULAR DEPENDENCE OF CRITICAL CURRENT OF COATED CONDUCTORS WHEN A MAGNETIC FIELD IS APPLIED CLOSE TO THE VICINITY OF B || A-B. IT WAS FOUND THAT THE TILT ANGLE OF THE HOMO-EPI MGO LAYER AND $LAMNO_3$ (LMO) LAYERS ARE THE SAME. THE TILTING ANGLE IS FOUND TO BE < 3 DEGREES UNDER IBAD PROCESS CONDITIONS THAT YIELDS TEXTURE BETWEEN 4.4 DEGREES TO 12 DEGREES FULL-WIDTH-AT-HALF MAXIMUM (FWHM). WE HAVE OBSERVED THAT THE TILT ANGLE VARIES FROM 0° TO 3° AND WE ARE STUDYING THE INFLUENCE OF PROCESS CONDITIONS ON THE TILT ANGLE AND THE SUBSEQUENT INFLUENCE ON THE ANGULAR DEPENDENCE OF CRITICAL CURRENT IN THE PRESENCE OF A MAGNETIC FIELD. ANOTHER AREA OF CURRENT RESEARCH IS THE DEVELOPMENT OF IBAD AND BUFFER PROCESS CONDITIONS ON UNPOLISHED SUBSTRATES THAT HAVE BEEN SMOOTHENED BY PLANARIZATION. PLANARIZATION PROVIDES THE BENEFIT OF COMBINING THE EFFECTS OF TWO PROCESS STEPS (SUBSTRATE ELECTROPOLISHING AND ALUMINA BARRIER DEPOSITION) INTO ONE AND, HENCE, ENABLES HIGHER THROUGHPUT

1MPB-01

STUDY OF MGO-BASED BUFFER LAYER ARCHITECTURE FOR THE DEVELOPMENT OF ALTERNATIVE YBCO COATED CONDUCTOR *A. VANNOZZI*[1]*, V. GALLUZZI*[1]*, A. MANCINI*[1]*, A. RUFOLONI*[1]*, A. AUGIERI*[1]*, A. ANGRISANI ARMENIO*[1]*, S. GAUDIO*[1]*, L. CIONTEA*[2]*, G. THALMAIER*[2]*, T. PETRISOR*[2]*,* ***G. CELENTANO***[1]*;* [1]ENEA, [2]U.T. CLUJ. — MGO FILM IS WIDELY USED AS FIRST BUFFER LAYER IN IBAD-YBCO COATED CONDUCTORS, WHEREAS THERE ARE ONLY A FEW EXAMPLES OF ITS EMPLOYMENT ON RABITS YBCO COATED CONDUCTORS. NEVERTHELESS MGO, THOUGH CHALLENGING IN TERMS OF LATTICE PARAMETER AND EPITAXY, CAN EFFECTIVELY PASSIVE THE METAL SUBSTRATE THUS ENABLING THE USE OF NI-CU-BASED ALLOY TAPES. SUCH SUBSTRATES DEVELOP A VERY SHARP CUBE TEXTURE AND AT THE SAME TIME CAN BE SAFELY HANDLED ALSO WHEN THEIR THICKNESS IS AS LOW AS 40 UM.EPITAXIAL MGO FILM WAS DEPOSITED BY E-BEAM EVAPORATION AT 400 °C ON BIAXIALLY TEXTURED METAL SUBSTRATES. A TRANSIENT PD LAYER WAS USED TO ALLEVIATE THE LATTICE MISMATCH BETWEEN MGO AND SUBSTRATE AND TO ENHANCE FILM ADHESION. DUE TO THE REDUCED DIFFUSION OF OXYGEN IN MGO, THIS TEMPLATE IS EFFECTIVE AGAINST SUBSTRATE OXIDATION EVEN IN THE EXTREME CONDITIONS TYPICAL OF THE YBCO GROWTH. ON SUCH A TEMPLATE, LAMNO3 (LMO), LA2ZR2O7 (LZO) AND BAZRO3 (BZO) FILMS WERE EPITAXIALLY DEPOSITED BY EITHER PLD OR MOD TECHNIQUES. ADDITIONALLY, HIGH QUALITY PLD AND MOD YBCO FILMS WERE SUCCESSFULLY GROWN, EXHIBITING GOOD STRUCTURAL AND SUPERCONDUCTING PROPERTIES AS REVEALED BY CRITICAL TEMPERATURE TC AND CRITICAL CURRENT DENSITY JC EXCEEDING 90 K AND 1 MA/CM2 AT 77 K IN SELF-FIELD, RESPECTIVELY.

1MPB-02

STUDIES OF MULTI-LAYER $CE_{0.8}GD_{0.2}O_{1.9}$ (CGO) THICK FILMS DEPOSITED ON HOME-MADE TEXTURED NIW SUBSTRATES BY A SIMPLE METAL-ORGANIC DEPOSITION TECHNIQUE ***M. LIU;*** BEIJING UNIVERSITY OF TECHNOLOGY. — A MULTI-LAYER $CE_{0.8}GD_{0.2}O_{1.9}$ (CGO) THICK BUFFER LAYER WAS SUCCESSFULLY GROWN ON THE HOME-MADE TEXTURED NI5W SUBSTRATES FOR YBCO COATED CONDUCTORS BY A SIMPLE MOD TECHNIQUE. THE PREPARATION AND CHARACTERIZATION OF SAMPLES ARE DISCUSSED IN DETAIL. THE PRECURSOR SOLUTION WAS SPIN COATED ON NI5W SUBSTRATES AND HEAT-TREATED AT 1100 ^{0}C IN A MIXTURE GAS OF 5% H_2 IN AR FOR AN HOUR. A MULTI-LAYER CGO THICK BUFFER LAYER WAS FABRICATED BY REPEATING ABOVE PROCESS FOR SEVERAL TIMES. X-RAY STUDIES INDICATED THAT THE MULTI-LAYER CGO THICK FILMS HAD THE SAME GOOD OUT-OF-PLANE AND IN-PLANE TEXTURES AS A SINGE CGO FILM HAD. AFM INVESTIGATIONS REVEALED THAT ARITHMETICAL MEAN ROUGHNESS OF THE GD DOPED AND UNDOPED FILMS BECAME FIRST LARGE, SUBSEQUENTLY BECAME SMALL WITH INCREASING COATING TIMES. HOWEVER, DOPED FILMS HAD DENSER AND SMOOTHER SURFACE THAN THAT OF UNDOPED

FILMS WITH SAME COATING TIME. ADDITIONALLY, THE SCANNING AUGER NANOPROBE MEASURE INDICATED THAT THE OBTAINED CGO FILM COULD EFFECTIVELY PREVENT THE DIFFUSION OF NI FROM THE NI5W SUBSTRATE. THE HIGH QUALITIES OF YBCO FILMS ON OBTAINED MULTI-LAYER CGO THICK FILM FURTHER PROVED THAT OUR MOD TECHNIQUE IS VERY PROMISING FOR DEVELOPMENT OF BUFFER LAYER ARCHITECTURE FOR YBCO COATED CONDUCTORS, DUE TO ITS LOW COST AND SIMPLE PROCESS.

THIS WORK IS FINANCIALLY SUPPORTED BY THE NATIONAL NATURAL SCIENCE FOUNDATION OF CHINA (50802004)

1MPB-03

PREPARATION OF A NOVEL $CE_{1-X}LA_XO_2$ /$GD_2ZR_2O_7$ BUFFER LAYER STACK ON NIW ALLOY SUBSTRATES BY THE MOD ROUTE ***Y. ZHAO***[1]*, D. PAVLOPOULOS*[1]*, A. ABRAHAMSEN*[1]*, J. GRIVEL*[1]*, M. ZIMMERMANNZ*[2]*;* [1]RISØ DTU, [2]HAMBURGER SYNCHROTRONSTRAHLUNGSLABOR, DEUTSCHES ELEKTRONEN-SYNCHROTRON,. — AN OPTIMIZED BUFFER LAYER ARCHITECTURE FOR ROLLING-ASSISTED BIAXIALLY TEXTURED SUBSTRATE ROUTE IS PROPOSED AND DEVELOPED BY THE METAL ORGANIC DEPOSITION METHOD. THE MAJOR ACHIEVEMENT OF THIS WORK IS A $CE_{1-X}LA_XO_2$ LAYER WITH PREFECT LATTICE MISMATCH WITH THE SUPERCONDUCTOR LAYER, WHICH IS CHOSEN AS CAP LAYER, WHILE A 120 NM THICK $GD_2ZR_2O_7$ FILM ACTS AS BARRIER LAYER. THE EFFECT OF FABRICATION PARAMETERS, SUCH AS DIP COATING TIMES, ANNEALING ATMOSPHERE, AS WELL AS SINTERING TEMPERATURE ON THE TEXTURE AND MORPHOLOGY OF THE CRYSTALLIZED FILM WERE DISCUSSED. IN PARTICULAR, THE TEXTURE QUALITY AND THE EPITAXIAL RELATIONSHIP BETWEEN THE BUFFER LAYER STACK AND THE METALLIC SUBSTRATE WERE STUDY BY SYNCHROTRON X-RAY FOR THE FIRST TIME. ALL THE RESULTS SHOW THAT REPRODUCIBLY TEXTURED, DENSE AND CRACK-FREE $CE_{1-X}LA_XO_2$ /$GD_2ZR_2O_7$ BUFFER LAYER STACKS COULD BE OBTAINED ON NIW ALLOY SUBSTRATE, DEMONSTRATING THE STRONG PROSPECT OF NOVEL BUFFER LAYER STACK FOR THE PRACTICAL DEVELOPMENT OF COATED CONDUCTORS.

1MPB-04

MOCVD OF YBCO AND OXIDE BUFFER LAYERS ON TEXTURED NI-TAPES *O. STADEL*[1]*, **R. MUYDINOV***[2]*, J. SCHMIDT*[1]*, H. KEUNE*[1]*, G. BRÄUER*[2]*;* [1]PERCOTECH AG, [2]TECHNICAL UNIVERSITY OF BRAUNSCHWEIG. — CSD AND MOCVD TECHNIQUES MIGHT ALLOW PRODUCING LOW COST COATED CONDUCTORS ON THE RABITS BASIS AND USING THE SIMPLEST LAYER ARCHITECTURES. MOCVD-YBCO ON SINGLE CSD-LZO OR DOUBLE MOCVD BUFFER LAYERS ENABLE REACHING CURRENT DENSITIES OF 1-2 MA/CM2.OXIDE BUFFER LAYERS WERE DEPOSITED ONTO MAGNETIC AND NONMAGNETIC NI-TAPES AT LOW OXYGEN PARTIAL PRESSURE BY MOCVD. SUPERCONDUCTING LAYERS WERE OBTAINED BY MOCVD ON CSD- AND MOCVD-BUFFER LAYERS.A NEW MOCVD SETUP IS DESIGNED FOR FABRICATION OF UP TO 100 M LONG AND 1 CM WIDE TAPES. THIS MOCVD EQUIPMENT CONSISTS OF SEVERAL MOCVD-REACTORS CONNECTED TO ONE REEL-TO-REEL LINE, TO BE USED SIMULTANEOUSLY. THE SYSTEM ENABLES TO DEPOSIT IN A ONE PASS BUFFER AND SUPERCONDUCTING LAYERS. UP TO 50 M LONG TAPE PIECES WERE USED. MOCVD BUFFER AND YBCO FILMS HAVE BEEN DEPOSITED AT SPEEDS OF 5-20 M/H. 1 µM THICK YBCO LAYERS WERE OBTAINED WITH A CURRENT DENSITY OF MAX. 1.5 MA/CM2, WHICH CORRESPONDS TO 150 A/CM-WIDTH.

THE AUTHORS THANK ZENERGY POWER, NEXANS SUPERCONDUCTORS AND SUPEROX FOR THE DELIVERY OF BUFFERED TAPES.

1MPB-05

INK-JET PRINTING OF FLUORINE-FREE WATER-BASED PRECURSORS FOR COATED CONDUCTORS ***I. VAN DRIESSCHE***[1]*, J. FEYS*[1]*, M. BÄCKER*[2]*, K. DE BUYSSER*[1]*, P. LOMMENS*[1]*, V. CLOET*[1]*, P. VERMEIR*[1]*, I. CARDINAEL*[1]*, N. VAN DE VELDE*[1]*, V. NARAYANAN*[1]*, B. GLOWACKI*[3]*;* [1]GHENT UNIVERSITY, BELGIUM, [2]ZENERGY POWER GMBH, GERMANY, [3]CAMBRIDGE UNIVERSITY, UK. — THE ACHIEVEMENT OF LOW-COST DEPOSITION TECHNIQUES FOR HIGH CRITICAL CURRENT YBA2CU3O7−Δ-COATED CONDUCTORS IS ONE OF THE MAJOR OBJECTIVES IN ACHIEVING A WIDESPREAD USE OF SUPERCONDUCTIVITY IN POWER APPLICATIONS. CHEMICAL SOLUTION DEPOSITION TECHNIQUES ARE APPEARING AS A VERY PROMISING METHODOLOGY.THE DEPOSITION OF BUFFER LAYERS AND $YBA_2CU_3O_{7-\Delta}$ COATINGS ON NIW SUBSTRATES USING A DROP-ON-DEMAND INK-JET PRINTING TECHNIQUE WAS INVESTIGATED IN THIS STUDY. SOME OF THE GREAT ADVANTAGES OF THIS DEPOSITION TECHNIQUE ARE CONTROL OF THE WASTE OF THE PRECURSOR SOLUTION, THE PREVENTION OF SOLVENT EVAPORATION AND THE POSSIBILITY TO SWITCH QUITE EASILY FROM DEPOSITING A COATING TO A WELL-DEFINED PATTERN. THIS CAN BE DONE BY TUNING THE SOLVENT AND PRINT PARAMETERS.THE PRECURSORS USED WERE BASED ON FLUORINE-FREE SOL-GEL SYSTEMS OF METAL ACETATES USING WATER AS THE PRIMARY SOLVENT. TO MAINTAIN STABILITY IN THE PRECURSORS, CHELATING AGENTS WERE EXPLORED. AFTER DEPOSITION OF THE AQUEOUS FILM, AN APPROPRIATE HEAT TREATMENT WAS APPLIED. THE RESULTING CERAMIC FILMS WERE ANALYSED WITH OPTICAL MICROSCOPY, XRD, FIB/TEM AND ELECTRICAL CHARACTERISATION.

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1MPB-06

DEVELOPMENT OF SIMPLIFIED BUFFER ARCHITECTURES BASED ON IBAD-TIN FOR COATED CONDUCTOR APPLICATIONS *R. GÄRTNER, R. HÜHNE, L. SCHULTZ, **B. HOLZAPFEL**;* IFW DRESDEN. — ION BEAM ASSISTED DEPOSITION (IBAD) IS ONE OF THE MAJOR APPROACHES TO PROVIDE BIAXIALLY TEXTURED TEMPLATES FOR REBCO COATED CONDUCTORS. WHEREAS IBAD-MGO LAYERS ARE ALREADY IN USE FOR LONG-LENGTH PRODUCTION, OTHER MATERIALS LIKE TIN MIGHT BE APPLIED IN THE SAME WAY AS THEY SHOW A SIMILAR STRONG CUBE TEXTURE AT A

THICKNESS OF LESS THAN 10 NM, IF AN AMORPHOUS OR NANOCRYSTALLINE SEED LAYERS IS USED. ACCORDINGLY, CUBE TEXTURED IBAD-TIN LAYERS HAVE BEEN DEPOSITED REACTIVELY USING PULSED LASER DEPOSITION ON POLISHED METAL TAPES AS HASTELLOY OR STAINLESS STEEL. THE INFLUENCE OF DIFFERENT AMORPHOUS OR NANOCRYSTALLINE SEED LAYER AS WELL AS OF THE ROUGHNESS OF THE USED METAL TAPE ON THE IN-PLANE TEXTURE HAS BEEN STUDIED. AN AMORPHOUS METALLIC TAXNI1-X SEED LAYER WAS TESTED SUCCESSFULLY FOR THE IBAD-PROCESS LEADING TO HIGHLY TEXTURED TIN FILMS WITH AN IN-PLANE ORIENTATION BELOW 10°. FURTHERMORE, SUITABLE SINGLE BUFFER LAYERS AS FOR EXAMPLE SRZRO3 WERE USED AFTERWARDS DIRECTLY ON TIN. AS A RESULT, BIAXIALLY TEXTURED YBCO LAYERS WERE OBTAINED SHOWING AN IN-PLANE ALIGNMENT BELOW 8° AND CRITICAL CURRENT DENSITIES OF MORE THAN 1 MA/CM².

1MPB-07

INFLUENCE OF BUFFER LAYER SURFACE MORPHOLOGY ON YBCO CRITICAL CURRENT DENSITY DEPOSITED ON NIW TAPES ***Y. LI****, L. LIU, Z. ZHAO, H. LIU;* SHANGHAI JIAO TONG UNIVERSITY. — YBCO THIN FILMS WERE GROWN ON NIW TAPES UNDER CONTINUOUS MOVING DEPOSITION PROCESS. ALL OF YBCO LAYER, BUFFER LAYER, AND CAP LAYER WERE DEPOSITED IN A COMPACT REEL-TO-REEL PULSED LASER DEPOSITION SYSTEM. SINCE HIGH CRITICAL CURRENT DENSITY IS THE MOST IMPORTANT AND EFFECTIVE FACTOR TO IMPROVE PERFORMANCE/PRICE RATIO OF COATED CONDUCTOR FOR LARGE SCALE APPLICATIONS, WE FOCUSED OUR RESEARCH WORK ON ENHANCING CRITICAL CURRENT DENSITY OF YBCO LAYERS ON NIW SUBSTRATES. IT WAS FOUND THAT SUPERCONDUCTING TRANSPORT PROPERTIES OF YBCO LAYERS WERE DEPENDENT ON NOT ONLY IN-PLANE TEXTURE BUT ALSO SURFACE MORPHOLOGY OF BUFFER LAYERS, ESPECIALLY SURFACE STRUCTURE AND LARGE PARTICLES ALONG GRAIN BOUNDARY IN NIW SUBSTRATES. HIGH QUALITY YBCO LAYERS WITH >4.0X10^6 A/CM^2 (AT 77 K, IN ZERO MAGNETIC FIELD) WERE FABRICATED ON CAP LAYERS WITH NANO-SCALE SURFACE ROUGHNESS.

1MPB-08

DEVELOPMENT OF ALL-CSD PROCESSES FOR COATED CONDUCTORS AT NEXANS: LIMITATIONS AND POSSIBLE SOLUTIONS ***M. O. RIKEL****, J. EHRENBERG, M. KLEIN, S. MAHACHI, B. HOPPE, J. SCHUETZ, J. BOCK;* NEXANS SUPERCONDUCTORS. — NEXANS EXPERIENCE IN DEVELOPING ALL CSD PROCESSES FOR COATED CONDUCTORS (CCS) WITH THE YBCO/$CE_{0.8}GD_{0.2}O_2$(CGO)/$LA_{2+X}ZR_{2-X}O_{7-X/2}$(LZO)/NI5%W-RABITS ARCHITECTURE IS SUMMARIZED.PROCESSES FOR PRODUCING FULLY EPITAXIAL LZO (20 TO 200 NM THICK), CGO (20 TO 50 NM) AND DOUBLE (CGO/LZO) LAYERS ON NI5%W RABITS WERE OPTIMIZED AND SCALED UP TO FABRICATE 10 M LONG BUFFERED RABITS. COMBINED WITH PVD, MOCVD, OR PLD DEPOSITION OF YBCO, THESE SUBSTRATES CAN BE USED FOR PRODUCING CCS WITH THE SIMPLEST ONE BUFFER-LAYER ARCHITECTURE ATTAINING CRITICAL CURRENTS I_C(77 K) UP TO 500 A/CM-W.THE CSD YBCO-TFA PROCESS WAS OPTIMIZED TO ENSURE J_C(77 K, SF) ≤ 3 MA/CM^2 IN 0.3 µM THICK YBCO ON SINGLE CRYSTALLINE (LAO) SUBSTRATES. IN ALL-CSD CONDUCTORS, HIGHLY IRREPRODUCIBLE J_C (< 0.2 MA/CM^2) WERE OBSERVED. WE BELIEVE THAT THIS IRREPRODUCIBILITY IS A PRINCIPAL DISADVANTAGE OF THE CHOSEN CC ARCHITECTURE, IN WHICH THE NEXT LAYER ONLY CLONES, BUT MORE OFTEN DETERIORATES THE OUT-OF-PLANE TEXTURE OF THE PREVIOUS LAYER (BY 15 TO 30% FOR LZO). ESTIMATES SHOW THAT THIS INCREASES THE AMOUNT OF GRAIN BOUNDARIES NOT TRANSPARENT FOR THE SUPERCURRENT CLOSE TO THE PERCOLATION LIMIT FOR THE CURRENT-BREAKING PATH.POSSIBLE WAYS TO OVERCOME THIS DIFFICULTY BY MODIFYING THE BUFFER ARCHITECTURE AND/OR YBCO LAYER ARE DISCUSSED.

FINANCIAL SUPPORT FROM EU (HIPERCHEM, SUPER3C), BMBF (SUPRANANOSOL), AND BAVARIAN MBF (FOROXID) PROJECTS IS ACKNOWLEDGED

1MPC-02

THICKNESS DEPENDENCE OF THE CRITICAL-CURRENT DENSITY AND ITS RELATION TO THE NEAR-INTERFACE CRYSTAL IMPERFECTION IN FLUORINE-FREE-MOD YBCO FILMS ***H. MATSUI****, K. TSUKADA, T. TSUCHIYA, M. SOHMA, I. YAMAGUCHI, T. MANABE, T. KUMAGAI;* NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY (AIST). — WE HAVE STUDIED THE THICKNESS DEPENDENCE OF THE CRITICAL-CURRENT DENSITY (JC) IN THE EPITAXIAL YBCO FILMS GROWN BY FLUORINE-FREE MOD TO UNDERSTAND THE MECHANISM OF THE DEPLETION OF JC IN LARGE THICKNESSES. WE OBTAINED A JC-VS-THICKNESS(T) RELATION WITH GOOD STATISTICS FOR 0.2 < T < 1.4 MM, AND FOUND IT WELL REPRODUCED BY AN INVERSE FUNCTION OF FILM THICKNESS IN THE RANGE OF T > 0.4 MM, BUT NOTICEABLY DEVIATED FROM THAT FUNCTION BELOW 0.4 MM. WE DISCUSS THE IMPLICATIONS OF THIS BEHAVIOR COMPARING WITH THE CROSS-SECTIONAL TEM RESULTS, WHICH SHOW A CHARACTERISTIC LONGITUDINAL DISTRIBUTION OF CRYSTAL DEFECTS NEAR THE FILM/SUBSTRATE INTERFACE. THIS STUDY IS BASED ON A NEW F-FREE MOD PROCESS INCLUDING UV-LAMP IRRADIATION, WHICH WE HAVE RECENTLY DEVELOPED FOR THE FABRICATION OF MICRON-ORDER-THICK EPITAXIAL YBCO FILMS.

1MPC-04

DEVELOPMENT OF ^{TFA}YBCO COATED CONDUCTORS ON ^{ABAD}YSZ SUBSTRATES ***R. VLAD****[1], A. POMAR[1], A. PALAU[1], A. CALLEJA[1], T. PUIG[1], X. OBRADORS[1], A. USOSKIN[2], B. HOLZAPFEL[3], R. HÜHNE[3];* [1]INSTITUT DE CIÈNCIA DE MATERIALS DE BARCELONA, ICMAB-CSIC, CAMPUS UAB, 08193, BELLATERRA, SPAIN, [2]BRUKER HTS GMBH, SIEMENSSTR 88, 63755 ALZENAU, GERMANY, [3]IFW DRESDEN, HELMHOLTZSTRASSE 20, D-01069 DRESDEN,GERMANY. — (00L) ORIENTED CERIA LAYER IS NOW WIDELY USED AS A TEMPLATE FOR GROWTH OF EPITAXIAL HIGH-TEMPERATURE SUPERCONDUCTOR, $Y_1BA_2CU_3O_{7-\Delta}$, WHICH IS A CRITICAL COMPONENT OF SO-CALLED SECOND GENERATION SUPERCONDUCTORS. IN THE PRESENT WORK, SINGLE THIN

$CE_{0.9}ZR_{0.1}O_{2-\Delta}$ (CZO) BUFFER LAYERS WERE PREPARED USING METAL-ORGANIC DECOMPOSITION (MOD) STARTING FROM A SOLUTION CONTAINING CE(III), ZR(IV) ACETYLACETONATES SALTS. THIS PRECURSOR SOLUTION WAS SPIN COATED ON DIFFERENT SUBSTRATES: YSZ SINGLE CRYSTALS AND ALSO ON ^{ABAD}YSZ/STAINLESS STEEL (SS) SUBSTRATES WHICH IS COMPARED WITH A MODEL SYSTEM ^{TFA}YBCO/$^{PLD}CEO_2$/^{ABAD}YSZ/SS. SEVERAL CHARACTERIZATION METHODS WERE USED TO SEE THE STRUCTURE AND THE MORPHOLOGY OF THESE SAMPLES: ATOMIC FORCE MICROSCOPY (AFM), SCANNING ELECTRON MICROSCOPY (SEM), X-RAY DIFFRACTION (XRD) AND REFLECTION HIGH ENERGY ELECTRON DIFFRACTION (RHEED). THE RHEED MEASUREMENTS CONFIRMED THE RESULTS GAVE BY THE AFM, IN WHICH GOOD FLAT SURFACE WITH LARGE GRAINS AND SMALL ROUGHNESS WAS OBSERVED.WE HAVE DEMONSTRATED THE GROWTH OF HIGH PERFORMANCE MOD-YBCO FILMS USING THESE ARCHITECTURES WITH A CRITICAL CURRENT DENSITY JC OF 5.2 MA/CM^2 (SF, 77 K) ACHIEVED ON YSZ SINGLE CRYSTAL AND 1.7 MA/CM^2 ON SS.

MICINN (MAT2008-01022, NAN2004-09133-CO3-01, CONSOLIDER NANOSELECT AND FPU), GENERALITAT DE CATALUNYA (CATALAN PLA DE RECERCA 2009-SGR-770 AND XARMAE), AND EU (HIPERCHEM AND NESPA).

1MPC-05

SURFACE PLANARIZATION OF HASTELLOY SUBSTRATE BY USING Y_2O_3 SOLUTION DEPOSITION ***J. L. PARK***[1]*, O. J. KWON*[1]*, K. E. KO*[1]*, J. Y. KIM*[1]*, S. S. OH*[2]*, C. PARK*[1]*;* [1]SEOUL NATIONAL UNIVERSITY, [2]KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE (KERI). — THE FABRICATION OF COATED CONDUCTOR (CC) USING IBAD-MGO TEMPLATE INVOLVES SEVERAL PROCESS STEPS. THE PROCESS STARTS WITH POLISHING AND CLEANING OF THE POLYCRYSTALLINE METAL TAPE WHICH IS FOLLOWED BY DEPOSITION OF AMORPHOUS SEED LAYER AND BARRIER LAYER (Y_2O_3 AND AL_2O_3). THE ELECTROPOLISHING STEP WHICH IS USED TO IMPROVE THE SMOOTHNESS OF THE METAL SURFACE NEEDS A LOT OF ENERGY AND PRODUCES LARGE AMOUNT OF ACID WASTE. IT HAS BEEN SHOWN THAT THIS ELECTROPOLISHING STEP CAN BE REPLACED BY CHEMICAL SOLUTION DEPOSITION WHICH CAN COVER UP THE UPS AND DOWNS OF THE METAL SURFACE. MULTIPLE COATINGS ARE NEEDED TO COMPLETELY COVER THE ROUGH FEATURES OF THE SURFACE. IN THIS WORK, Y_2O_3 FILMS WERE DIP-COATED ON THE SURFACE OF THE UNPOLISHED METAL TAPE. THE SURFACE MORPHOLOGY AND THE THICKNESS OF THE FILM WERE OBSERVED BY FE-SEM AND AFM. THE EFFECT OF THE VISCOSITY OF THE SOLUTION AND THE NUMBER OF COATINGS WERE INVESTIGATED. TO INVESTIGATE THE EFFECTIVENESS OF THIS CHEMICAL SOLUTION DEPOSITED LAYER AS THE BARRIER, THE COATED TAPE WAS HEAT TREATED UP TO 800^{O}C AND THE COMPOSITION OF THE SURFACE OF THE FILM WAS ANALYZED USING XPS. THESE RESULTS WILL BE PRESENTED TOGETHER WITH THE PRELIMINARY RESULTS OF CC FABRICATED USING THIS PLANARIZED METAL TAPE.

THIS RESEARCH WAS SUPPORTED BY A GRANT FROM CENTER FOR APPLIED SUPERCONDUCTIVITY TECHNOLOGY OF THE 21ST CENTURY FRONTIER R&D PROGRAM FUNDED BY THE MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY, REPUBLIC OF KOREA.

1MPC-06

DEPOSITION OF YBCO THIN FILM BY AEROSOL ASSISTED SPRAY PYROLYSIS USING LOW COST METAL PRECURSORS ***B. J. KIM***[1]*, J. G. KIM*[2]*, J. H. KIM*[2]*, S. X. DOU*[2]*, H. G. LEE*[1]*, G. W. HONG*[1]*;* [1]KOREA POLYTECHNIC UNIVERSITY, [2]ISEM, UNIVERSITY OF WOLLONGONG. — THE APPLICATION OF COATED CONDUCTOR BECAME VERY CLOSE THROUGH INTENSIVE RESEARCH AND DEVELOPMENT EFFORTS BY MANY SCIENTIST AND ENGINEER INVOLVED. THE TECHNICAL CRITERIA FOR THE APPLICATION ARE NEARLY SATISFIED FOR MOST APPLICATIONS. BUT STILL THERE ARE ISSUES FOR COMMERCIALIZATION OF COATED CONDUCTOR, AND COST OF THE PRECURSORS USED FOR MOCVD IS ONE OF THEM. R&D EFFORT FOR A PROCESS CAPABLE OF UTILIZING CHEAP ALTERNATIVE PRECURSORS WERE TRIED BY MANY RESEARCH GROUPS BUT FEW OF THEM SHOWED RESULTS HAVING POTENTIAL FOR REPLACING CURRENT MOCVD VIA FUTURE RESEARCH EFFORTS. SPRAY PYROLYSIS METHOD ADOPTING AEROSOL IS ONE OF POSSIBLE METHOD.Y123 FILMS HAVE BEEN DEPOSITED ON $LAALO_3$ (100) SINGLE-CRYSTAL AND IBAD SUBSTRATES BY SPRAY PYROLYSIS METHOD. ULTRASONIC ATOMIZATION WAS USED IN ORDER TO GENERATE FINE DROPLETS OF PRECURSOR SOLUTION. VARIOUS ORGANIC AND INORGANIC METAL SALT PRECURSORS WERE USED. A PREHEATER WAS LOCATED BETWEEN SPRAYING NOZZLE AND SUBSTRATE FOR FAST DRYING AND ENHANCING DECOMPOSITION OF PRECURSORS. SEM AND XRD OBSERVATION REVEALED THAT DEPOSITED FILMS HAVE SMOOTH AND DENSE MICROSTRUCTURE. THE DEPENDENCE OF OPERATING PARAMETERS SUCH AS CATION STOICHIOMETRY, OXYGEN PARTIAL PRESSURE, SUBSTRATE TEMPERATURE ON THE MICROSTRUCTURE, EVOLUTION OF SUPERCONDUCTING 123 PHASES AND SUPERCONDUCTING PROPERTIES OF DEPOSITED FILMS WILL BE DISCUSSED.

THIS WORK WAS SUPPORTED BY THE AUSTRALIAN RESEARCH COUNCIL LINKAGE INTERNATIONAL PROJECT (LX0989591) AND MANPOWER DEVELOPMENT PROGRAM FOR ENERGY & RESOURCES SUPPORTED BY THE KOREAN MINISTRY OF KNOWLEDGE AND ECONOMY (MKE)

1MPC-07

CHEMICAL SOLUTIONS AND DEPOSITION SYSTEMS FOR BUFFER LAYERS AND YBCO-TFA GROWTH FOR COATED CONDUCTOR ARCHITECTURES ***A. CALLEJA****, S. RICART, X. GRANADOS, C. F. SÁNCHEZ VALDÉS, M. VILARDELL, T. PUIG, X. OBRADORS;* INSTITUT DE CIÈNCIA DE MATERIALS DE BARCELONA-CSIC. — CHEMICAL SOLUTION DEPOSITION (CSD) OFFERS THE PROSPECT FOR COST-EFFECTIVE AND VERSATILE PROCESSING OF COATED CONDUCTORS. GENERALLY, CHEMICAL SOLUTIONS HAVE TO BE CAREFULLY FORMULATED TO OBTAIN DESIRED THICKNESS, PLANARITY AND

NANOSTRUCTURING OF THE DEPOSITED LAYERS. FURTHERMORE, THE DEPOSITION SYSTEM STRONGLY DICTATES THE SOLUTION PHYSICO-CHEMICAL PROPERTIES SUCH AS VISCOSITY, SURFACE TENSION OR VAPOUR PRESSURE IN ORDER TO OBTAIN GOOD FILM MORPHOLOGY AND THUS HIGH PERFORMANCE.IN THIS WORK, INK-JET PRINTING AND SPIN-COATING HAVE BEEN USED AS DEPOSITION SYSTEMS FOR BOTH CERIA-BASED BUFFER AND YBCO-TFA SUPERCONDUCTOR LAYER ON MODEL SINGLE CRYSTALS. WE HAVE STUDIED THE RELATIONSHIP BETWEEN THE FORMULATION OF THE PRECURSOR SOLUTIONS AND THE STRUCTURAL PROPERTIES OF THE DEPOSITED LAYERS SUCH AS THICKNESS HOMOGENEITY, TEXTURE, GRAIN SIZE, SURFACE COVERAGE AND PLANARITY.IN ADDITION, FOR THE CASE OF THE YBCO LAYERS AND BASED ON PREVIOUS EXPERIMENTS AT SUB-ATMOSPHERIC TOTAL PRESSURE, WE ANALYZE THE NUCLEATION AND GROWTH PROCESSES IN A SEPARATE WAY BASICALLY MODIFYING WATER VAPOUR PRESSURE (P_{H2O}) DURING THERMAL PROCESSING. THE AIM IS TO CONTROL THE C-AXIS NUCLEATION AT THE INITIAL STAGES TO ENABLE HIGH GROWTH RATES AT HIGH THICKNESSES. THE CORRESPONDING MICROSTRUCTURE AND ITS RELATIONSHIP WITH THE SUPERCONDUCTING PROPERTIES WILL BE PRESENTED.

WE ACKNOWLEDGE FINANCIAL SUPPORT FROM MICINN (MAT2008-01022, RAMON Y CAJAL), CONSOLIDER NANOSELECT, GENERALITAT DE CATALUNYA (PLA DE RECERCA SGR-770, XARMAE, VALTEC), EU (NESPA AND HIPERCHEM) AND NOVARE-ENDESA (SUPERCABLE PROJECT).

1MPC-08

ANALYSIS OF YBCO PHASE FORMATION IN THIN FILMS GROWN USING A METAL PROPIONATE COATING SOLUTION

A. ANGRISANI ARMENIO[1]*, G. CELENTANO*[1]*, V. GALLUZZI*[1]*, A. MANCINI*[1]*, A. AUGIERI*[1]*, A. RUFOLONI*[1]*, S. GAUDIO*[1]*, A. VANNOZZI*[1]*, T. PETRISOR*[2]*, L. CIONTEA*[2]*, G. CONTINI*[3]*, I. DAVOLI*[4]*;* [1]ENEA, [2]TECHNICAL UNIVERSITY OF CLUJ-NAPOCA, [3]ISTITUTO DI STRUTTURA DELLA MATERIA—CNR, [4]UNIVERSITÀ DI ROMA 'TOR VERGATA'. — $YBA_2CU_3O_{7-\Delta}$*(YBCO)* THIN FILMS WERE SUCCESSFULLY GROWN ON BOTH SINGLE CRYSTALS $SRTIO_3$ AND BUFFERED NI-W METALLIC SUBSTRATE BY CHEMICAL SOLUTION DEPOSITION (CSD), USING LOW FLUORINE COATING SOLUTION. IN CONTRAST TO THE STANDARD TFA METHOD, YTTRIUM AND COPPER TRIFLUOROACETATES *(TFA)* WERE REPLACED BY THE ALCOHOLIC SOLUTIONS OF CU AND Y ACETATES DISPERSED IN PROPIONIC ACID. X-RAY PHOTOELECTRON SPECTROSCOPY *(XPS)* AND X-RAY DIFFRACTION *(XRD)* ANALYSES WERE PERFORMED ON SAMPLES QUENCHED, DURING THE RE-CRYSTALLIZATION PROCESS, AT DIFFERENT TEMPERATURES UP TO THE COMPLETE FORMATION OF THE YBCO FILM. THE XPS AND XRD ANALYSES ON THE PYROLYSED SAMPLES HAVE SHOWN THE PRESENCE OF COPPER OXIDE AND A MIXTURE OF AMORPHOUS Y AND BA OXY-FLUORIDE *(OF)*. DURING THE RE-CRYSTALLIZATION PROCESS, THE OXY-FLUORIDE MATRIX EVOLVES: THE YOF REACTS WITH THE WATER PRESENT IN THE PROCESSING ATMOSPHERE, PRIOR TO THE BAOF COMPOUND. INCREASING THE TEMPERATURE UP TO 700 °C, THE BAOF MATRIX IS COMPLETELY CONVERTED TO A CRYSTALLINE BAF_2. ONCE THE CONVERSION TEMPERATURE IS REACHED (795 °C), THE YBCO PHASE IS ALREADY DETECTED AND CO-EXISTS WITH A BAF_2-BASED PHASE.

1MPD-01

DEVELOPMENT OF THE LONG YBCO COATED CONDUCTOR USING TFA-MOD PROCESS

T. KOIZUMI[1]*, K. KIMURA*[1]*, T. NAKANISHI*[1]*, Y. AOKI*[1]*, N. AOKI*[1]*, T. HASEGAWA*[1]*, Y. IIJIMA*[2]*, T. SAITOH*[2]*, Y. TAKAHASHI*[3]*, Y. MASATERU*[3]*, S. MIYATA*[3]*, Y. YAMADA*[3]*, T. IZUMI*[3]*, Y. SHIOHARA*[3]*;* [1]SWCC SHOWA CABLE SYSTEMS CO., LTD., [2]FUJIKURA LTD., [3]ISTEC-SRL. — WE SUCCESSFULLY DEVELOPED 500M-LONG $YBA_2CU_3O_Y$ (YBCO) COATED CONDUCTOR, WHICH HAS THE IC VALUE OF OVER 300 A/CM-WIDTH (AT 77K IN SELF-FIELD), .WITH A TFA-MOD TECHNIQUE USING A LARGE SCALE BATCH FURNACE. THE BATCH FURNACE IS COMMON DEVICE IN INDUSTRY, BUT THE ONE WE DEVELOPED INCLUDES MANY DESIGN IDEAS FOR APPLYING THE TFA-MOD. THAT TECHNIQUE IS WELL OPERATED IN OUR PROGRAM AND WE COULD OBTAIN YBCO SUPERCONDUCTOR TAPES HAVING 300 A/CM-WIDTH IN REASONABLE YIELD. RECENTLY, WE FABRICATED OVER 10 KM YBCO CONDUCTORS IN 5MM WIDE. THE PRODUCTION YIELD WAS OVER 70%. WHEREIN, WE USED A DIP-COATING TECHNIQUE AND A CONTINUOUS REEL-TO-REEL MULTI-COATING SYSTEM FOR YBCO PRECURSOR FILMS ON $HASTELLOY^{(TM)}$/$GD_2ZR_2O_7$(IBAD)/CEO_2(SPUTTERING) SUBSTRATES. FROM AN INDUSTRIAL VIEWPOINT, THE ISSUES TO APPLY THE YBCO CONDUCTOR FOR TARGET APPLICATIONS SUCH AS TRANSMISSION CABLES AND TRANSFORMERS, MOTORS, ETC. ARE IMPROVEMENT PRODUCTION YIELD FOR PRICE DOWN AND INTRODUCTION OF ARTIFICIAL PINNING CENTERS, ETC FOR IMPROVING THE PERFORMANCE. TO SOLVE THESE PROBLEMS, WE INVESTIGATED THE WEAK-POINT OF OUR PROCESS AND IMPROVED THEM TO GET HIGH YIELD. IN THIS STUDY, WE REPORT THE PROCESS ANALYSIS AND IMPROVEMENT. IN ADDITION, WE WILL REPORTS THE EFFORTS FOR INTRODUCTION OF ARTIFICIAL PINNING CENTERS.

THIS WORK WAS SUPPORTED BY THE NEW ENERGY AND INDUSTRIAL TECHNOLOGY DEVELOPMENT ORGANIZATION (NEDO) AS MATERIALS AND POWER APPLICATION OF COATED CONDUCTORS.

1MPD-03

SMBCO/IBAD-MGO COATED CONDUCTORS FABRICATED BY CO-EVAPORATION AND EX-SITU CONVERSION PROCESS

H. HA[1]*, S. OH*[1]*, J. MAEONG*[2]*, Y. YUN*[1]*, H. KIM*[1]*, R. KO*[1]*, D. HA*[1]*, S. MOON*[1]*, C. PARK*[3]*;* [1]KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE, [2]GYEONGSANG NATIONAL UNIVERSITY, [3]SEOUL NATIONAL UNIVERSITY. — HIGH PRODUCTION RATE OF COATED CONDUCTOR IS NEEDED TO REDUCE FABRICATION COST FOR PRACTICAL APPLICATIONS. LONG SMBCO(SMBA2CU3O7)/IBAD (ION BEAM ASSISTED DEPOSITION) -MGO COATED CONDUCTOR WITH HIGH CRITICAL CURRENT HAS BEEN FABRICATED BY CO-EVAPORATION AND IN-SITU CONVERSION METHOD USING EDDC(EVAPORATION DRUM IN DUAL CHAMBER) IN KOREA. TO

INCREASE THE PRODUCTION RATE, IT IS NEEDED TO SEPARATE DEPOSITION AND CONVERSION PROCESSES. IN THIS STUDY, WE DEMONSTRATE CO-EVAPORATION AND EX-SITU CONVERSION PROCESS TO FABRICATE COATED CONDUCTOR. SM, BA, AND CU WERE CO-DEPOSITED ON IBAD-MGO TEMPLATE UNDER CONTROLLED OXYGEN PARTIAL PRESSURE AND TEMPERATURE. AND, SMBCO/IBAD-MGO COATED CONDUCTOR WAS HEAT-TREATED IN HIGH TEMPERATURE HEATING FURNACE. CRITICAL CURRENT AND TEXTURE OF COATED CONDUCTOR WERE MEASURED AFTER FABRICATION OF COATED CONDUCTOR.

THIS RESEARCH WAS SUPPORTED BY A GRANT FROM CENTER FOR APPLIED SUPERCONDUCTIVITY TECHNOLOGY OF THE 21ST CENTURY FRONTIER R&D PROGRAM FOUNDED BY THE MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY, REPUBLIC OF KOREA.

1MPD-04

SUPERCONDUCTING PROPERTIES OF COATED CONDUCTORS ON TEXTURED HIGHLY ALLOYED NI-W TAPES ***J. HAENISCH****, R. HÜHNE, J. EICKEMEYER, T. D. THERSLEFF, A. KAUFFMANN, J. FREUDENBERGER, L. SCHULTZ, B. HOLZAPFEL;* IFW DRESDEN, HELMHOLTZSTR. 20, 01069 DRESDEN, GERMANY. — THE DEVELOPMENT OF CUBE TEXTURED SUBSTRATES WITH IMPROVED MECHANICAL STRENGTH AND REDUCED FERROMAGNETISM AT LOW TEMPERATURES, AS WELL AS THE IMPROVEMENT OF THE IN-FIELD JC BY THE ADDITION OF ARTIFICIAL PINNING CENTERS, IS A MAJOR GOAL FOR THE PREPARATION OF COATED CONDUCTORS USING THE RABITS APPROACH. RECENTLY, HIGHLY TEXTURED NI-W TAPES WITH W-CONTENTS UP TO 9 AT.% WERE SUCCESSFULLY PREPARED. AN EPITAXIAL Y_2O_3/YSZ/CEO_2 BUFFER ARCHITECTURE HAS BEEN GROWN ON THESE CUBE TEXTURED TAPES USING PULSED LASER DEPOSITION. X-RAY DIFFRACTION AND EBSD MEASUREMENTS SHOW PERFECT TEXTURE TRANSFER THROUGHOUT THE BUFFER ARCHITECTURE. THE EPITAXIAL YBCO LAYERS HAD A SUPERCONDUCTING TRANSITION TEMPERATURE T_C OF ABOUT 90 K WITH A SMALL TRANSITION. IN ADDITION TO PURE YBCO, FILMS WITH ADDITIONAL $BAZRO_3$ NANOPARTICLES SERVING AS PINNING CENTERS ARE PREPARED ON THESE TEMPLATES. THE SUPERCONDUCTING PROPERTIES WERE MEASURED AND COMPARED TO FILMS GROWN ON $SRTIO_3$ SINGLE CRYSTALS. A CRITICAL CURRENT DENSITY J_C OF ABOUT 1 MA/CM² WAS MEASURED AT 77 K IN SELF-FIELD. IT WAS FOUND THAT J_C IS MAINLY LIMITED BY THE GRAIN BOUNDARY NETWORK IN MAGNETIC FIELDS BELOW 4 T. ABOVE THIS CROSS-OVER FIELD IS THE REGION WHERE ADDITIONAL PINNING CENTERS ARE ACTIVE. FINALLY, THE FULL ANISOTROPY OF J_C AT VARIOUS MAGNETIC FIELDS WAS DETERMINED FOR SELECTED SAMPLES IN HIGH MAGNETIC FIELDS.

1MPD-05

FABRICATION OF GD1BA2CU3OX COATED CONDUCTORS FOR HTS CABLES ***K. ABIRU****, Y. SHINGAI, M. KONISHI, K. OHMATSU;* SUMITOMO ELECTRIC INDUSTRIES, LTD. — WE HAVE BEEN FABRICATING GD1BA2CU3OX (GDBCO) COATED CONDUCTORS (CCS) ON TEXTURED CLAD-TYPE SUBSTRATES BY USING PULSED LASER DEPOSITION (PLD) METHOD FOR HIGH TEMPERATURE SUPERCONDUCTING (HTS) POWER CABLES. IN THIS PROJECT, NUMEROUS NUMBERS OF CCS ARE REQUIRED FOR FABRICATING A 66 KV CLASS, 3-IN-ONE HTS CABLE AND FOR THE EVALUATION OF ITS PROPERTIES. IN ORDER TO ACHIEVE THIS, IT IS IMPORTANT TO ENSURE THE STABLE PRODUCTION AND THE HIGH-THROUGHPUT MANUFACTURING.IN THIS WORK, WE HAVE NEWLY INSTALLED A HIGH POWER LASER OF 300 W FOR THE PLD EQUIPMENT, WHICH HAS 1.5 TIMES HIGHER POWER THAN THE PREVIOUS ONE. AS A RESULT, THE STABILITY OF MANUFACTURING AND THE PRODUCTION RATE WERE GREATLY IMPROVED. IN ADDITION, WE HAVE ADOPTED A WIDE TAPE APPROACH USING 30 MM WIDTH SUBSTRATES. SUPERCONDUCTING PROPERTIES OF THE 30 MM WIDTH CCS ARE ALMOST UNIFORM ACROSS THE TAPE WIDTH. WITH THIS APPROACH, 1 KM GDBCO CCS IN 1 CM WIDTH PER MONTH HAVE BEEN ROUTINELY PRODUCED.

A PART OF THIS WORK WAS SUPPORTED BY THE NEW ENERGY AND INDUSTRIAL TECHNOLOGY DEVELOPMENT ORGANIZATION (NEDO).

1MPD-06

NOVEL YBCO GROWTH ON CARBON NANOTUBE STRUCTURES ***A. IGNATIEV****[1], X. ZHANG[1], J. BYKOVA[2], E. GALSTYAN[2], A. KUZNETSOV[2], B. MIRKHAIDAROV[2], A. HOWARD[2], A. ZAKHIDOV[2];* [1]UNIVERSITY OF HOUSTON, [2]UNIVERSITY OF TEXAS AT DALLAS. — THE DEVELOPMENT OF YBCO COATED CONDUCTORS HAS ADVANCED TO THE POINT OF NEAR PRODUCTION CAPABILITIES WORLD-WIDE. HOWEVER, A NUMBER OF MATERIALS SCIENCE ISSUES STILL REMAIN IN TERMS OF THE APPLICATION OF HTS SUPERCONDUCTORS IN UNIQUE ENVIRONMENTS. ONE SUCH PROSPECT IS THE POSSIBILITY OF INTEGRATING HTS MATERIALS WITH CARBON NANOTUBES (CNT). CNT'S HAVE A PLETHORA OF UNIQUE PROPERTIES, NOT THE LEAST OF WHICH IS STRENGTH. FOR THIS PURPOSE WE HAVE UNDERTAKEN A STUDY OF THE INTEGRATION OF YBCO SUPERCONDUCTOR THIS FILMS WITH CNT'S. THE CNT'S WERE PULLED FROM A CNT 'FOREST' TO FORM CNT SHEETS AND FILAMENTS. YBCO WAS DEPOSITED BY MOCVD ONTO THE CNT SHEETS AND FILAMENTS AFTER THE DEPOSITION OF A BUFFER LAYER WHICH WAS NEEDED TO PREVENT THE OXIDATION OF THE CNT'S UNDER THE HIGH GROWTH TEMPERATURE AND OXIDIZING ENVIRONMENT OF THE MOCVD PROCESS. GOOD COVERAGE OF THE CNT WITH YBCO WAS ACHIEVED, WITH X-RAY DIFFRACTION INDICTING NEAR STOICHIOMETRIC YBCO WITH POLYCRYSTALLINE ORDER AS WOULD BE EXPECTED FROM COVERAGE OF A CNT FILAMENT. SEM ANALYSIS INDICATED A CNT FILAMENT FULLY COATED WITH MICROCRYSTALLINE YBCO WITH THE MICROCRYSTALLITES PARTIALLY ORIENTED ALONG THE LENGTH OF THE CNT FILAMENT. CONDUCTIVITY MEASUREMENTS ARE UNDERWAY AS ARE MAGNETIZATION MEASUREMENTS.

THIS WORK WAS PARTIALLY SUPPORTED BY THE CENTER FOR ADVANCED MATERIALS, THE R.A. WELCH FOUNDATION

UNDER GRANT E-632, AND BY AFOSR GRANT FA 9550-09-1-0384.

1MPD-07

THE DEVELOPMENT OF DOUBLE-SIDED COATED CONDUCTOR ***B. W. TAO***[1]*, J. XIONG*[2]*, X. H. ZHAO*[1]*, Y. D. XIA*[1]*, N. ZHANG*[1]*, F. ZHANG*[1]*, Y. R. LI*[1]*;* [1]UESTC, [2]LANL. — A DOUBLE-SIDED STRUCTURE COULD DOUBLE THE CRITICAL CURRENT OF THE COATED CONDUCTORS. THIS IS ESPECIALLY USEFUL FOR INCREASING THE ENGINEERING CRITICAL CURRENT DENSITY. WE DEVELOPED A DOUBLE-SIDED DEPOSITION SYSTEM WHICH CAN SPUTTER Y_2O_3/YSZ/CEO_2 STACKED LAYERS ON THE BOTH SIDES OF NI-W RABITS TAPE. THE BUFFER LAYERS WERE EPITAXIAL GROWTH ON THE SUBSTRATE AND IMPROVED THE TEXTURE, WITH $\Delta\Phi$ ABOUT 5 DEGREE, AND $\Delta\Omega$ ABOUT 3 DEGREE ON BOTH SIDES. ON THE BUFFERED TAPE, YBCO FILMS HAD BEEN DEPOSITED ON BOTH SIDES SIMULTANEOUSLY. THE *JC* WAS MORE THAN 1 MA/CM^2 FOR 1.2 MICROMETER FILMS FOR EACH SIDE.

1MPD-08

POSSIBILITY OF ND:YAG-PLD METHOD FOR FABRICATING REBCO COATED CONDUCTOR ***Y. ICHINO***[1]*, Y. YOSHIDA*[2]*, T. YOSHIMURA*[2]*, Y. KANAZAWA*[2]*, Y. TAKAI*[2]*, M. YOSHIZUMI*[3]*, T. IZUMI*[3]*, Y. SHIOHARA*[3]*;* [1]ECOTOPIA SCIENCE INSTITUTE, NAGOYA UNIVERSITY, [2]DEPT. OF ENERGY ENGINEERING AND SCIENCE, NAGOYA UNIVERSITY, [3]SUPERCONDUCTIVITY RESEARCH LABORATORY. — A ND:YAG LASER IS ENVIRONMENTALLY SAFE AND ECONOMICAL WITH NO POISONOUS OR HAZARDOUS GASES AND NO EXPENSIVE GASES. WE HAVE STUDIED A FABRICATION OF YBCO FILMS BY USING A PLD METHOD WITH A FOURTH HARMONIC ND:YAG LASER. THE YBCO FILMS SHOWED GOOD SUPERCONDUCTING PROPERTIES, FOR EXAMPLE, ON MGO SINGLE CRYSTALLINE AND METAL SUBSTRATES WITH MGO BUFFER LAYER DEPOSITED BY IBAD METHOD, T_C~90 K, J_C>1 MA/CM^2 AT 77 K AND I_C~190 A/CM-WIDTH AT 77 K WITH 2 MICRO-METERS IN THICKNESS. THESE RESULTS MEANS THAT THE ND:YAG-PLD METHOD IS USEFUL FOR PRODUCING YBCO COATED CONDUCTOR. HOWEVER, J_C OF THE FILMS WERE NOT SUFFICIENT. THE REASONS MIGHT BE POOR PINNING CENTERS (PC) WITHIN THE FILMS AND/OR J_C LOSS AT GRAIN BOUNDARIES (GB). THE PC ARE INTRODUCED BY ADDING $BASNO_3$ AND THE J_C ACROSS GB ARE IMPROVED BY CARRIER DOPING (CA DOPING). THEREFORE, IN ORDER TO ENHANCE THE J_C, $BASNO_3$ AND CA ARE DOPED INTO YBCO FILMS BY MEANS OF THE COMBINATORIAL ND:YAG-PLD METHOD. THE COMBINATORIAL METHOD ENABLED US TO GROW AND STUDY A LIBRARY OF SAMPLES RANGING FROM PURE-YBCO TO DOPED-YBCO. WE WILL REPORT THE RAPID OPTIMIZATION OF THE DOPING AMOUNT BY THE COMBINATORIAL METHOD.

THIS WORK WAS PARTLY SUPPORTED BY A GRANT-IN-AID FOR SCIENTIFIC RESEARCH (19676005 AND 20686065) AND ALSO BY THE NEW ENERGY AND INDUSTRIAL TECHNOL. DEVELOPMENT ORGANIZATION AS PROJECT FOR DEVELOPMENT OF MATERIALS & POWER APPL. OF COATED CONDUCTORS.

1MPD-09

PUSHING COATED CONDUCTOR CRITICAL CURRENTS BEYOND 1 KA PER CM WIDTH: STACKS OF YBCO LAYERS ***Y. JUNG****, C. J. SHEEHAN, J. Y. COULTER, V. MATIAS;* SUPERCONDUCTIVITY TECHNOLOGY CENTER, LOS ALAMOS NATIONAL LABORATORY, LOS ALAMOS, NM 87545, USA. — FOR A NUMBER OF SUPERCONDUCTING POWER APPLICATIONS, A HIGH VALUE OF THE ENGINEERING CRITICAL CURRENT DENSITY (J_E) FOR THE WIRE IS CRUCIAL. THE SUPERCONDUCTING LAYER IN THE COATED CONDUCTOR IS TYPICALLY A SMALL PORTION OF THE OVERALL CROSS-SECTION, SO INCREASING THE SUPERCONDUCTOR FRACTION WILL DIRECTLY RESULT IN AN INCREASE OF J_E. HOWEVER, AS THE THICKNESS OF THE SUPERCONDUCTOR IS INCREASED, J_C EVENTUALLY DROPS. WE DESCRIBE A WAY TO INCREASE J_E BY MAKING A STACK OF SUPERCONDUCTING LAYERS USING SEQUENTIAL ION-BEAM ASSISTED DEPOSITION (IBAD)/SUPERCONDUCTOR DEPOSITION. REACTIVE COEVAPORATION BY CYCLIC DEPOSITION AND REACTION (RCE-CDR) IS USED FOR SUPERCONDUCTOR DEPOSITION. USING THIS PROCESS WE HAVE DEMONSTRATED 950 A PER CM-WIDTH IN A 6 μM THICK SUPERCONDUCTING FILM. AN IBAD-TEXTURED LAYER RESETS THE CRYSTALLINE STRUCTURE AFTER EACH SUPERCONDUCTING LAYER, AND WE USE IBAD-MGO FOR THIS PURPOSE. HOWEVER, IBAD-MGO TEXTURING REQUIRES AN EXTREMELY SMOOTH STARTING SURFACE (ABOUT 1 NM RMS ROUGHNESS), WHEREAS THE YBCO LAYER IS TYPICALLY TEN TIMES ROUGHER. WE EMPLOY THE SOLUTION DEPOSITION PLANARIZATION (SDP) PROCESS TO PLANARIZE THE ROUGH SURFACE OF YBCO. THE SDP LAYER IS INSULATING, AND IT PROVIDES FOR AN EASY WAY TO SEPARATE THE SUPERCONDUCTING LAYERS ELECTRICALLY. WE DISCUSS UNIQUE FEATURES OF THE STACKING STRUCTURE THAT ALLOW FOR HIGH I_C, LOW AC LOSSES IN APPLIED FIELDS, AS WELL AS HIGH J_E.

THIS WORK AT LANL IS FUNDED BY THE DEPARTMENT OF ENERGY OFFICE OF ELECTRICITY DELIVERY AND ENERGY RELIABILITY.

1MPE-01

THE MAGNETIC PROPERTIES OF SMBCO COATED CONDUCTOR ON IBAD-MGO TEMPLATE FABRICATED BY EDDC ***K. SONG***[1]*, S. KANG*[1]*, R. KO*[2]*, H. KIM*[2]*, H. HA*[2]*, S. OH*[2]*, S. MOON*[3]*, C. PARK*[4]*, S. YOO*[4]*;* [1]CHONBUK NATIONAL UNIVERSITY, [2]KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE, [3]SUNAM CO., LTD, [4]SEOUL NATIONAL UNIVERSITY. — WE INVESTIGATED THE MAGNETIC PROPERTIES OF SMBCO COATED CONDUCTORS THAT WERE FABRICATED ON LMO/IBAD-MGO SUBSTRATES BY EMPLOYING EDDC (EVAPORATION USING DRUM IN DUAL CHAMBER), WHICH IS SPECIALLY DESIGNED BATCH TYPE CO-EVAPORATION SYSTEM. LMO ($LAMNO_3$) BUFFER LAYER WAS DEPOSITED ON IBAD-MGO TEMPLATES BY PLD METHOD. THE SMBCO (WHICH THICKNESS WAS 2.2 MM) WAS DEPOSITED FOR 90 MINUTES WITHIN CONDITIONS SUCH AS THE EVAPORATION CHAMBER PRESSURE OF 9.4×10^{-5} TORR, THE OXYGEN PARTIAL PRESSURE OF 15 MTORR IN REACTION

CHAMBER, AND THE DRUM TEMPERATURE OF 780 ^{O}C IN THE EDDC SYSTEM. THE MEASUREMENT OF BOTH THE MAGNETIZATION M(H) AND THE RESISTANCE R(T) FOR THE SMBCO COATED CONDUCTOR, WERE CARRIED OUT AT TEMPERATURES BETWEEN 10 AND 100 K IN FIELDS UP TO 8.5 T, USING A PPMS-9 (WITH BOTH ACMS AND DCR OPTIONS, QUANTUM DESIGN). THE SMBCO COATED CONDUCTOR EXHIBITED T_C OF 92 K AND I_C OF 105 A/CM AT 77 K IN SELF-FIELD. THE LOWER CRITICAL FIELD H_{C1} AND THE UPPER CRITICAL FIELD H_{C2} NEAR T_C OF THE SMBCO COATED CONDUCTORS HAVE BEEN ESTIMATED BY THE MAGNETIZATION M(H) AND THE RESISTANCE R(T) APPROACHES, RESPECTIVELY. THE CRITICAL CURRENT DENSITY (J_C) VALUES HAVE BEEN ESTIMATED FROM THE M(H) DATA, USING BEAN MODEL, AS WELL. THESE AND OTHER RESULTS WILL BE DISCUSSED.

THIS RESEARCH WAS SUPPORTED IN PART BY BOTH THE CHONBUK NATIONAL UNIVERSITY R&D PROGRAM AND THE CAST.

1MPE-02

ADVANCED FAST RCE PROCESS FOR REBCO COATED CONDUCTOR ***J. LEE****, S. YOON, H. LEE, S. MOON;* SUNAM CO.,LTD. — REBCO LONG COATED CONDUCTOR(CC) DERIVED FROM ADVANCE FAST RCE(REACTIVE CO-EVAPORATION) PROCESS BY USING A 30 KW ELECTRON GUN, WHICH CAN CONTROL DEPOSITION RATE OF EACH MATERIALS AUTOMATICALLY.FOR THE COMMERCIALIZATION OF CC, HOWEVER, WE HAVE TO REDUCE PRODUCTION COST BY SPEEDING UP THE DEPOSITION PROCESS AS WELL AS BY RAISING IC VALUES. FROM THIS REASON, WE SET UP A NEW RCE PILOT SYSTEM FOR HIGH RATE DEPOSITION, WE CALLED "FAST RCE PROCESS", SIMILAR TO THE LIQUID PHASE EPITAXY (LPE) PROCESS. MINIMUM PROCESS SPEEDS IN EXCESS OF 300 M/HR (4 MM WIDTH) ARE ATTAINED FOR "FAST RCE SYSTEM".OUR CC CONSISTS OF REBCO SUPERCONDUCTING LAYER WHICH IS DEPOSITED BY IN-SITU RCE ON IBAD TEMPLATE THE ARCHITECTURE OF WHICH IS $LAMNO_3$/EPI-MGO/IBAD-MGO/Y_2O_3/AL_2O_3/ELECTRO-POLISHED HASTELLOY. SOME TYPICAL CHARACTERISTICS OF OUR HIGHLY TEXTURED 1.5 *M*M-THICK REBCO LAYER INCLUDE; IN-PLANE FWHM IS LESS THAN 4°, AND CRITICAL CURRENT EXCEEDS 400 A/WIDTH FOR > 100 M IN LENGTH CC.

THIS RESEARCH WAS SUPPORTED BY A GRANT FROM CENTER FOR APPLIED SUPERCONDUCTIVITY TECHNOLOGY OF THE 21ST CENTURY FRONTIER R&D PROGRAM FUNDED BY THE MINISTRY OF SCIENCE AND TECHNOLOGY, REPUBLIC OF KOREA.

1MPE-03

COATED CONDUCTORS OF $YBA_2CU_3O_{7-\Delta}$ (YBCO) USING PECHINI´S SOLUTION ***P. A. GARCÉS****, M. B. LÓPEZ, A. MARIÑO;* UNIVERSIDAD NACIONAL DE COLOMBIA. — COATED CONDUCTORS OF YBCO (123) WERE DEPOSITED ON METALLIC SUBSTRATES OF NI%5W WITH A CEO_2 BUFFER LAYER AT DIFFERENT DIPPING VELOCITIES INTO A PRECURSOR SOLUTION. THE PRECURSOR, A PECHINI´S SOLUTION WAS PREPARED USING ACETATES LIKE $(OOCCH_3)_3Y$. $4H_2O$, $(OOCCH_3)_2BA$, $(OOCCH_3)_2CU$. H_2O OF HIGH PURITY IN STOICHIOMETRIC RATIOS. THE COATED CONDUCTORS WERE TREATED IN A TWO STAGE ANNEALING PROCESS: HEATED UP TO 850°C AND A SUBSEQUENTLY ANNEALING AT 500°C IN OXYGEN FLUX. THE SAMPLES WITH THICKNESS ≤ 1 µM SHOWED TC AROUND 90 K, TRANSITION WIDTH AROUND 1K AND CRITICAL CURRENT DENSITIES IN THE ORDER OF 1 X 10^6 A / CM^2. THESE COATED CONDUCTORS DISPLAYED A GRANULAR CHARACTER WITH GRAIN SIZES WHICH, DEPEND OF DIP VELOCITY AS DETERMINED BY ELECTRON SCANNING MICROSCOPY (SEM). THE X-RAY DIFFRACTION PATTERNS FIT WELL MAINLY TO THE YBCO (123) CRYSTALLINE STRUCTURE.**KEYWORDS:** YBCO, DIP-COATING, PECHINI´S SOLUTIONS, COATED CONDUCTORS.

1MPE-04

INK-JET PRINTING OF WATER-BASED YBCO COATINGS AND PATTERNS ***P. VERMEIR***[1]*, J. FEYS*[1]*, I. CARDINAEL*[1]*, S. HOPKINS*[2]*, J. BENNEWITZ*[3]*, P. LOMMENS*[1]*, K. DE BUYSSER*[1]*, I. VAN DRIESSCHE*[1]*;* [1]GHENT UNIVERSITY, BELGIUM, [2]UNIVERSITY OF CAMBRIDGE, UK, [3]ZENERGY POWER GMBH, GERMANY. — FOR THE MOMENT, $YBA_2CU_3O_X$ (YBCO) REMAINS THE MATERIAL OF CHOICE IN THE PRODUCTION OF LONG LENGTH COATED CONDUCTORS. THE COATED CONDUCTOR DESIGN WHICH IS MOST PROMISING IS BASED ON A METALLIC NI-5%W TAPE WITH A $LA_2ZR_2O_7$ - CEO_2 BUFFER STRUCTURE ON TOP. IN THIS WORK, THE DEPOSITION OF YBCO COATINGS ON $SRTIO_3$ AND ON BUFFERED NIW SUBSTRATES USING PIEZOELECTRIC INK-JET PRINTING (DIMATIX MATERIALS PRINTER AND MICROFAB SINGLE-NOZZLE) WAS INVESTIGATED. THE COMBINATION OF A CHEMICAL ROUTE WITH INK-JET PRINTING GIVES SOME IMPORTANT ADVANTAGES OVER TRADITIONAL DEPOSITION TECHNIQUES (E.G. SPINCOATING) SUCH AS CONTROL OF THE WASTE OF THE PRECURSOR SOLUTION, PRODUCTION IN LONG LENGTHS AND THE POSSIBILITY TO SWITCH QUITE EASILY FROM DEPOSITING A COATING TO A MULTIFILAMENTARY SUPERCONDUCTOR. THE PRECURSOR SOLUTIONS FOR PRINTING YBCO LAYERS ARE BASED ON A FLUORINE-FREE SOL-GEL SYSTEM CONTAINING METAL ACETATES AND WATER AS PRIMARY SOLVENT. TO MAINTAIN STABILITY IN THE PRECURSORS, THE INFLUENCE OF CHELATING AGENTS SUCH AS TRIETHANOLAMINE AND EDTA WAS EXPLORED. THIS STUDY WAS SPECIFICALLY CONCERNED WITH THE OPTIMIZATION OF THE INK RHEOLOGY AND PRINTING PARAMETERS NECESSARY TO OBTAIN A WELL TEXTURED YBCO COATING. AFTER AN APPROPRIATE HEAT TREATMENT, THE RESULTING CERAMIC FILMS WERE ANALYSED WITH OPTICAL MICROSCOPY, SEM AND XRD. SUPERCONDUCTING PROPERTIES OF THE YBCO FILMS WERE INVESTIGATED.

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1MPE-05

EX-SITU **CONVERSION OF CO-EVAPORATED PRECURSORS FOR FABRICATING SMBCO COATED CONDUCTORS** ***J. LEE***[1]*, K. KO*[1]*,*

H. KIM[2], S. MOON[2], H. HA[3], S. OH[3], S. YOO[1]; [1]DEPARTMENT OF MATERIALS SCIENCE & ENGINEERING, SEOUL NATIONAL UNIVERSITY, KOREA, [2]SUPERCONDUCTOR, NANO & ADVANCED MATERIALS CORPORATION, ANYANG, KOREA, [3]SUPERCONDUCTIVITY RESEARCH CENTER, KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE, CHANGWON, KOREA. — WE SUCCESSFULLY FABRICATED HIGH-J_C $SMBA_2CU_3O_{7-D}$(SMBCO) COATED CONDUCTORS (> 1MA/CM^2 AT 77K IN A SELF-FIELD) BY *EX-SITU* CONVERSION OF CO-EVAPORATED PRECURSORS ON THE $LAMNO_3$-BUFFERED IBAD-MGO SUBSTRATES. THE IBAD-MGO SUBSTRATE WAS PREPARED ON Y_2O_3/AL_2O_3/HASTELLOY TAPES. IN ORDER TO OBTAIN THE STABLE SM/BA/CU/O PRECURSORS, WE USED THE CO-EVAPORATION METHOD, CALLED EDDC (EVAPORATION USING DRUM IN DUAL CHAMBER). THE PRECURSOR FILMS WERE ANNEALED AT VARIOUS HIGH TEMPERATURES IN REDUCED OXYGEN PARTIAL PRESSURES. GRAIN ORIENTATIONS OF SMBCO FILMS AND THUS THEIR SUPERCONDUCTING PROPERTIES WERE FOUND STRONGLY DEPENDENT ON THE NOMINAL COMPOSITION OF PRECURSORS AND ANNEALING CONDITIONS. HIGH-J_C SMBCO FILMS COULD BE OBTAINED ONLY FROM HIGHLY *C*-AXIS ORIENTED FILMS.

THIS WORK WAS SUPPORTED BY A GRANT FROM CENTER FOR APPLIED SUPERCONDUCTIVITY TECHNOLOGY OF THE 21ST CENTURY FRONTIER R&D PROGRAM FUNDED BY THE MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY, REPUBLIC OF KOREA.

1MPE-06

VECTOR MAGNETIC FIELD CRITICAL CURRENT CHARACTERIZATION OF HTS COATED CONDUCTORS DEPOSITED ON SOLUTION DEPOSITION PLANARIZED IBAD ***D. REAGOR[1], J. COULTER[1], F. BACA[1], T. G. HOLESINGER[1], V. MATIAS[1], C. SHEEHAN[1], B. MOECKLY[2];*** [1]LOS ALAMOS NATIONAL LABORATORY, [2]SUPERCONDUCTOR TECHNOLOGIES INC.. — SECOND GENERATION HIGH TEMPERATURE SUPERCONDUCTOR (HTS) WIRE CONSISTS OF METAL SUBSTRATE TAPES TEXTURED WITH INTERMEDIATE BUFFER LAYERS THAT ARE COATED WITH A SUPERCONDUCTING LAYER. THE APPLICATIONS OF THESE COATED CONDUCTORS REQUIRE A HIGH CURRENT IN MAGNETIC FIELDS THAT ARE NOT RESTRICTED TO A NARROW RANGE OF ANGLES. ION BEAM ASSISTED DEPOSITION (IBAD) TEMPLATE TILT, IN COMBINATION WITH REBCO VAPOR DEPOSITION, RESULTS IN ASYMMETRIC SAMPLE GROWTH. THIS REQUIRES VECTOR MAGNETIC FIELD (VMF) MEASUREMENT OVER 180 DEGREES TO BE FULLY DESCRIBED. WE HAVE DEVELOPED A PIECE WISE CHARACTERIZATION AND ANALYSIS METHOD OF THE VMF USING A NUMBER OF IC SCALING MODELS. SOLUTION DEPOSITION PLANARIZATION (SDP) PERMITS REBCO FILM DEPOSITION ON 100NM RMS ROUGHNESS SUBSTRATES. TO TEST BUFFER LAYER EFFECTS ON FILM GROWTH, WITH AND WITHOUT SDP, SUPERCONDUCTING FILMS WERE DEPOSITED AT SUPERCONDUCTOR TECHNOLOGIES, INC. BY CO-EVAPORATION OF REBCO ON IBAD BUFFER LAYER TEMPLATES FROM LOS ALAMOS. CRITICAL CURRENT MEASUREMENTS IN VMF UP TO A MAGNITUDE OF ~0.9 TESLA SHOW BEHAVIORS TRACEABLE TO THE EFFECTS OF BUFFER LAYER TEMPLATE ON PINNING. THE ABILITY TO DISCRIMINATE BETWEEN BUFFER LAYERS BASED ON IN-FIELD IC BEHAVIOR IS A USEFUL TECHNIQUE FOR THE OPTIMIZATION OF BUFFER LAYERS FOR FUTURE REBCO FILM DEPOSITION.

THIS WORK WAS SUPPORTED BY THE UNITED STATES DEPARTMENT OF ENERGY, OFFICE OF ELECTRICITY DELIVERY AND ENERGY RELIABILITY.

1MPE-07

FABRICATION OF ROUND WIRE USING COATED CONDUCTOR FOR POWER APPLICATIONS ***H. HA[1], S. OH[1], Y. YUN[1], J. MAENG[2], K. SIM[1], S. KIM[1], J. CHO[1];*** [1]KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE, [2]GYEONGSANG NATIONAL UNIVERSITY. — COATED CONDUCTORS HAVE BEEN DEVELOPED FOR THE ELECTRIC POWER APPLICATIONS. BUT, THE APPLICATION OF COATED CONDUCTOR ARE NOT CONVENIENT BECAUSE THE CROSS-SECTION OF COATED CONDUCTOR IS NOT ROUND SHAPE BUT THIN AND WIDE SHAPE. IN THIS STUDY, WE DEMONSTRATE ROUND SHAPE SUPERCONDUCTING WIRE USING COATED CONDUCTORS. FIRST OF ALL, WE PREPARED AG COATED NARROW COATED CONDUCTORS BY REACTIVE CO-EVAPORATION OF SMBA2CU3OY(SMBCO) ON ION BEAM ASSISTED DEPOSITION(IBAD)-MGO TEMPLATES WITH 1~2MM WIDTH. COATED CONDUCTORS WERE HEAT-TREATED TO MAKE DIFFUSION-BONDING TOGETHER AFTER STACKED WIRES TO CROSS-SECTION OF RECTANGULAR SHAPE. STACKED WIRES WERE PLATED WITH COPPER FOR STABILIZER TO MAKE ROUND SHAPE. CRITICAL CURRENT AND MECHANICAL PROPERTIES OF ROUND SHAPE WIRES WERE MEASURED.

THIS RESEARCH WAS SUPPORTED BY A GRANT FROM CENTER FOR APPLIED SUPERCONDUCTIVITY TECHNOLOGY OF THE 21ST CENTURY FRONTIER R&D PROGRAM FOUNDED BY THE MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY, REPUBLIC OF KOREA.

1MPE-08

FABRICATION AND CHARACTERIZATION OF GDBCO COATED CONDUCTOR USING CEO_2-BUFFERED IBAD-MGO TEMPLATE ***K. KO[1], J. LEE[1], R. KO[2], H. KIM[3], S. MOON[3], S. OH[2], S. YOO[1];*** [1]DEPARTMENT OF MATERIALS SCIENCE & ENGINEERING, SEOUL NATIONAL UNIVERSITY, KOREA, [2]SUPERCONDUCTIVITY RESEARCH CENTER, KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE, CHANGWON, KOREA, [3]SUPERCONDUCTOR, NANO & ADVANCED MATERIALS CORPORATION, ANYANG, KOREA. — WE HAVE SYSTEMATICALLY FABRICATED $GDBA_2CU_3O_{7-\Delta}$ (GDBCO) FILMS ON ION-BEAM ASSISTED DEPOSITION (IBAD) MGO TEMPLATE BY PULSED LASER DEPOSITION (PLD). TO IMPROVE BIAXIAL TEXTURE OF GDBCO FILMS, CEO_2 BUFFER LAYER WAS DEPOSITED ON IBAD-MGO TEMPLATE BY PLD. PRIOR TO CEO_2 GROWTH, IBAD-MGO TEMPLATES WERE IN-SITU ANNEALED FOR 1H AT 800°C TO ELIMINATE HYDRATES AND CARBONATES ON AIR-EXPOSED MGO TEMPLATE. A PURE CUBE-ON-CUBE ORIENTATION GROWTH OF CEO_2 LAYER ON IN-SITU ANNEALED MGO TEMPLATE COULD BE OBTAINED. BY OPTIMIZING PLD CONDITIONS, GDBCO FILMS ON THE CEO_2

BUFFER LAYER SHOWED HIGH T_C > 90 K AND CRITICAL CURRENT DENSITY (J_C) > 2 MA/CM^2. WE ALSO MEASURED MAGNETIC FIELD DEPENDENCE OF J_C FOR GDBCO FILMS GROWN ON THE CEO_2 BUFFER LAYER. IN THIS WORK, WE REPORT THE EPITAXIAL PROPERTIES OF CEO_2 BUFFER LAYERS AND THE EFFECT OF CEO_2 ON THE SUPERCONDUCTING PROPERTIES OF GDBCO FILMS.

THIS RESEARCH WAS SUPPORTED BY A GRANT FROM CENTER FOR APPLIED SUPERCONDUCTIVITY TECHNOLOGY OF THE 21ST CETURY FRONTIER R&D PROGRAM FUNDED BY THE MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY.

1MPF-01

NOVEL SUBSTRATE BASED ON TEXTURED CU {100}<001> FOR COATED CONDUCTORS ***N. KASHIMA***[1]*, K. SHIMA*[2]*, S. KUBOTA*[2]*, S. NAGAYA*[1]*, T. DOI*[3]*, M. INOUE*[4]*, T. KISS*[4]*;* [1]CHUBU ELECTRIC POWER CO., INC., [2]TANAKA KIKINZOKU KOGYO K. K., [3]KAGOSHIMA UNIVERSITY, [4]KYUSHU UNIVERSITY. — A TEXTURED CU {100}<001> SUBSTRATE IS ONE OF THE CANDIDATES FOR A LOW COST COATED CONDUCTOR. THE SUBSTRATE STRUCTURE OF ELECTRO-PLATED NI / TEXTURED CU / SUS316 WAS SUCCESSFULLY FABRICATED [1] AND WE ACHIEVED HIGH JC, OVER 3 MA/CM^2, ON THIS SUBSTRATE BY A PLD PROCESS. TO MAKE A THICKER FILM OR USE IN MORE HIGH TEMPERATURE COATING PROCESSES, IT IS IMPORTANT TO MAKE CLEAR AN OPTIMAL THICKNESS OF A NI LAYER ON A TEXTURED CU WITH CONSIDERATION OF ITS ORIENTATION AND ROUGHNESS ETC. FROM THIS POINT OF VIEW, WE INVESTIGATED A THICKNESS DEPENDENCE OF A CRYSTALLINE AND ROUGHNESS OF AN ELECTRO-PLATED NI LAYER. WE CONFIRMED THAT THE ORIENTATION OF THE NI LAYER WAS NOT SIGNIFICANTLY CHANGED TILL 10 MM OF THE NI LAYER, HOWEVER, THE ROUGHNESS OF THE NI SURFACE WAS SIGNIFICANTLY DEGRADED OVER 3 MM IN THE THICKNESS OF THE NI LAYER. FROM THESE RESULTS, IT WAS SUGGESTED THAT THE PREFERRED THICKNESS OF THE NI LAYER ON THE TEXTURED CU WAS ROUGHLY FROM 0.5 MM TO 3 MM. THE DEPTH PROFILE OF THE NI LAYER AS A PARAMETER OF TIME AND TEMPERATURE WAS ALSO INVESTIGATED. WE MADE CLEAR THE DIFFUSION LENGTH OF THE CU ATOMIC INTO THE NI LAYER AS A MEASURE OF DIFFUSION INTO THE SUPERCONDUCTING LAYER AND ALLOYING OF NI AND CU. [1] N. KASHIMA, K. SHIMA, T. DOI, S. KUBOTA, T. WATANABE, M. INOUE, T. KISS, AND S. NAGAYA, “DEVELOPMENT OF CU SUBSTRATE FOR LOW COST COATED CONDUCTORS,” *IEEE TRANS. APPL. SUPERCOND*. VOL. 19, PP. 3299-3302, JUNE 2009.

1MPF-02

FABRICATION OF THE TEXTURED NI-9.3AT.%W ALLOY SUBSTRATE USED FOR COATED CONDUCTORS ***H. SUO***[1]*, M. GAO*[1]*, P. GAO*[1]*, Y. ZHAO*[1]*, J. GRIVEL*[2]*;* [1]BEIJING UNIVERSITY OF TECHNOLOGY, [2]DTU RISØ NATIONAL LABORATORY. — IT IS DIFFICULT TO OBTAIN SHARP CUBE IN NI-9.3AT.% SUBSTRATE USED FOR COATED CONDUCTORS DUE TO THE DECREASING STACK FAULT ENERGY. IN THIS PAPER, THE TRADITIONAL COLD ROLLING PROCEDURE WAS OPTIMIZED BY INTRODUCING THE INTER-MEDIATE RECOVERY ANNEALING TREATMENT. THE DEFORMATION TEXTURE HAS BEEN OBVIOUSLY IMPROVED AFTER THREE TIMES RECOVERY ANNEALING AT 500ºC FOR 2H DURING THE COLD ROLLING PROCESS. AFTER RECRYSTALLIZATION ANNEALING, THE NI-9.3AT.% SUBSTRATE WITH CUBE TEXTURE CONTENT OF 86.7% (<10º) HAS BEEN OBTAINED.

FOUNDATION FOR THE AUTHOR OF NEDDC (200331), NKBRP (2006CB601005), NSFC (50771003), BJMNSF (2072004) AND 111 TPBJUT

1MPF-03

FABRICATION A TEXTURED NON-MAGNETIC NI-12AT.%V ALLOY SUBSTRATE FOR COATED CONDUCTORS ***M. GAO;*** BEIJING UNIVERSITY OF TECHNOLOGY. — **M1.5FABRICATION A TEXTURED NON-MAGNETIC NI-12AT.%V ALLOY SUBSTRATE FOR COATED CONDUCTORS**MANGMANG GAO1,2, HONGLI SUO1, J-C GRIVEL2, YUE ZHAO2 LIN MA1, MIN LIU11 KEY LABORATORY OF ADVANCED FUNCTIONAL MATERIALS, MINISTRY OF EDUCATION, COLLEGE OF MATERIALS SCIENCE AND ENGINEERING, BEIJING UNIVERSITY OF TECHNOLOGY, 100 PINGLEYUAN, CHAOYANG DISTRICT, BEIJING 100124,CHINA2 TECHNICAL UNIVERSITY OF DENMARK, RISØ NATIONAL LABORATORY, MATERIALS RESEARCH DIVISION, 399 FREDERIKSBORGVEJ, 4000 ROSKILDE, DENMARK**ABSTRACT:** NI-12AT.%V ALLOY IS ONE OF THE PROMISING CANDIDATES FOR NON-MAGNETIC CUBE TEXTURED METALLIC SUBSTRATES USED FOR HIGH TEMPERATURE COATED CONDUCTORS. IN THIS PAPER, THE TEXTURED NI-12AT.%V SUBSTRATE HAS BEEN FABRICATED BY THE POWDER METALLURGY ROUTE. AFTER COLD ROLLING AND RECRYSTALLIZATION ANNEALING, THE CUBE TEXTURE CONTENT IS AS HIGH AS 97.6% (<10°) AND THE LOW ANGLE GRAIN BOUNDARY FRACTION IS 87%. IN ADDITION, THE FWHM VALUES OF PHI-SCAN AND ROCKING CURVE ARE 7.77°AND 7.37°, RESPECTIVELY. ACCORDING TO MAGNETIC MEASUREMENTS, THE CURIE TEMPERATURE OF THE NI-12AT.%V SUBSTRATE IS BELOW 4.2K.

1MPF-04

PREPARATION OF SMOOTH METAL SUBSTRATE BY WET-CHEMICAL COATING METHOD ***J. LEE***[1]*, S. PARK*[1]*, S. MOON*[2]*, H. LEE*[1]*, G. HONG*[1]*;* [1]KOREA POLYTECHNIC UNIVERSITY, [2]SUNAM CO., LTD.. — THE PROPERTIES OF METAL SUBSTRATE USED FOR COATED CONDUCTOR IS VERY IMPORTANT TO OBTAIN THE GOOD SUPERCONDUCTING LAYER. GOOD THERMAL AND CHEMICAL STABILITY ARE REQUIRED TO SUSTAIN THE VARIOUS PROCESS STEPS INVOLVED IN DEPOSITING VARIOUS LAYERS OF COATED CONDUCTOR. FOR THE FIRST, SURFACE SMOOTHNESS IS VERY PRIMITIVE ISSUE FOR THE PROCESS QUALITY OF LATER PROCESS SUCH AS IBAD OR FOLLOWING EPITAXIAL GROWTH LAYER. WE TRIED TO IMPROVE THE SURFACE ROUGHNESS OF METAL SUBSTRATES SUCH AS HASTELLOY AND STAINLESS STEEL BY WET-CHEMICAL COATING METHOD. THE LOW COST COATING SOLUTION WAS SYNTHESISED USING INORGANIC METAL-NITRATE AND ACETIC ACID AS STARING MATERIALS. MULTIPLE DIP COATING WAS VERY EFFECTIVE TO IMPROVE THE SURFACE SMOOTHNESS OF

THE PREPARED SUBSTRATE AND VISCOSITY WAS CONTROLLED TO OPTIMIZE THE PROCESS PARAMETER. FINALLY, WE OBTAINED SMOOTH AL_2O_3, Y_2O_3 LAYER, WHICH HAS IMPROVED RQ VALUE FROM 70 NM TO 4.8 NM. THE CHARACTERISTICS OF PREPARED LAYER AND COMPATIBILITY CHECKING WITH LATER PROCESS WILL BE PRESENTED.

1MPF-05

LZO AS A PROTECTIVE BARRIER AGAINST OXIDATION OF NIW SUBSTRATES *S. PETIT,* ***J. L. SOUBEYROUX****, M. MIKOLAJCZYK, N. DECHOUX, S. PAIRIS, P. ODIER;* CNRS. — LOW COST COATED CONDUCTORS (CC) ARE REQUIRED TO ACCESS COMPETITIVE SUPERCONDUCTING CABLES. THE BUFFER LAYER ARCHITECTURE IS A KEY ASPECT OF CC PROCESSING AND VERY EFFICIENT RESULTS HAVE BEEN OBTAINED WITH COMPLEX ARCHITECTURE. HOWEVER, IT MAY BE NOT USEFUL TO HAVE SO HIGH JC FOR CABLE APPLICATIONS, AND THEN SIMPLER ARCHITECTURES MUST BE CONSIDERED. OUR GROUP HAS SUGGESTED IN 2008 THAT ONLY ONE BUFFER COULD BE SUFFICIENT. BECAUSE THE DEPOSITION OF YBCO NEEDS AN OXYGENATED ATMOSPHERE AT RATHER HIGH TEMPERATURE, IT IS CRUCIAL TO STUDY THE EFFECTS OF OXYGENATION ON THE BUFFER LAYER.THE AIM OF THIS PRESENTATION IS TO DISCUSS RESULTS OF ANNEALING NIW/LZO SUBSTRATES WITH LA2ZR2O7 (LZO) DEPOSITED BY MOD UNDER DIFFERENT OXYGEN ATMOSPHERES, IN CONDITIONS CLOSED TO THOSE USED IN DEPOSITION OF YBCO BY MOCVD. THE MICROSTRUCTURE OF THE BUFFER LAYER IS STUDIED IN DETAILS AND TENTATIVELY RELATED TO OXIDATIONS BEHAVIOR. IT IS SHOWN IN ADDITION THAT THE SUBSTRATE PLAYS IN FACT A CRUCIAL ROLE, GRAIN BOUNDARIES BEING THE MAIN SOURCE OF OXIDATION. WE ANTICIPATE THAT OXIDATION IS PROBABLY THE MAIN SOURCE OF DEGRADATION OF CRITICAL CURRENT IN YBCO FILMS AND THAT MORE EFFORTS SHOULD BE DONE TO TAKE IT INTO ACCOUNT.

THE AUTHORS THANK THE EUROPEAN FUNDS FOR REGIONAL DEVELOPMENTS (FEDER) FOR FINANCIAL SUPPORT, DRS C.E. BRUZEK, A. ALLAIS, T. WAECKERLE AND C. JIMENEZ FOR FRUITFUL DISCUSSIONS.

1MPF-06

STUDY OF CSD BUFFER LAYERS AND THEIR BUFFER CAPACITY IN COATED CONDUCTORS ***I. VAN DRIESSCHE***[1]*, N. VAN DE VELDE*[1]*, V. NARAYANAN*[1]*, P. LOMMENS*[1]*, K. DE BUYSSER*[1]*, M. BÄCKER*[2]*;* [1]GHENT UNIVERSITY, BELGIUM, [2]ZENERGY POWER GMBH, GERMANY. — THREE DIFFERENT TYPES OF BUFFER LAYERS (CEO_2, $LA_2ZR_2O_7$, $LA_2CE_2O_7$) WERE SYNTHESIZED. ALL BUFFER LAYERS ARE DEPOSITED BY AN AQUEOUS SOL-GEL TECHNIQUE, CONTAINING STABILIZED METAL SALTS IN WATER. EACH LAYER IS DEPOSITED BY DIP-COATING. YBCO LAYERS ARE DEPOSITED ON TOP OF THE BUFFERED TAPE BY DIP-COATING, CHEMICAL VAPOR DEPOSITION (MOCVD) OR PULSED LASER DEPOSITION (PLD). THE SUPERCONDUCTING PROPERTIES (TC, JC) WERE MEASURED TO EVALUATE THE COATED CONDUCTOR QUALITY.IMPROVING THE BUFFER CAPACITY OF THE SINGLE LZO LAYERS WAS EXPLORED BY INCREASING THE THICKNESS OF THE BUFFER LAYER, WHICH WAS OBTAINED BY INCREASING THE VISCOSITY OF THE PRECURSOR SOLUTION OR THE DIP-COAT SPEED AND BY ADDING A LZO SEED LAYER. THE CEO_2 -PRECURSOR SOLUTION CONTAINS CITRIC ACID TO STABILIZE THE CE^{3+} IN ORDER TO AVOID THE FORMATION OF PRECIPITATES. A NOVEL BUFFER LAYER, $LA_2CE_2O_7$ (LCO), WAS SYNTHESIZED BY A WATER-BASED SOLUTION. ITS PERFORMANCE AS A SINGLE BUFFER LAYER WAS COMPARED TO MORE CONVENTIONAL LZO LAYERS. ALL BUFFER LAYERS WERE THOROUGHLY EXAMINED BY XRD, POLE FIGURES, AFM AND SEM. FURTHER INVESTIGATIONS OF THE INTERFACIAL REACTIONS (NIW-LZO-YBCO AND NIW-LCO-YBCO) WERE CARRIED OUT BY XPS AND TEM.

1MPF-07

SOLUTION DERIVED SM_2O_3 BUFFER LAYERS ON BIAXIALLY TEXTURED NI-W SUBSTRATES FOR YBCO COATED CONDUCTOR ***L. WANG***[1]*, D. SHI*[1]*, X. ZHU*[2]*, Q. LI*[1]*, S. DOU*[1]*;* [1]INSTITUTE FOR SUPERCONDUCTING AND ELECTRONIC MATERIALS, UNIVERSITY OF WOLLONGONG, [2]KEY LABORATORY OF MATERIALS PHYSICS, INSTITUTE OF SOLID STATE PHYSICS, CHINESE ACADEMY OF SCIENCES. — SM_2O_3 THIN FILMS HAVE BEEN PREPARED ON BIAXIALLY TEXTURED NI-5%W METALLIC SUBSTRATES AS A POTENTIAL BUFFER LAYER FOR YBCO COATED CONDUCTOR BY CHEMICAL SOLUTION DEPOSITION. THE THERMAL PHENOMENON OF PRECURSOR SOLUTION IS STUDIED WITH TGA AND DSC. X-RAY DIFFRACTION INDICATES THAT SM_2O_3 FILMS HAVE A PURE SM_2O_3 CUBIC PHASE WITH HIGHLY (004) ORIENTATION. TEXTURE ANALYSIS SHOWS THAT THE FILMS HAVE A SINGLE CUBIC TEXTURE WITH GOOD IN-PLANE AND OUT-OF-PLANE ALIGNMENT. AFM IMAGE REVEALS THAT THE FILMS ARE DENSE, HOMOGENOUS AND CRACK-FREE. THE ROUTE-MEAN-SQUARE SURFACE ROUGHNESS IS LESS THAN 4 NM.

1MPF-08

REEL-TO-REEL COPPER ELECTROPLATING ON PLD COATED CONDUCTOR ***U. FLOEGEL-DELOR***[1]*, F. N. WERFEL*[1]*, T. RIEDEL*[1]*, D. WIPPICH*[1]*, B. GOEBEL*[1]*, R. ROTHFELD*[1]*, P. SCHIRRMEISTER*[1]*, A. USOSKIN*[2]*, A. RUTT*[2]*;* [1]ADELWITZ TECHNOLOGIEZENTRUM GMBH (ATZ), [2]BRUKER HTS GMBH. — BY APPLYING HIGH - RATE COPPER ELECTROPLATING RELIABLE FABRICATION AND PROPERTIES OF CU STABILIZER ON COATED CONDUCTOR IS INVESTIGATED. THE MECHANICAL, ELECTRICAL AND ENCAPSULATION PROPERTIES DUE TO CU STABILIZER IMPROVE THE PRACTICAL AND TECHNICAL PERFORMANCE OF THE YBCO - CU HYBRID COATED CONDUCTOR IN ELECTRIC POWER DEVICE APPLICATIONS. THE COPPER SULPHATE BASED PULSE PLATING TECHNIQUE IS CAPABLE TO DEPOSIT A 20 MICROMETER THICK HIGH - DENSE COPPER LAYER IN NON-VACUUM PROCESS. A SURROUND CU LAYER AFTER OXIDATION PROTECTS THE HTS CONDUCTOR AGAINST SALT AQUEOUS SOLUTIONS, HUMIDITY, AND CRYOGENIC LIQUIDS LN2 AND LHE2. WITH THE COPPER STABILIZER PRACTICAL CONDUCTOR JOINING WITH100 NANO-OHM RESISTANCE AS WELL AS A MORE THAN ONE DECADE BETTER THERMAL CONDUCTIVITY COMPARED TO HASTELLOY BECOMES POSSIBLE. FURTHER EFFORT IS BEING MADE TO DEVELOP AND CONSTRUCT A

CONTINUOUS HIGH - RATE AND HIGH THROUGHPUT REEL-TO-REEL MODULAR PLATING UNIT FOR LONG LENGTH (> 100 M) CU DEPOSITION. THE PAPER DESCRIBES THE PRACTICAL ACHIEVEMENTS WITHIN THE CONDUCTOR FABRICATION.

1MPG-01

GROWTH OF SUPERCONDUCTING FILMS BY ATOMIC LAYER DEPOSITION ***J. A. KLUG****, T. PROSLIER, J. W. ELAM, M. J. PELLIN, J. NOREM;* ARGONNE NATIONAL LABORATORY. — WE HAVE BEGUN USING ATOMIC LAYER DEPOSITION (ALD) TO SYNTHESIZE A VARIETY OF SUPERCONDUCTING THIN FILMS. ALD IS A TECHNIQUE WHICH EXPLOITS SEQUENTIAL SELF-TERMINATING SURFACE CHEMICAL REACTIONS IN ORDER TO PRODUCE COATINGS WITH ATOMIC SCALE CONTROL ON SUBSTRATES WITH ARBITRARY SHAPE. THE ALD PROCESS THEREFORE OFFERS THE POSSIBILITY OF CONFORMALLY COATING COMPLEX SHAPES WITH PRECISE, LAYERED STRUCTURES WITH TIGHTLY CONSTRAINED MORPHOLOGY AND CHEMICAL PROPERTIES. AMONG OTHER APPLICATIONS, SUCH COATINGS MAY ENABLE THE PRODUCTION OF SUPERCONDUCTING RF (SRF) STRUCTURES WITH SIGNIFICANTLY BETTER PERFORMANCE AND YIELD THAN THOSE OBTAINED FROM BULK NIOBIUM. IN THIS RESPECT, WE WILL PRESENT RESULTS OF PRELIMINARY RESULTS OF ALD-GROWN NBN FILMS WITH OPTIMIZED SUPERCONDUCTING PROPERTIES, AND THE DEVELOPMENT OF NEW GROWTH PROCESSES SUPERCONDUCTING INTERMETALLIC COMPOUNDS (E.G. NB-SI AND NB-SN). OUR PROGRAM LOOKS BOTH AT THE METALLURGY AND SUPERCONDUCTING PROPERTIES OF THESE COATINGS, AND ALSO THEIR PERFORMANCE IN WORKING SRF STRUCTURES.

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1MPG-02

AMORPHOUS AND CRYSTALLINE MAGNETIC/SUPERCONDUCTING HYBRIDS: INTERPLAY BETWEEN PERIODIC DEFECTS AND RANDOM DEFECTS *A. GOMEZ[1], D. PEREZ DE LARA[1], A. ALIJA[2], E. M. GONZALEZ[1], J. I. MARTIN[2], M. VELEZ[2],* ***J. L. VICENT****[1];* [1]UNIVERSIDAD COMPLUTENSE, [2]UNIVERSIDAD OVIEDO. — ELECTRON BEAM LITHOGRAPHY, SPUTTERING AND ETCHING TECHNIQUES HAVE BEEN USED TO FABRICATE HYBRID MAGNETIC/SUPERCONDUCTING SYSTEMS. THESE HYBRIDS ARE MAGNETIC NANODOT ARRAYS EMBEDDED IN SUPERCONDUCTING FILMS. THE SUPERCONDUCTING FILMS ARE AMORPHOUS MO_3SI (*A* -MO_3SI) AND POLYCRYSTALLINE NB FILMS. THE MAGNETIC DEFECTS ARE NANOMETRIC NI DOTS. CLOSE TO THE CRITICAL TEMPERATURE, PINNING POTENTIALS INDUCED BY THE MAGNETIC ARRAYS STRONGLY MODIFIED THE DISSIPATION MECHANISMS; SEE THE REVIEW (1).IN THE PRESENT WORK WE HAVE MEASURED THE FORCE-VELOCITY CHARACTERISTICS OF THE VORTICES AND WE HAVE FOUND:I) MOTION OF ORDERED VORTICES WITH CHANNELING EFFECTS WHICH ARE GOVERNED BY THE INTERPLAY BETWEEN THE INTRINSIC AND RANDOM PINNING POTENTIALS AND THE ARTIFICIALLY INDUCED PERIODIC MAGNETIC POTENTIALS.II) THE VELOCITIES OF THE ORDERED AND SYNCHRONIZED VORTICES ARE THE SAME IN BOTH SYSTEMS (HYBRIDS BASED ON NB FILMS OR *A* -MO_3SI FILMS), BUT REMARKABLY THE NEEDED DRIVING FORCES ARE ONE ORDER OF MAGNITUDE SMALLER IN *A* -MO_3SI HYBRIDS THAN IN NB BASED HYBRIDS. THESE EXPERIMENTAL BEHAVIORS POINT OUT THAT THESE MAGNETIC/SUPERCONDUCTING HYBRIDS BASED ON AMORPHOUS SUPERCONDUCTORS FILMS COULD BE A PROMISING MATERIAL FOR CONTROLLING VORTEX MOTION WITH VERY LOW DRIVING FORCES.(1) M. VELEZ, JI MARTÍN, JE VILLEGAS, A HOFFMANN, EM GONZÁLEZ, JL VICENT, IK SCHULLER, J. MAGN. MAGN. MATER. 320, 2547 (2008)

WORK SUPPORTED BY SPANISH MINISTERIO DE CIENCIA E INNOVACION GRANTS FIS2008-06249 (GRUPO CONSOLIDADO), AND CONSOLIDER CSD2007-00010, COMUNIDAD AUTÓNOMA DE MADRID GRANT S2009/MAT-1467, PRINCIPADO DE ASTURIAS GRANT IB08-106.

1MPG-04

ADVANCEMENTS IN EPITAXIAL TRILAYER GROWTH UTILIZING NB/RE BILAYERS ON SAPPHIRE ***P. B. WELANDER****;* MIT LINCOLN LABORATORY. — A NEW APPROACH TO ALL-EPITAXIAL "TRILAYER" GROWTH HAS BEEN DEVELOPED FOR SUPERCONDUCTING JOSEPHSON JUNCTION APPLICATIONS, UTILIZING A MULTI-LAYER STACK WHICH INCLUDES BUFFER LAYERS BETWEEN THE ELECTRODES AND THE TUNNEL-BARRIER. THESE BUFFER LAYERS SERVE AS BOTH DIFFUSION BARRIERS AND STRUCTURAL TRANSITIONS BETWEEN DISSIMILAR MATERIALS, AND IF KEPT THIN (~ 10 NM) PROXIMITY EFFECTS WITH THE ELECTRODES DOMINATE AND THE ENTIRE STRUCTURE BEHAVES LIKE AN SIS TRILAYER. THIS COURSE HAS BEEN CHARTED DUE TO ADVANCEMENTS IN THE HETERO-EPITAXIAL GROWTH OF RE (0001) LAYERS ON NB (110) SURFACES BY MBE. THICK NB (110) FILMS WERE GROWN ON A-PLANE SAPPHIRE AND FOUND TO BE SINGLE-CRYSTAL AND ATOMICALLY SMOOTH (RMS ROUGHNESS ~ 0.2-0.3 NM). THIN RE (0001) OVERLAYERS RETAINED THIS ATOMICALLY SMOOTH SURFACE MORPHOLOGY, PROVIDING AN IDEAL TEMPLATE ONTO WHICH AN ULTRA-THIN AL2O3 LAYER COULD BE GROWN. RHEED ANALYSIS ALSO INDICATED THAT ANY MISFIT STRAIN IN THE RE LAYER HAD NEARLY DIMINISHED WITHIN THE FIRST 10 NM OF DEPOSITION. THESE MATERIALS HAVE BEEN INCORPORATED INTO ALL-EPITAXIAL NB/RE/AL2O3/AL/NB TRILAYERS. BOTH THE MATERIALS ANALYSIS AND ELECTRICAL CHARACTERIZATION WILL BE REPORTED.

THIS WORK IS SPONSORED BY THE DEPARTMENT OF THE AIR FORCE UNDER AIR FORCE CONTRACT NUMBER FA8721-05-C-0002. OPINIONS, INTERPRETATIONS, CONCLUSIONS, AND RECOMMENDATIONS ARE THOSE OF THE AUTHOR AND ARE NOT NECESSARILY ENDORSED BY THE U.S. GOVERNMENT.

1MPG-05

GIANT CONDUCTANCE ANISOTROPY IN MAGNETICALLY COUPLED F/S/F STRUCTURES ***G. KARAPETROV****[1], A. BELKIN[2],*

M. IAVARONE[3], R. DIVAN[1], J. HILLER[1], T. PROSLIER[1], J. E. PEARSON[1], V. NOVOSAD[1]; [1]ARGONNE NATIONAL LABORATORY, [2]ARGONNE NATIONAL LABORATORY AND ILLINOIS INSTITUTE OF TECHNOLOGY, [3]TEMPLE UNIVERSITY. — WE DEMONSTRATE THE EVOLUTION OF THE ANISOTROPIC CONDUCTIVITY IN THESUPERCONDUCTOR THAT IS MAGNETICALLY COUPLED WITH TWO ADJACENTFERROMAGNETIC LAYERS. STRIPE MAGNETIC DOMAIN STRUCTURE IN THEFERROMAGNETIC LAYERS RESULTS IN DIRECTIONAL SUPERCONDUCTING ORDERPARAMETER IN THE SUPERCONDUCTING LAYER. THE CONDUCTANCE ANISOTROPYSTRONGLY DEPENDS ON THE PERIOD OF THE MAGNETIC DOMAINS AND THESTRENGTH OF THE LOCAL MAGNETIZATION. THE ANISOTROPIC CONDUCTIVITY OFUP TO THREE ORDERS OF MAGNITUDE CAN BE ACHIEVED WITH SPATIALCRITICAL TEMPERATURE MODULATION OF 5% OF TC. THE EFFECT COULD BEEXPLOITED IN LOW TEMPERATURE NONVOLATILE LOGIC AND STORAGE ELEMENTS.THIS WORK AS WELL AS THE USE OF THE CENTER FOR NANOSCALE MATERIALSAND THE ELECTRON MICROSCOPY CENTER AT ARGONNE NATIONAL LABORATORYWERE SUPPORTED BY UCHICAGO ARGONNE, LLC, OPERATOR OF ARGONNENATIONAL LABORATORY (``ARGONNE''). ARGONNE, A U.S. DEPARTMENT OFENERGY OFFICE OF SCIENCE LABORATORY, IS OPERATED UNDER CONTRACT NO.DE-AC02-06CH11357.

1MX-01

(INVITED) **RECENT ENHANCEMENT OF CRITICAL CURRENT AND SPATIAL HOMOGENEITY IN THICK GDBCO/IBAD COATED CONDUCTORS** ***T. KISS***[1], *A. MATSEKH[1], K. HIGASHIKAWA[1], R. FUGER[1], M. INOUE[1], S. AWAJI[2], K. WATANABE[2], Y. IIJIMA[3], T. SAITOH[3], T. IZUMI[4];* [1]KYUSHU UNIVERSITY, [2]TOHOKU UNIVERSITY, [3]FUJIKURA LTD., [4]SUPERCONDUCTIVITY RESEARCH LABORATORY, ISTEC. — RECENT PROCESS OPTIMIZATION IN FUJIKURA CO. ENABLES TO DEPOSIT HIGH QUALITY $GD_1BA_2CU_3O_{7-\Delta}$ (GDBCO) LAYERS OVER SEVERAL MICRO-METES IN THICKNESS. THIS RESULTS IN STABLE PRODUCTION OF HIGH CURRENT LONG LENGTH COATED CONDUCTORS. FOR EXAMPLE, CRITICAL CURRENT (I_C) OF 600 A AND 900 A, AT 77 K, FOR 1 CM WIDE TAPES HAVE BEEN OBTAINED IN REEL-TO-REEL PROCESS FOR 2.5 MM AND 5.2 MM THICK GDBCO LAYERS, RESPECTIVELY. IN THIS STUDY, WE HAVE INVESTIGATED IN-FIELD CURRENT TRANSPORT PROPERTIES AND STUDIED THE INFLUENCE OF GDBCO THICKNESS OF THESE GDBCO/IBAD TAPES OVER BROAD CONDITIONS OF MAGNETIC FIELD, S.F. TO 27 T, AND TEMPERATURE, 20 TO 83 K. FURTHERMORE, SPATIALLY RESOLVED MEASUREMENTS ON I_C AND T_C WITH MICRO-METER SCALE RESOLUTION HAVE BEEN CARRIED OUT TO CLARIFY IN-PLANE UNIFORMITY. THESE RESULTS SHOW VERY PROMISING CURRENT CARRYING CAPABILITY OF PRESENT TAPES FOR VARIOUS KINDS OF APPLICATIONS EVEN WITH STRIATION PROCESSING FOR AC MODE OPERATION.

THIS WORK WAS SUPPORTED BY THE “NEDO AS THE PROJECT FOR DEVELOPMENT OF MATERIALS & POWER APPLICATION OF COATED CONDUCTORS, M-PACC”, “JSPS: KAKENHI (20360143)”.

1MX-02

PROGRESS IN FABRICATION OF HIGH-PERFORMANCE LONG LENGTH GDBCO COATED CONDUCTORS BY IN-PLUME PULSED LASER DEPOSITION TECHNIQUE ***S. LEE****, N. CHIKUMOTO, K. NAKAO, T. MACHI, K. TANABE, M. YOSHIZUMI, T. IZUMI;* SUPERCONDUCTIVITY RESEARCH LABORATORY, ISTEC. — HERE WE OVERVIEW THE RESULTS OF UP-SCALE, TEST AND OPERATION OF PILOT EQUIPMENT FOR ECONOMICALLY FEASIBLE MANUFACTURING OF COATED CONDUCTORS (CC). IN-PLUME PULSED LASER DEPOSITION (IP-PLD) AT REDUCED TAPE-TO-TARGET DISTANCE OF 5-7CM COMBINED WITH THE UTILIZATION OF MAXIMAL LASER POWER OF 200W AND 5-TURNS REEL-TO-REEL CHAMBER ALLOWED DEPOSITION OF SUPERCONDUCTING FILMS AT A HIGH-RATE OF 15-20NM/SEC WITH THE MATERIAL YIELD OF >50%. EXCELLENT STABILITY OF DEPOSITION PROCESS WAS ACHIEVED BY ADJUSTMENT OF TAPE LOCATION INSIDE RANDOMLY-FRUSTRATED MULTIPLE PLUMES, OPTIMIZATION OF TARGET ROTATION/SWING RATE AND STABILIZATION OF TEMPERATURE.RELIABILITY OF IPL-PLD TECHNIQUE FOR DEPOSITION OF 0.5-3.0 MICRONS THICK OFF-STOICHIOMETRIC (BA-POOR) GDBCO FILMS AT A TAPE TRAVELING SPEED OF 60-10M/H RESPECTIVELY WITH J_C(77K) VALUE IN A RANGE OF 2-4MA/CM^2 WAS CONFIRMED. SO FAR THE RESULTS ON SEVERAL 50-200M LONG HASTELLOY/IBAD-MGO/CEO_2 TAPES USED FOR OPTIMIZATION OF PROCESSING PARAMETERS SHOWED AN ABSENCE OF ACCIDENTAL I_C DROPS ALONG THE TAPE LENGTH AND IMPLY THE PROCESSING YIELD CLOSE TO 100%. HOMOGENEITY OF IC ACROSS THE 1CM OF TAPE WIDTH WAS TESTED ON 1-2MM WIDE STRIPES. VARIOUS CC WITH THE IC OF 200-600A/CM WERE OBTAINED WITH ESTIMATED FUTURE TECHNICAL COST OF <30$/KAM. FLUX-PINNING CHARACTERISTICS OF CC WERE TUNED BY ADDITION OF $BAZRO_3$ AND $BASNO_3$ ARTIFICIAL PINNING CENTERS.

THIS WORK IS SUPPORTED BY THE NEW ENERGY AND INDUSTRIAL TECHNOLOGY DEVELOPMENT ORGANIZATION (NEDO)

1MX-03

COATED CONDUCTORS IN LARGE SCALE PRODUCTION VIA HR-PLD AND ABAD: COMPROMISE BETWEEN OPTIMAL CONDUCTOR DESIGN, PROCESSING COSTS AND PERFORMANCE ***A. USOSKIN****, A. RUTT, A. HALLBAUER, M. WASCHULEWSKI, L. KIRCHHOFF, J. KNOKE, T. SCHNEIDER, K. SCHLENGA;* BRUKER HTS GMBH. — RELIABLE AND STABLE PROCESSING OF HTS COATED CONDUCTOR (CC) IN LONG LENGTHS REPRESENTS ONE OF THE PRIMARY GOALS IN ALL KINDS OF CC TECHNOLOGIES. MANUFACTURING ROUTE BASED ON HIGH-RATE PULSED LASER DEPOSITION (HR-PLD) AND ALTERNATING BEAM ASSISTED DEPOSITION (ABAD) BEING EMPLOYED IN THE LARGE SCALE PRODUCTION IS ANALYSED FROM THE VIEWPOINT OF COST-PERFORMANCE RATIO. SIMPLIFICATION OF CROSS-SECTIONAL DESIGN RELATES TO THE MAJOR TASKS WHICH ULTIMATELY DETERMINE THE COST-EFFICIENCY OF THE PRODUCTION PROCESS. DIFFERENT ALTERNATIVES FOR THE INTERNAL ARCHITECTURE OF COATED CONDUCTOR ARE CONSIDERED IN ORDER TO DEFINE A VIABLE

CHOICE. ANALYSIS OF AVAILABLE MEANS FOR ACHIEVING OF SUFFICIENTLY HIGH PROCESSING YIELDS IS PROVIDED. COMPARISON OF VARIOUS PROCESSING ALTERNATIVES WILL BE GIVEN REGARDING SUBSTRATE MATERIAL AND DEPOSITION TECHNIQUES EMPLOYED IN MANUFACTURING OF COATED CONDUCTORS. WE REPORT ALSO THE RECENT STATUS REGARDING UP-SCALING OF DEPOSITION EQUIPMENT TOWARDS 2KM CC PIECE-LENGTHS AS WELL AS OUR RECENT PROGRESS IN ACHIEVING ENHANCED PERFORMANCE OF HTS COATED CONDUCTORS.

THIS WORK IS SUPPORTED IN PART BY GERMAN MINISTRY OF ECONOMY AND TECHNOLOGY (BMWI), PROJECT NO. 0327456A.

1MX-04

SCALE UP OF COATED CONDUCTOR SUBSTRATE PROCESS BY REEL-TO-REEL PLANARIZATION OF AMORPHOUS OXIDE LAYERS ***Y. QIAO***[1]*, Y. CHEN*[1]*, X. XIONG*[1]*, S. KIM*[1]*, V. MATIAS*[2]*, C. SHEEHAN*[2]*, Y. ZHANG*[3]*, V. SELVAMANICKAM*[3]*;* [1]SUPERPOWER, INC., 450 DUANE AVE., SCHENECTADY, NY 12304 USA, [2]SUPERCONDUCTIVITY TECHNOLOGY CENTER, LOS ALAMOS NATIONAL LABORATORY, LOS ALAMOS, NM USA, [3]DEPARTMENT OF MECHANICAL ENGINEERING, TEXAS CENTER FOR SUPERCONDUCTIVITY AT THE UNIVERSITY OF HOUSTON, HOUSTON, TX 77024, USA. — SUBSTRATE SURFACE SMOOTHNESS COMPARABLE TO ELECTROPOLISHED SUBSTRATE HAS BEEN DEMONSTRATED BY PLANARIZATION OF MULTILAYERS OF AMORPHOUS OXIDE FILMS ON AS RECEIVED FLEXIBLE METAL TAPES. 6.4 DEGREES OF IN-PLANE TEXTURE WERE ACHIEVED ON SHORT SAMPLES AFTER THE FINAL BUFFER PROCESS. JC OVER 3MA/CM^2 HAS BEEN ACHIEVED ON SHORT SAMPLES. THE PLANARIZATION PROCESS HAS BEEN SCALED UP TO BE CAPABLE OF PRODUCING 100 METERS FROM A FEW METERS LOOP PROCESS. 20M OF PLANARIZED SUBSTRATE WERE PROCESSED WITH SUPERPOWER STANDARD BUFFER TAPE AND MOCVD MANUFACTURING RUN. EIGHT TO NINE DEGREES OF TEXTURE WERE OBTAINED ON THE ENTIRE 20M PIECE AFTER THE FINAL BUFFER LMO PROCESS. A UNIFORM IC OF 160A WAS ACHIEVED ON UP TO 15M OF THE SUBSTRATE AFTER THE MOCVD PROCESS. THE PLANARIZATION PROCESS HAS THE POTENTIAL TO REDUCE COMPLICATED BUFFER LAYERS, ALLEVIATE THE BURDEN OF HAZARDOUS WASTE GENERATED FROM THE ELECTROPOLISHING PROCESS, AND IS CAPABLE OF PLANARIZING ANY SUBSTRATE ALLOYS, WHICH, IN ELECTROPOLISHING, WAS LIMITED TO ONLY A SMALL NUMBER OF ALLOYS.

1MX-05

DEVELOPMENT OF SOLUTION BASED BUFFER LAYERS FOR COATED CONDUCTORS ***M. P. PARANTHAMAN***[1]*, T. AYTUG*[1]*, C. CANTONI*[1]*, S. H. WEE*[1]*, Y. ZUEV*[1]*, V. SELVAMANICKAM*[2]*, L. STAN*[3]*, Q. XIA*[3]*;* [1]OAK RIDGE NATIONAL LABORATORY, [2]SUPERPOWER/UNIVERSITY OF HOUSTON, [3]LOS ALAMOS NATIONAL LABORATORY. — THE SUPERPOWER/ORNL HIGH PERFORMANCE LMO-ENABLED, HIGH TEMPERATURE SUPERCONDUCTING TAPE (LMO E-HTS) IS A ROBUST, HIGH-CURRENT SECOND-GENERATION SUPERCONDUCTING WIRE. THIS SUPERCONDUCTING WIRE WITH FIVE-LAYER ARCHITECTURE OF NI-ALLOY/AL_2O_3/Y_2O_3/IBAD-MGO/HOMOEPI-MGO/LMO CAN BE FABRICATED AT HIGH THROUGHPUT RATES USING REEL-TO-REEL PROCESSES. TO REDUCE COST AND COMPLEXITY, AS WELL AS ASSOCIATED MECHANICAL AND RELIABILITY CONCERNS, IT IS HIGHLY DESIRABLE TO ELIMINATE THE ELECTRO-POLISHING STEP AND REPLACE THE PHYSICAL VAPOR DEPOSITED BARRIER LAYERS WITH SOLUTION LAYERS. WE HAVE SUCCESSFULLY DEVELOPED PROCESS CONDITIONS TO PLANARIZE THE MECHANICALLY POLISHED HASTELLOY SUBSTRATES USING SOLUTION AL_2O_3 LAYERS AND DEMONSTRATED THE GROWTH OF ROBUST IBAD-MGO/LMO TEMPLATES. WE WILL REPORT IN DETAIL ABOUT THE GROWTH OF HIGH PERFORMANCE YBCO FILMS ON THESE NEWLY DEVELOPED TEMPLATES.RESEARCH SPONSORED BY THE US DEPARTMENT OF ENERGY, OFFICE OF ELECTRICITY DELIVERY AND ENERGY RELIABILITY - ADVANCED CABLES AND CONDUCTORS.

RESEARCH SPONSORED BY THE US DEPARTMENT OF ENERGY, OFFICE OF ELECTRICITY DELIVERY AND ENERGY RELIABILITY – ADVANCED CABLES AND CONDUCTORS.

1MX-06

PARAMAGENTIC SUBSTRATES FOR COATED CONDUCTORS: NI-W AND NI-W-CR ***U. GAITZSCH****, J. EICKEMEYER, C. RODIG, H. KLAUSS, J. FREUDENBERGER, B. HOLZAPFEL, L. SCHULTZ;* IFW DRESDEN. — COATED CONDUCTORS ARE ONE VARIANT OF SUPERCONDUCTORS WITH REGARDS TO SUPERCONDUCTING CABLES. IN ORDER TO REDUCE MAGNETIC LOSSES IN AC APPLICATIONS, NON-MAGNETIC SUBSTRATES ARE BENEFICIAL. FOR AN EPITAXIAL GROWTH OF THE SUPERCONDUCTOR OR THE FIRST BUFFER LAYER, THE SUBSTRATE HAS TO BE TEXTURED. CUBE TEXTURED NI AND NI5%W METALLIC TAPES HAVE BEEN PREPARED DURING THE LAST YEARS AND HAVE BEEN DEVELOPED UP TO INDUSTRIAL SCALE. HOWEVER, NI5%W IS STILL FERROMAGNETIC AT 77 K. ONE POSSIBILITY TO SUPPRESS THE FERROMAGNETISM FURTHER IS TO ADD CR OR FURTHER W INTO THE ALLOY. NI4WXCR AND NIYW (Y>8%) ALLOYS HAVE BEEN PREPARED BY INDUCTION MELTING AND CASTING INTO A COPPER MOLD. THE MAGNETISATION OF THESE ALLOYS WAS DETERMINED BETWEEN 5 K AND 200 K USING A VIBRATING SAMPLE MAGNETOMETER. FOR NI4W6CR, NI9W AND HIGHER ALLOYS THE CURIE TEMPERATURE IS WELL BELOW 77 K. THE INGOTS WERE INITIALLY HOT ROLLED AND SUBSEQUENTLY COLD ROLLED, WITH THE COLD ROLLING DEFORMATION EXCEEDING 95%. TEXTURE ANALYSIS HAS BEEN PERFORMED USING X-RAY DIFFRACTION AT VARIOUS INTERMEDIATE DEFORMATION STEPS AND BY ELECTRON BACK SCATTER DIFFRACTION AFTER THE FINAL THERMAL TREATMENT. THE EVOLUTION OF THE S-TYPE ROLLING TEXTURE IS OBSERVED DURING THE DEFORMATION, WHICH CHANGES TO THE CUBE TEXTURE AFTER ANNEALING. VOLUME FRACTIONS OF UP TO 99% CUBE TEXTURE AT 10 DEG. ANGULAR DEVIATION COULD BE ACHIEVED. ON NI9W A SUPERCONDUCTING LAYER CARRYING 1.1 MA/CM² COULD BE DEPOSITED USING PLD.

1MX-07

ELECTRODEPOSITED AG AND CU-STABILIZATION LAYER FOR HIGH TEMPERATURE SUPERCONDUCTING COATED CONDUCTORS ***R. N. BHATTACHARYA***[1]*, J. MANN*[1]*, Y. QIAO*[2]*, Y. ZHANG*[3]*, V. SELVAMANICKAM*[3]*;* [1]NATIONAL RENEWABLE ENERGY LABORATORY, [2]SUPERPOWER INC., [3]UNIVERSITY OF HOUSTON. — NON-VACUUM ELECTRODEPOSITION TECHNIQUES HAVE THE POTENTIAL TO PREPARE LARGE-AREA UNIFORM STABILIZATION LAYERS USING LOW-COST SOURCE MATERIALS AND LOW-COST CAPITAL EQUIPMENT. IN PARTICULAR, CONVENTIONAL SOLUTIONS USED IN ELECTROPLATING OF AG OR CU LAYERS USE CYANIDE BASED SOLUTION TO PREVENT THE UNCONTROLLED HYDROGEN EVOLUTION FROM THE AQUEOUS BASED SOLUTION, ARE VERY REACTIVE WITH THE SUPERCONDUCTOR LAYER AND THUS DESTROY THE CRITICAL CURRENT CAPABILITY OF THE SUPERCONDUCTOR LAYER WHEN PLATED DIRECTLY ON THE HTS TAPE. IT HAS BEEN FOUND THAT A CAPPING LAYER AT LEAST 1 MICRON IN THICKNESS IS NEEDED BETWEEN THE SUPERCONDUCTOR LAYER AND THE STABILIZER LAYER IN ORDER TO AVOID SUCH A REACTION AND REDUCTION IN THE CRITICAL CURRENT CAPABILITY OF THE SUPERCONDUCTOR LAYER. ALSO, SOLDERS USED IN BONDING A STRIP OF THE STABILIZER LAYER TO THE SUPERCONDUCTOR LAYER HAVE ALSO BEEN FOUND TO DETERIORATE THE QUALITY OF THE SUPERCONDUCTOR IF A SUFFICIENTLY THICK CAPPING LAYER IS NOT USED. IN CONTRAST, THE NON-AQUEOUS ELECTROPLATING SOLUTION IS NON-REACTIVE TO THE HTS LAYER ALLOWING THE AG CAPPING LAYER TO BE REDUCED IN THICKNESS.WE HAVE DEVELOPED A NON-AQUEOUS ELECTRODEPOSITION PROCESS TO FOR BOTH AG AND CU STABILIZATION LAYERS. IN THIS MEETING WE WILL DISCUSS THE RECENT DEVELOPMENTS IN THIS PROJECT

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1MX-08

QUENCH CHARACTERISTICS OF A CU-STABILIZED 2G HTS CONDUCTOR *E. A. YOUNG*[1]*,* ***I. FALORIO***[1]*, S. CHAPELL*[2]*, Y. YANG*[1]*;* [1]UNIVERSITY OF SOUTHAMPTON, [2]OXFORD INSTRUMENTS. — THE PROSPECT OF MEDIUM/HIGH FIELD SUPERCONDUCTING MAGNETS USING 2G HTS TAPES IS APPROACHING TO REALITY WITH CONTINUED ENHANCEMENT IN THE PERFORMANCE OF THESE CONDUCTORS. DIRECT MEASUREMENTS OF 1D ADIABATIC QUENCH INITIATION AND PROPAGATION OF A CU-STABILIZED 2G CONDUCTOR HAVE BEEN CARRIED OUT WITH SPATIAL-TEMPORAL RECORDING OF TEMPERATURE AND VOLTAGE FOLLOWING THE DEPOSITION OF VARIOUS LOCAL HEAT PULSES TO THE CONDUCTOR AT DIFFERENT TEMPERATURES BETWEEN 30K AND 77K CARRYING DIFFERENT TRANSPORT CURRENTS. IT WAS FOUND THAT THE STABILIZER-FREE 2G TAPE MAINTAINS THE UNIQUE CHARACTERISTICS PREVIOUSLY MEASURED IN NON-STABILIZED TAPE OF INCREASING MPZ WITH TRANSPORT CURRENT AND HIGHER QUENCH ENERGY AT LOWER TEMPERATURES. THE MINIMUM QUENCH ENERGY, MINIMUM PROPAGATION ZONE (MPZ) LENGTH AND THE PROPAGATION VELOCITY ARE DETERMINED AS A FUNCTION OF TEMPERATURE AND TRANSPORT CURRENT. THE CHANGE IN MPZ SIZE IS INVESTIGATED WITH MEASURED TEMPERATURE DEPENDENT E-J CHARACTERISTICS AND 1D MODELING. THE RESULTS ADD ANOTHER CONTEXT TO THE UNIQUE CHARACTERISTICS OF INCREASING MPZ WITH TRANSPORT CURRENT AND HIGHER QUENCH ENERGY AT LOWER TEMPERATURES

WE GRATEFULLY ACKNOWLEDGE OXFORD INTRUMENTS UK AND THE DTI FOR FUNDING THIS WORK

1MX-09

SINGLE-MEASUREMENT APPROACH FOR DERIVING THE INTRA-GRANULAR CRITICAL CURRENT DENSITY OF RABITS BASED COATED CONDUCTORS WITH LARGE THROUGH-BOUNDARY CURRENT FLOW ***R. FEENSTRA***[1]*, J. W. SINCLAIR*[2]*, J. R. THOMPSON*[2]*, D. K. CHRISTEN*[1]*;* [1]OAK RIDGE NATIONAL LABORATORY, [2]UNIVERSITY OF TENNESSEE. — FOR RBCO COATED CONDUCTORS IN THE REGIME OF MAGNETIC FIELD H LESS THAN THE TEMPERATURE T DEPENDENT CROSSOVER FIELD H^*, THE CRITICAL CURRENT DENSITY J_C IS LIMITED PRIMARILY BY THE GRAIN BOUNDARY (GB) NETWORK. THE RATIO H = J_C / J_C^G OF THE CONDUCTOR J_C OVER THE AVERAGE INTRAGRANULAR J_C^G IS AN INFORMATIVE PARAMETER IN THIS RANGE, AS IT QUANTIFIES THE GB LIMITATION AND PROVIDES FEEDBACK ON THE ONSET OF THE PINNING REGIME $H > H^*$ THROUGH A DEPENDENCE OF H^* ON H. WE DESCRIBE A FACILE MEANS FOR DERIVING J_C^G FROM H DEPENDENT MAGNETIC MEASUREMENTS. THE APPROACH EXTENDS A SIMILAR METHODOLOGY DESCRIBED BY PALAU ET AL. BY PROPERLY TREATING THE SUPERPOSITION OF MACROSCOPIC AND INTRAGRANULAR CURRENT FLOWS, TAKING INTO ACCOUNT ASYMMETRIC FIELD DISTRIBUTIONS OVER GRAINS ADJACENT TO A HIGHLY TRANSMITTING GB. INFORMATION ON J_C^G IS DERIVED FROM LOCAL CANCELLATION OF THE APPLIED FIELD BY SELF-FIELDS INDUCED BY THE COMPONENT OF J_C^G FLOWING PARALLEL TO THE GB. THIS CANCELLATION IS READILY OBSERVED IN THE FORM OF A PEAK IN J_C AT $H > 0$ IN THE DECREASING-H BRANCH OF A HYSTERESIS LOOP. RESULTS ARE PRESENTED FOR THICK *EX SITU* RBCO COATINGS ON RABITS. ANALYSIS OF J_C^G SHOWS A CLEAR UPTURN FOR $T < 40$ K, WHICH IS NOT REFLECTED IN THE THROUGH-BOUNDARY J_C. EXAMPLES ARE PRESENTED ALSO OF PROCESSING INDUCED VARIATIONS IN J_C^G AND H.

THIS RESEARCH WAS SPONSORED BY THE U.S. DOE, OFFICE OF ELECTRICITY DELIVERY AND ENERGY RELIABILITY, SUPERCONDUCTIVITY PROGRAM FOR ELECTRIC POWER SYSTEMS.

1MY-01

COMPARATIVE STUDY OF VORTEX PINNING AND CREEP IN SUPERCONDUCTORS ***N. HABERKORN***[1]*, S. A. BAILY*[1]*, B. MAIOROV*[1]*, T. G. HOLESINGER*[1]*, Q. X. JIA*[1]*, H. ZHOU*[2]*, T. TAJIMA*[1]*, L. CIVALE*[1]*;* [1]LOS ALAMOS NATIONAL LABORATORY, [2]NORTH CAROLINE STATE UNIVERSITY. — ALTHOUGH THE INTRODUCTION OF DEFECTS IN HTS TO IMPROVE VORTEX

PINNING HAS BEEN EXTENSIVELY EXPLORED, THE PRESENT KNOWLEDGE OF THE STRUCTURE-PROPERTIES CORRELATIONS IS INCOMPLETE. VORTEX DYNAMICS DEPENDS ON BOTH INTRINSIC SUPERCONDUCTING PARAMETERS, SUCH AS T_C, CRITICAL FIELDS, ANISOTROPY AND THE SINGLE- OR MULTI-BAND CHARACTER, AND ON THE EXTRINSIC EFFECTS PRODUCED BY THE INTERACTIONS OF VORTICES WITH THE PINNING ENERGY LANDSCAPE GENERATED BY THE MATERIAL MICROSTRUCTURE. TO GAIN A MORE GENERAL UNDERSTANDING OF VORTEX MATTER, WHICH IS A TOPIC OF BOTH FUNDAMENTAL AND TECHNOLOGICAL RELEVANCE, WE HAVE PERFORMED COMPARATIVE STUDIES OF PINNING AND CREEP PHENOMENA IN A VARIETY OF TYPE-II SUPERCONDUCTORS.WE HAVE STUDIED THIN FILMS AND SINGLE CRYSTALS OF OXIDE HTS, PNICTIDES, MGB_2 AND CONVENTIONAL LOW T_C SUPERCONDUCTORS. THE MATERIALS WERE SELECTED TO COVER A LARGE SPECTRUM OF ELECTRONIC ANISOTROPIES AS WELL AS SINGLE AND DOUBLE BAND EXAMPLES. THEY ALSO SPAN SEVERAL ORDERS OF MAGNITUDE IN THE CRITICAL CURRENT DENSITY J_C AND IN THE FRACTION J_C/J_0, WHERE J_0 IS THE DEPAIRING CURRENT DENSITY, AS WELL AS IN THE GINZBURG NUMBER (G_I) THAT MEASURES THE INFLUENCE OF THE THERMAL FLUCTUATIONS.

WORK AT LANL WAS SUPPORTED BY THE US DOE, OFFICE OF BASIC ENERGY SCIENCE (DIV. OF MATERIALS SCIENCES AND ENGINEERING) AND OFFICE OF ELECTRICITY DELIVERY & ENERGY RELIABILITY

1MY-02

VERY STRONG INTRINSIC FLUX PINNING AND VORTEX AVALANCHES IN (BA,K)FE_2AS_2 SUPERCONDUCTING SINGLE CRYSTALS ***X. WANG***[1]*, R. GHORBANI*[1]*, S. LEE*[2]*, S. DOU*[1]*, C. LIN*[3]*, T. JOHANSEN*[4]*, Z. CHENG*[1]*, G. PELECKIS*[1]*, K. MULLER*[5]*, M. SHABAZI*[1]*, G. SUN*[6]*, D. SUN*[3]*;* [1]UNIVERSITY OF WOLLONGONG, [2]SOGANG UNIVERSITY, [3]MAX PLANCK INSTITUTE FOR SOLID STATE RESEARCH, [4]UNIVERSITY OF OSLO, [5]CSIRO, [6]4MAX PLANCK INSTITUTE FOR SOLID STATE RESEARCH. — THE NEWLY DISCOVERED PNICTIDE SUPERCONDUCTORS SHOW T_C AS HIGH AS 55 K AND HIGH H_{C2}, WITH A SMALL ANISOTROPY FOR $REFEASO_{1-X}F_X$ AND AN ALMOST ISOTROPIC SUPERCONDUCTIVITY FOR (BA,K)FE_2AS_2. THESE PROPERTIES MAKE THE PNICTIDES SUPERCONDUCTORS PROMISING CANDIDATES FOR HIGH FIELD APPLICATIONS AT RELATIVELY HIGH TEMPERATURES. THE CURRENT CARRYING ABILITY OF THESE SUPERCONDUCTORS IS LARGELY DETERMINED BY THE FLUX PINNING STRENGTH AND THE BEHAVIOR OF THE VORTEX. THE DETERMINATION OF THEIR INTRINSIC VORTEX PINNING STRENGTH IS A CENTRAL ISSUE FROM BOTH AN APPLIED AND A FUNDAMENTAL PERSPECTIVE. WE REPORT THAT THE (BA,K)FE_2AS_2 CRYSTAL SHOWS A PINNING POTENTIAL U_0, AS HIGH AS 10^4 K, WITH U_0 SHOWING VERY LITTLE FIELD DEPENDENCE. THE (BA,K)FE_2AS_2 SINGLE CRYSTALS BECOME ISOTROPIC AT LOW TEMPERATURES AND HIGH MAGNETIC FIELDS, RESULTING IN A VERY RIGID VORTEX LATTICE, EVEN IN FIELDS VERY CLOSE TO HC2, AS WELL AS HIGH HIRR, HC2 AND JC. THE ISOTROPIC RIGID VORTICES IN THE TWO DIMENSIONAL (BA,K)FE_2AS_2 DISTINGUISH THIS COMPOUND FROM 2D HIGH T_C CUPRATES WITH 2D VORTICES. THE VORTEX AVALANCHES WERE ALSO OBSERVED AT LOW TEMPERATURES IN THE (BA,K)FE_2AS_2 CRYSTAL. IT IS PROPOSED THAT IT IS THE K SUBSTITUTION THAT INDUCES BOTH ALMOST ISOTROPIC SUPERCONDUCTIVITY AND THE VERY STRONG INTRINSIC PINNING IN THE (BA,K)FE_2AS_2 CRYSTAL.

1MY-03

(INVITED) **THE EFFECT OF THE FINAL SIZE HEAT TREATMENTS ON THE PINNING PROPERTIES OF NBTI FILAMENTS: A VALIDATION OF THE 2-COMPONENTS PINNING MODEL** ***L. MUZZI***[1]*, G. DE MARZI*[1]*, U. BESI VETRELLA*[1]*, C. FIAMOZZI ZIGNANI*[1]*, A. DELLA CORTE*[1]*, J. SOMERKOSKY*[2]*;* [1]ENEA, [2]LUVATA PORI OY. — A TWO-COMPONENTS MODEL HAS BEEN RECENTLY DEVELOPED, FOR DESCRIBING THE NORMALIZED BULK PINNING FORCE CURVES AND THE CRITICAL CURRENT DENSITY OF NBTI STRANDS OVER A WIDER B-T RANGE WITH RESPECT TO CONVENTIONAL SINGLE-COMPONENT MODELS. THE MODEL WAS PREVIOUSLY SUCCESSFULLY APPLIED TO DATA COLLECTED ON SEVERAL NBTI COMMERCIAL STRANDS, WITH DIFFERENT SIZE, CU:NONCU RATIO, FILAMENT DIAMETER AND LAYOUT, THUS CONFIRMING THE PRESENCE OF TWO DIFFERENT PINNING MECHANISMS IN NBTI WIRES. IN ORDER TO FURTHER VALIDATE THE MODEL, WE VARIED THE WEIGHT OF EACH PINNING COMPONENT, EXTENDING THE MEASUREMENTS ON A SERIES OF NBTI STRANDS, USING FINAL SIZE HEAT TREATMENTS AS A FREE PARAMETER. TO THIS AIM, MULTI-FILAMENTARY CU-NBTI SAMPLES WERE COLD DRAWN DIRECTLY TO A FINAL SIZE AND HEAT TREATED AT 375 °C FOR A VARIETY OF ANNEALING TIMES. NBTI FILAMENTS EXTRACTED FROM COPPER MATRIX WERE THEN ELECTROMAGNETICALLY CHARACTERIZED. THE I_C CURVES WERE OBTAINED FROM THE MAGNETIZATION CYCLES FOR A WIDE TEMPERATURE RANGE, AND THE NORMALIZED PINNING FORCES (F_P) WERE PLOTTED AS A FUNCTION OF THE REDUCED APPLIED FIELD (B). IT IS FOUND THAT THE F_P PEAK GREATLY SHIFTS AS THE TEMPERATURE APPROACHES T_C, AND THAT THE PINNING CURVES ALSO DEPEND ON THE ANNEALING TIME. THE F_P VS. B CURVES HAVE BEEN FITTED TO THE 2-COMPONENTS MODEL, AND RESULTS HAVE BEEN COMBINED WITH AN EXTENDED MICROSTRUCTURE ANALYSIS FOR EXPLAINING THE OBSERVED BEHAVIORS.

1MY-04

PARITY EFFECT OF FLUX QUANTIZATION IN A PERFORATED SUPERCONDUCTING NB FILM ***K. MUHAMMAD****;* COMSATS INSTITUTE OF IT. — **PARITY EFFECT OF FLUX QUANTIZATION IN A PERFORATED SUPERCONDUCTING NB FILM***M. KAMRAN*[1]*, M. ANIS-UR-REHMAN*[1]*, S. K. HE*[3]*, X.G. QIU*[31]*DEPARTMENT OF PHYSICS, COMSATS INSTITUTE OF INFORMATION TECHNOLOGY, ISLAMABAD, PAKISTAN*[3]*INSTITUTE OF PHYSICS, CHINESE ACADEMY OF SCIENCES AND BEIJING NATIONAL LABORATORY OF CONDENSED MATTER PHYSICS, BEIJING100190, CHINASUPERCONDUCTIVITY HAS BEEN FULL OF SURPRISES AND WONDER. ONE OF THE MOST ELEGANT PROPERTY OF SUPERCONDUCTORS IS THE QUANTIZATION OF MAGNETIC FLUX IN UNITS OF Φ_0=H/2E, 2E THE ELECTRON-PAIR CHARGE SERVING THE FUNDAMENTAL BUILDING BLOCK OF THE SUPERCONDUCTING CONDENSATE. HERE WE REPORT*

OUR DISCOVERY OF A NEW TWIST OF THIS PHENOMENON IN A FILM GEOMETRY PERFORATED WITH A PERIODIC LATTICE OF SUB-MICRON HOLES, A VARIATION OF THE FLUX QUANTIZATION BASED ON THE PARITY OF THE FLUX QUANTA. MEASURED IN TERMS OF MAGNETO-RESISTANCE AT TEMPERATURES JUST BELOW THE TRANSITION TEMPERATURE OF THE BULK SUPERCONDUCTOR, WE FIND THAT SUPERCONDUCTIVITY IS MOST ENHANCED AT ODD MULTIPLES OF THE FLUX QUANTUM. WE EXPLAIN THE PHENOMENON BY NOTING THAT THERMAL QUASI-PARTICLES, WHICH SEE THE SUPERCONDUCTING FLUX QUANTUM ONLY AS HALF, ARE IN FACT SUPPRESSED AT THESE FLUX VALUES. IN FIELDS LARGER THAN THE THERMODYNAMIC CRITICAL FIELD, WHERE QUASI-PARTICLES DOMINATE, MAGNETO-RESISTANCE MINIMA ONLY OCCUR AT SUCH ODD VALUES.

THIS WORK IS SUPPORTED BY THE COMSATS INSTITUTE OF INFORMATION TECHNOLOGY, ISLAMABAD, PAKISTAN

1MY-05

THE SUPERCONDUCTING PROPERTIES OF NANOCRYSTALLINE NIOBIUM CARBONITRIDE ***M. J. RAINE**, D. P. HAMPSHIRE;* DURHAM UNIVERSITY. — WE HAVE FABRICATED THE LOW TEMPERATURE SUPERCONDUCTOR NIOBIUM CARBONITRIDE WITH THE OPTIMUM COMPOSITION $NBC_{0.3}N_{0.7}$ IN BULK FORM USING HIGH PURITY POWDER PRECURSORS TO PRODUCE A TRANSITION TEMPERATURE OF ~ 17.63 K AND AN UPPER CRITICAL MAGNETIC FIELD OF ~ 10.7 T. THIS MATERIAL HAS A SUFFICIENTLY HIGH CRITICAL TEMPERATURE FOR APPLICATIONS IF THE UPPER CRITICAL MAGNETIC FIELD CAN BE INCREASED - DOPING OR NANOCRYSTALLISATION ARE PROCESSES THAT CAN ACHIEVE THIS INCREASE. LIMITED DATA DESCRIBING THE SUPERCONDUCTING PROPERTIES OF $NBC_{0.3}N_{0.7}$ ARE AVAILABLE IN THE LITERATURE. WE WILL PRESENT OUR MOST RECENT DATA ON NANOCRYSTALLINE MATERIALS PRODUCED USING BALL MILLING AND HOT ISOSTATIC PRESSING, WHICH PROVIDES A VERY COMPREHENSIVE AND DETAILED CHARACTERISATION OF BOTH THE FUNDAMENTAL AND APPLIED SUPERCONDUCTING PROPERTIES. THE CRITICAL CURRENT DENSITY OF THESE MATERIALS IS INVESTIGATED IN DETAIL THROUGHOUT THE SUPERCONDUCTING PHASE USING SQUID MEASUREMENTS AND THE NATURE OF THE FLUX PINNING MECHANISM IS IDENTIFIED. THE IMPLICATIONS FOR USING THIS MATERIAL IN HIGH-MAGNETIC-FIELD NUCLEAR APPLICATIONS ARE DISCUSSED.

WE ACKNOWLEDGE THE SUPPPORT OF EPSRC

1MY-06

SIMULATION OF VORTEX-ANTIVORTEX PAIR ANIQUILATION IN A MESOSCOPIC SUPERCONDUCTOR *J. BARBA-ORTEGA[1], **A. AGUIAR**[2];* [1]GRUPO DE FÍSICA DE NUEVOS MATERIALES, UNIVERSIDAD NACIONAL DE COLOMBIA, BOGOTÁ - COLOMBIA, [2]UFPE. — WITHIN THE GINZBURG-LANDAU FORMALISM, WE ANALYZE THE VORTEX ANTI-VORTEX DYNAMICS IN A SUPERCONDUCTING MESOSCOPIC CYLINDER OF SQUARE TRANSVERSAL SECTION WITH A SQUARE ENGINEERING DEFECT AT ITS CENTER. DEFECTS MAY LEAD TO APPEARANCE OF ANTIVORTICES IN THE VICINITY OF THE SUPERCONDUCTING/NORMAL STATE BOUNDARY, WHERE MESOSCOPIC CONFINEMENT IS PARTICULARLY STRONG. IN THIS WORK WE ASSUMED THAT THE DEFECT IS IN CONTACT WITH A METALLIC MATERIAL WHOSE PROPERTIES ARE ACCOUNTED WITH DE GENNES EXTRAPOLATION LENGTH. WE CALCULATE THE MAGNETIC INDUCTION, CURRENT DENSITY, THE POSITION AND THE VELOCITY OF THE VORTEX AND ANTI-VORTEX SINGULARITIES AS A FUNCTION OF TIME OUR RESULTS INDICATE THAT THE VORTEX ANTI-VORTEX COLLISION CAN TAKE PLACE IN POINTS CLOSEST TO THE DEFECT FOR LOWEST VALUES OF *B* PARAMETER.WORK FINANCED BY CAPES, CNPQ AND FACEPE.

1MY-07

BACKFLOW OF TRANSPORT CURRENT IN TYPE-II SUPERCONDUCTORS ***H. S. RUIZ**[1], A. BADÍA-MAJÓS[1], C. LÓPEZ[2];* [1]UNIVERSIDAD DE ZARAGOZA–I.C.M.A.-C.S.I.C., [2]UNIVERSIDAD DE ALCALÁ DE HENARES, DEPT. MATH.. — THE LONGITUDINAL TRANSPORT PROBLEM (CURRENT IS APPLIED PARALLEL TO SOME BIAS MAGNETIC FIELD) IN TYPE-II SUPERCONDUCTORS IS ANALYZED WITHIN THE CRITICAL STATE THEORY. BASED ON ANALYTICAL RESULTS FOR SIMPLIFIED CONFIGURATIONS AND RELYING ON NUMERICAL STUDIES FOR GENERAL SCENARIOS, IT IS SHOWN THAT BACKFLOW OF CURRENT IN A SURFACE LAYER MAY BE PREDICTED UNDER A WIDE SET OF EXPERIMENTAL CONDITIONS. STRONGLY INHOMOGENEOUS CURRENT DENSITY PROFILES, CHARACTERIZED BY OVERCRITICAL TRANSPORT TOWARDS THE CENTER AND REDUCED OR EVEN NEGATIVE VALUES AT THE PERIPHERY OF THE CONDUCTOR ARE EXPECTED WHEN THE PHYSICAL MECHANISMS OF FLUX DEPINNING AND CONSUMPTION (VIA LINE CUTTING) ARE RECALLED. A NUMBER OF COLLATERAL EFFECTS SUCH AS MAGNETIC FIELD REENTRY, AND MAGNETIZATION PEAKS RELATED TO THE FLUX CUTTING THRESHOLD ARE ALSO PREDICTED.

THIS WORK WAS SUPPORTED BY SPANISH CICYT PROJECT MAT2008-05983-C03-01. H. S. RUIZ ACKNOWLEDGES A GRANT FROM THE SPANISH CSIC (JAE PROGRAM).

1MZ-01

(INVITED) **SUPERCONDUCTING PROPERTIES OF DIFFUSION PROCESSED MUTI-FILAMENTARY MGB_2 WIRES** ***H. KUMAKURA**[1], J. HUR[2], K. TOGANO[1], A. MATSUMOTO[1], H. WADA[1], K. KIMURA[2];* [1]NATIONAL INSTITUTE FOR MATERIALS SCIENCE, [2]THE UNIVERSITY OF TOKYO. — WE FABRICATED 7- AND 19-FILAMENT MGB_2 COMPOSITE WIRES USING MG CORES SURROUNDED WITH B OR B+SIC POWDER AND APPLYING AN INTERNAL MG DIFFUSION (IMD) PROCESS. FE, NB OR TA TUBE AND CU-NI TUBE WERE USED AS AN INNER SHEATH AND AN OUTER SHEATH MATERIAL, RESPECTIVELY. THE WIRES WERE HEAT TREATED AT 600 ~ 800^{O}C FOR 0.25-10HR. DURING THE HEAT TREATMENT, MG DIFFUSED INTO THE B LAYER AND REACTED WITH B TO FORM MGB_2. THE THICKNESS OF REACTED MGB_2 LAYER RAPIDLY INCREASES WITH INCREASING HEAT TREATMENT TEMPERATURE AND/OR HEAT TREATMENT

TIME. EXCELLENT J_C VALUES WITH GOOD REPRODUCIBILITY CAN BE OBTAINED UNDER THE HEAT TREATMENT CONDITION OF ~640^{O}C FOR 1 HR, WHERE THE B LAYER IS ALMOST COMPLETELY REACTED WITH MG TO FORM MGB_2. HOWEVER, THE REPRODUCIBILITY OF HIGH J_C VALUES BECOMES LOW WHEN HEAT TREATED AT TEMPERATURES HIGHER THAN 650^{O}C. THIS IS PROBABLY DUE TO THE MELTING OF MG CORE. VICKERS HARDNESS OF MGB_2 LAYER IN THE IMD PROCESSED WIRES IS AROUND 1300 WHICH IS MUCH HIGHER THAN THAT OF PIT PROCESSED WIRE. THIS SUGGESTS THAT THE DENSITY OF MGB_2 LAYER IS MUCH HIGHER THAN THAT OF PIT PROCESSED WIRE. THE HIGHEST J_C VALUE OF 100KA/CM^2(CALCULATED FOR THE REACTED LAYER) WAS OBTAINED IN 10T AT 4.2K FOR 7-FILAMENT WIRES AND IN 3.7T AT 20K FOR 19-FILAMENT WIRE. THIS HIGH J_C VALUE CAN BE ATTRIBUTED TO THE HIGH DENSITY MGB_2 LAYER OBTAINED BY THE DIFFUSION METHOD.

PART OF THIS WORK WAS SUPPORTED BY JSPS KAKENHI (21560764).

1MZ-02

(INVITED) **A NEW GENERATION OF IN SITU MGB2 WIRES WITH IMPROVED CRITICAL CURRENT DENSITIES AND IRREVERSIBILITY FIELDS OBTAINED BY COLD DENSIFICATUON** ***R. L. FLÜKIGER***[1]*, S. M. A. HOSSAIN*[1]*, C. SENATORE*[1]*, M. RINDFLEISCH*[2]*;* [1]UNIVERSITY OF GENEVA, [2]HYPER TECH RESEARCH INC., COLUMBUS OH 43212, USA. — USING A NEW TECHNIQUE, COLD HIGH PRESSURE DENSIFICATION (CHPD), A CONSIDERABLE ENHANCEMENT OF THE CRITICAL CURRENT DENSITY, JC, AND THE IRREVERSIBILITY FIELD, BIRR, HAS RECENTLY BEEN OBTAINED IN *IN SITU* MGB2 WIRES[1)]. THE RELATIVE MGB_2 MASS DENSITY OF BINARY MGB_2 WIRES WAS ENHANCED TO ~60% AFTER APPLYING >1.5 GPA BEFORE REACTION. ALMOST ISOTROPIC J_C VALUES WERE OBTAINED FOR $C_4H_6O_5$ ADDED WIRES OF 1 X 0.5 MM^2 CROSS SECTION[2]). FOR PARALLEL AND PERPENDICULAR FIELDS, J_C(4.2K)=1X10^4 A/CM^2 WAS OBTAINED AT 13.8 AND 13.4 T (1 MICROV/CM CRITERION), RESPECTIVELY, BOTH VALUES FOR 20K BEING CLOSE TO 6.4 T. THE VALUE OF $B_{IRR}^{//}$ AT 20K WAS RAISED TO ~10 T. THESE ARE THE HIGHEST VALUES REPORTED SO FAR FOR IN SITU MGB_2 WIRES, AND FURTHER IMPROVEMENTS ARE EXPECTED. WE HAVE CONFIRMED THE POSITIVE EFFECTS OF COLD DENSIFICATION ON J_C AND BIRR ON MGB_2 WIRES ALLOYED WITH $C_4H_6O_5$, SIC OR CARBON.THE PRESENT METHOD WAS SUCCESSFULLY EXTENDED TO ALLOYED MGB_2 WIRES OF 150 MM LENGTH: AFTER A SUCCESSION OF 6 OVERLAPPING PRESSURE STEPS, THE IMPROVEMENT OF J_C AND B_{IRR} WAS CONFIRMED. THIS IS A PROMISING STEP IN VIEW OF THE APPLICATION OF CHPD TO INDUSTRIAL WIRE LENGTHS: FIRST RESULTS ON LONGER MGB_2 LENGTHS OBTAINED AT THE UNIVERSITY OF GENEVA ARE PRESENTED.1) R. FLÜKIGER, M.S.A. HOSSAIN, C. SENATORE, SUST 22, 085002 (2009).2) M.S.A. HOSSAIN, C. SENATORE, R. FLÜKIGER, M.A. RINDFLEISCH, M.J. TOMSIC, J.H. KIM, S.X. DOU, SUST 22, 095004 (2009).

1MZ-03

MGB2 - AN APPROACH FOR MANUFACTURING TECHNICAL MGB2 WIRES FOR APPLICATIONS IN HEALTH CARE ***A. AUBELE***[1]*, B. SAILER*[1]*, V. ABAECHERLI*[1]*, K. SCHLENGA*[1]*, W. HAESSLER*[2]*, M. HERRMANN*[2]*, C. RODIG*[2]*, B. HOLZAPFEL*[2]*;* [1]BRUKER EAS GMBH, [2]IFW DRESDEN. — SINCE THE DISCOVERY OF MGB2 IN 2001, A LOT OF PROGRESS HAS BEEN ACHIEVED IN MATERIAL RESEARCH AND WIRE PRODUCTION. WITH THEIR SUPERCONDUCTING PROPERTIES, MGB2 WIRES ARE A POTENTIAL CANDIDATE FOR VARIOUS APPLICATIONS OPERATING IN THE 4 K TO 20 K RANGE.TODAY, MGB2 WIRES ARE FABRICATED UNDER PROTOTYPE CONDITIONS IN THE KM CLASS LENGTH SCALE EITHER BY THE POWDER-IN-TUBE METHOD BASED ON REACTED MGB2, THE SO CALLED EX-SITU ROUTE, OR THE IN-SITU ROUTE, BASED ON A MIXTURE OF THE UNREACTED ELEMENTS MAGNESIUM AND BORON. THEREFORE, THE MANUFACTURING TECHNOLOGY OF MGB2 WIRES BY WIRE DRAWING OF MULTIFILAMENTARY SUPERCONDUCTING WIRES IS BASED ON THE SAME PRINCIPLES LIKE FOR 1G HTS SUPERCONDUCTORS.WITH A LOW COST PRODUCTION PROCESS MGB2 SUPERCONDUCTING WIRES WOULD HAVE THE POTENTIAL TO PARTIALLY REPLACE TODAY'S NBTI WIRES IN HEALTH CARE APPLICATIONS.THE PRESENTED WORK WILL GIVE AN OVERVIEW ON THE DEVELOPMENT AND PROPERTIES OF IN-SITU MGB2 WIRES UP TO 1000 M IN LENGTH WITH MECHANICALLY ALLOYED PRECURSOR POWDER.

1MZ-04

PROGRESS IN THE DEVELOPMENT OF MGB2 BASED WIRES AND APPLICATIONS ***G. GRASSO****, S. BERTA, S. BRISIGOTTI, A. TUMINO, M. PALOMBO, D. PIETRANERA, V. CUBEDA;* COLUMBUS SUPERCONDUCTORS SPA. — THE RECENT PROGRESS IN THE MANUFACTURE AND SUPPLY OF COMMERCIAL GRADE MGB2 CONDUCTORS HAS ALLOWED FOR A SIGNIFICANT INCREASE OF DEMONSTRATION ACTIVITIES BASED ON THEM. THANKS TO ITS LOW-COST, AVAILABILITY IN LONG LENGTHS, AND ADEQUATE PERFORMANCE IN MODERATE MAGNETIC FIELDS UP TO SEVERAL TESLA, IN COMBINATION WITH ITS SUPERIOR FLEXIBILITY IN WIRE DESIGN AND CONTINUOUS PROGRESS IN OPTIMIZING RELIABLE COOLING TECHNOLOGIES TO ATTAIN A REASONABLE OPERATING TEMPERATURE IN THE 10-25K RANGE, MGB2 IS INCREASINGLY BECOMING A MATERIAL OF CHOICE FOR VARIOUS PRACTICAL APPLICATIONS OF SUPERCONDUCTIVITY. IN THIS PAPER, RECENT ACHIEVEMENTS IN TERMS OF WIRE PERFORMANCE WE HAVE ACHIEVED, AS WELL AS AN UPDATE OF THE DIFFERENT APPLICATIONS UNDER DEVELOPMENT WILL BE REPORTED.

1MZ-05

DEVELOPMENT OF MGB_2 SUPERCONDUCTOR WIRE AND COILS FOR PRACTICAL APPLICATIONS AT HYPER TECH RESEARCH ***M. TOMSIC***[1]*, M. RINDFLEISCH*[1]*, J. YUE*[1]*, T. WIEBER*[1]*, D. DOLL*[1]*, M. SUMPTION*[2]*, M. SUSNER*[2]*, E. COLLINGS*[2]*, S. BOHNENSTIEHL*[2]*, S. DOU*[3]*;* [1]HYPER TECH RESEARCH, [2]OHIO STATE UNIVERSITY, [3]UNIVERSITY OF WOLLONGONG. — HYPER TECH RESEARCH WILL REPORT ON PROGRESS THAT HAS BEEN MADE ON DEVELOPING MAGNESIUM DIBORIDE

SUPERCONDUCTOR WIRES FOR RESEARCH AND COMMERCIALIZATION EFFORTS, WITH A SPECIFIC EMPHASIS ON RELATING SUPERCONDUCTOR PROPERTIES TO THE REQUIREMENTS OF THE APPLICATION. THE STATUS OF HYPER TECH RESEARCH'S CURRENT DEMONSTRATION PROJECTS FOR FABRICATING MGB_2 WIRE AND COILS FOR MRI, FCL, MOTORS, AND OTHER APPLICATIONS WILL BE PRESENTED.

1MZ-06

THE INFLUENCE OF DENSIFICATION ON THE CRITICAL CURRENT DENSITY OF MGB2 STRANDS ***Y. YANG***[1]*, M. SUSNER*[1]*, M. D. SUMPTION*[1]*, M. RINDFLEISCH*[2]*, M. TOMSIC*[2]*, E. W. COLLINGS*[1]*;* [1]CENTER FOR SUPERCONDUCTING AND MAGNETIC MATERIALS THE OHIO STATE UNIVERSITY, [2]HYPER TECH RESEARCH, COLUMBUS, OH. — THE INFLUENCE OF DENSIFICATION ON THE TRANSPORT J_C OF MGB_2 WAS STUDIED FOR STRANDS DENSIFIED BY SEVERAL DIFFERENT ROUTES, INCLUDING PRE-REACTION COMPRESSION, HOT ISOSTATIC COMPRESSION, AND STRANDS REACTED BY INTERNAL MG DIFFUSION. THE INFLUENCE OF THESE DIFFERENT TECHNIQUES BOTH ON THE OBSERVED MICROSTRUCTURAL DENSITY AS WELL AS THE TRANSPORT PROPERTIES IS REPORTED. THE STRANDS WHICH EXPERIENCE PRE-REACTION COMPRESSION WERE PROCESSED WITH THE AID OF A UNIAXIAL DIE WITH FIXED SIDE CONSTRAINTS. THESE RESULTS WERE COMPARED TO SAMPLES SUBJECTED TO HIPING, WHERE 30KPSI WAS APPLIED DURING THE REACTION. RESULTS FROM BOTH SETS OF SAMPLES WERE COMPARED TO THOSE PROCESSED BY AN INTERNAL MG DIFFUSION ROUTE, WHICH LEADS TO A DENSER SUPERCONDUCTING LAYER. J_C VALUES OF 10^5 A/CM^2 IN THE RANGE 5-6 T AT 4.2 K WERE SEEN FOR A NUMBER OF SAMPLES TYPES, INCLUDING THOSE WITH GLIDCOP SHEATHS. IN ALL CASES, CROSS SECTIONAL SEM WAS USED TO OBTAIN THE TRUE AREAS REDUCTIONS AND TO OBSERVE THE MICROSTRUCTURES OF THE STRANDS. TRANSPORT J_C VALUES WERE MEASURED, MOSTLY AT 4.2 K, ALTHOUGH SELECTED SAMPLES WERE MEASURED FOR J_C VS B AND T. B_{IRR} AND B_{C2} VALUES ARE REPORTED FOR HIGHER TEMPERATURES ON A REPRESENTATIVE SET OF SAMPLES. THE DENSIFICATION AND PROPERTIES ACHIEVED WITH THE DIFFERENT TECHNIQUES ARE COMPARED.

1PL-01

MONDAY OPENING REMARKS AND AWARD PRESENTATIONS ***M. OSOFSKY****;* NRL. — OPENING REMARKS CONCERNING SPONSORS, MEMORIALS, AND LOGISTICS FOR THE CONFERENCE WILL BE PRESENTED. THE IEEE COUNCIL ON SUPERCONDUCTIVITY AWARDS WILL BE PRESENTED BY DR. JOHN SPARGO AND DR. MARTIN NISENOFF.

1PL-02

SUPERCONDUCTIVITY FOR POWER APPLICATIONS IS GETTING MORE AND MORE ATTRACTIVE ***M. NOE****;* KARLSRUHE INSTITUTE OF TECHNOLOGY. — EFFICIENT AND RELIABLE POWER SYSTEMS ARE FUNDAMENTAL REQUIREMENTS FOR PROVIDING CITIZENS, SOCIETIES AND INDUSTRIES WITH ESSENTIAL ENERGY RESOURCES. A MAJOR FUTURE CHALLENGE WILL BE TO INTEGRATE MORE SUSTAINABLE GENERATION RESOURCES, MEET GROWING ELECTRICITY DEMAND AND RENEW ELECTRICITY NETWORKS. SUPERCONDUCTING POWER APPLICATIONS HAVE AN IMPORTANT ROLE TO PLAY IN ADDRESSING THESE CHALLENGES.SINCE THE DISCOVERY OF HIGH-TEMPERATURE SUPERCONDUCTIVITY (HTS), ESSENTIAL FOR POWER APPLICATIONS, IN 1986 THERE HAS BEEN A RAPID PROGRESS IN DEVELOPING SUPERCONDUCTING MATERIALS, WIRES AND APPLICATIONS. ESPECIALLY FOR LARGE-SCALE POWER APPLICATIONS LIKE ROTATING MACHINES, TRANSFORMERS, CABLES, FAULT CURRENT LIMITERS AND SUPERCONDUCTING MAGNETIC ENERGY STORAGE DEVICES A NUMBER OF RECENT SUCCESSFUL PROTOTYPES UNDERLINED THE FEASIBILITY AND SUPERIOR TECHNICAL PERFORMANCE OF SUPERCONDUCTOR TECHNOLOGY. FURTHERMORE, THE APPLICATION OF HTS IN FUSION MAGNETS, HIGH FIELD MAGNETS, CURRENT LEADS AND INDUCTION HEATING DEVICES HAS UNIQUE FEATURES AND IS EXTREMELY ATTRACTIVE.THIS PAPER SUMMARIZES THE STATE-OF-THE-ART OF DIFFERENT POWER APPLICATIONS, GIVES A SHORT OUTLOOK ON THE MOST IMPORTANT FUTURE R&D TOPICS AND OUTLINES THE POTENTIAL OF SUPERCONDUCTING POWER APPLICATIONS TO SAVE ENERGY AND CONTRIBUTE TO THE REDUCTION OF CO_2 EMISSIONS. IN ADDITION, THE MAIN HTS MATERIAL REQUIREMENTS FOR EACH APPLICATION AND AS FAR AS POSSIBLE THE ROLE OF SUPERCONDUCTING POWER APPLICATION IN SMART GRIDS IS DESCRIBED.THE TIME HORIZON FOR THE MARKET IMPLEMENTATION OF HTS POWER APPLICATIONS DEPENDS ON THE APPLICATION. HTS CURRENT LEADS AND INDUCTION HEATING DEVICES ARE COMMERCIALLY AVAILABLE AND SUPERCONDUCTING CABLES AND MEDIUM VOLTAGE SUPERCONDUCTING FAULT CURRENT LIMITERS ARE VERY CLOSE TO COMMERCIALIZATION, WHEREAS FIRST APPLICATIONS OF LARGE ROTATING GENERATORS (>100 MVA) AND LARGE SUPERCONDUCTING TRANSFORMERS CANNOT BE EXPECTED BEFORE THE SECOND HALF OF THIS DECADE.THERE IS NO DOUBT ABOUT THE TECHNICAL AND ECONOMIC BENEFITS OF SUPERCONDUCTING POWER APPLICATIONS BUT IT WILL STRONGLY DEPEND ON FURTHER MATERIAL AND TECHNOLOGY IMPROVEMENTS AND ON FURTHER SUCCESSFUL LONG TERM POWER SYSTEM DEMONSTRATIONS HOW FAST SUPERCONDUCTING POWER APPLICATIONS WILL PENETRATE THE MARKET.

1PL-03

NEW SCIENCE FOR ACHIEVING PRACTICAL CUPRATE SUPERCONDUCTORS ***J. L. MACMANUS-DRISCOLL****;* CAMBRIDGE. — THE LAST QUARTER OF A CENTURY HAS HERALDED AMAZING DISCOVERIES OF NEW SUPERCONDUCTING MATERIALS. AMONG THESE, THE CUPRATES HOLD THE GREATEST PROMISE FOR LIQUID N2-BASED APPLICATIONS. FOR THE MOST POPULAR OF CUPRATES, REBA2CU3O7, THERE HAVE BEEN MAJOR TECHNOLOGICAL ADVANCES BY DESIGNING ARCHITECTURES TO PERMIT STRONG GRAIN COUPLING THEREBY ALLOWING UNOBSTRUCTED CURRENT FLOW, AS WELL AS BY CREATING NANOCOMPOSITES TO PROVIDE STRONG FLUX PINNING. LOOKING TO THE FUTURE, OUR SHARED ASPIRATION OF WIDESPREAD APPLICATIONS WILL REQUIRE EITHER NEW

MATERIALS DISCOVERIES OR INSPIRED METHODS FOR TUNING THE MATERIALS ALREADY AT OUR DISPOSAL. THIS TALK WILL COVER NEW POSSIBILITIES AND OPPORTUNITIES FOR MATERIALS DESIGN, INCLUDING A RADICALLY NEW APPROACH TO OVERCOMING THE WEAK LINK PROBLEMS, WHICH INVOLVES MANIPULATION OF THE CRYSTAL MORPHOLOGY, THROUGH TO NEW AVENUES FOR CREATING PRACTICAL SUPERCONDUCTORS OUT OF THE NON-RARE EARTH-BASED CUPRATES. SOME OF THESE MATERIALS ARE VERY PROMISING IN TERMS OF THEIR LOW ANISOTROPY AND, IN SOME CASES, HIGH TC, BUT LESS PROMISING IN TERMS OF THE NEED FOR HIGH PRESSURE FABRICATION. HERE, I WILL DISCUSS NEW POSSIBILITIES TO MIMIC THE HIGH PHYSICAL PRESSURES, NAMELY THROUGH USE OF VERTICAL SCAFFOLD STRUCTURES.

1PL-04

QUANTUM INFORMATION PROCESSING WITH SUPERCONDUCTING CIRCUITS ***I. SIDDIQI****;* UNIVERSITY OF CALIFORNIA, BERKELEY. — OVER THE PAST 15 YEARS, THERE HAS BEEN GROWING EXCITEMENT ABOUT STORING, PROCESSING, AND TRANSMITTING INFORMATION USING PHYSICAL SYSTEMS THAT EXHIBIT QUANTUM COHERENT PHENOMENA. IN CLASSICAL SYSTEMS, INFORMATION IS DIGITALLY ENCODED IN BITS WHICH ONLY EXIST AS LOGICAL “0” OR “1”. IN A QUANTUM BIT (QUBIT), INFORMATION CAN BE ENCODED IN ANY LINEAR SUPERPOSITION OF TWO QUANTUM STATES, A|0> + B|1>. INDIVIDUAL QUBITS CAN BE ENTANGLED, GIVING RISE TO COHERENT GATE OPERATIONS AND ALGORITHMS DESIGNED, FOR EXAMPLE, TO SOLVE CERTAIN CLASSICALLY INTRACTABLE COMPUTATIONAL PROBLEMS OR TO ESTABLISH SECURE COMMUNICATION. A QUBIT CAN BE REALIZED IN ANY PHYSICAL SYSTEM IN WHICH TWO DISCRETE ENERGY LEVELS CAN BE ISOLATED--IONS, ATOMS, MOLECULES, AND ELECTRICAL CIRCUITS ALL BEING ACTIVELY PURSUED APPROACHES. SUPERCONDUCTING ELECTRONICS ARE ATTRACTIVE SINCE IN PRINCIPLE, IT IS POSSIBLE TO MASS PRODUCE TUNABLE NONLINEAR CIRCUITS WITH VANISHING INTERNAL DISSIPATION, RESULTING IN AN INTEGRATED QUANTUM PROCESSOR CAPABLE OF MANY COHERENT OPERATIONS. AT PRESENT, SIMPLE ALGORITHMS USING COUPLED QUBITS HAVE BEEN DEMONSTRATED. I WILL REVIEW THE BASIC ARCHITECTURE AND OPERATION OF DIFFERENT SUPERCONDUCTING QUBITS AND HIGHLIGHT RECENT ADVANCES. CONTINUED PROGRESS IN THIS FIELD HAS THE POTENTIAL TO UNITE MANY BRANCHES OF APPLIED SUPERCONDUCTIVITY RESEARCH INCLUDING WORK IN LOW NOISE AMPLIFICATION, HIGH SPEED SIGNAL PROCESSING/GENERATION, AND MATERIALS SCIENCE.

2EA-01

(INVITED) **DETECTION OF SINGLE 8-μM PHOTONS USING A NANO-HEB DETECTOR** *S. PEREVERZEV[1], **B. KARASIK**[1], A. SOIBEL[1], D. OLAYA[2], D. SANTAVICCA[3], F. CARTER[3], D. PROBER[3], M. GERSHENSON[4], A. SERGEEV[5];* [1]JET PROPULSION LABORATORY/CALTECH, [2]NIST, [3]YALE UNI., [4]RUTGERS UNI., [5]SUNY AT BUFFALO. — WE REPORT ON THE EXPERIMENTAL DEMONSTRATION OF SINGLE-PHOTON DETECTION IN MID-IR (8-μM WAVELENGTH) USING A SMALL (6μM X 0.4μM X 56NM) HOT-ELECTRON NANOBOLOMETER (NANO-HEB) MADE FROM THIN TI FILM WITH NB CONTACTS. THE UNLTRASMALL HEAT CAPACITY OF THE ELECTRON GAS MAKES THIS DEVICE A VERY SENSITIVE CALORIMETER. THE DEVICE OPERATED BELOW ITS CRITICAL TEMPERATURE (329 MK) DOWN TO 25 MK. THE T_C ADJUSTMENT WAS MADE USING A MAGNETIC FIELD. THE SOURCE OF PHOTONS WAS A PULSED QUANTUM CASCADE LASER INSTALLED AT 4K. A DC SQUID WITH A LOW-PASS FILTER BLOCKING THE INJECTION OF THE UNWANTED NOISE FROM THE SQUID WAS USED AS A READOUT.DEPENDING ON THE LASER PULSE ENERGY AND TEMPERATURE UP TO 3 PHOTON PEAKS WERE OBSERVED IN THE COUNT STATISTICS. THE WIDTH OF THE PEAKS (~ MINIMUM DETECTABLE ENERGY) WAS NEARLY CONSTANT BETWEEN 25 MK AND 100 MK AND WAS DETERMINED BY THE PHONON NOISE IN THE NANO-HEB (~10 PA/HZ^1/2). THE RESPONSE TIME FROM ~ 1 MS AT 100 MK TO ~ FEW μS AT 300 MK WAS DETERMINED BY THE ELECTRON-PHONON TIME (~ T^-4) MODIFIED BY THE ELECTRO-THERMAL FEEDBACK. THE ENERGY RESOLUTION GRADUALLY DEGRADED BETWEEN 100 MK AND 300 MK. SO FAR, THE EXPERIMENTAL ENERGY RESOLUTION IS LOWER THAN THE THEORY PREDICTS AND AN ON-GOING WORK ADDRESSES THE CAUSES OF THIS DISCREPANCY.INTEGRATION OF THE NANO-HEB WITH MID-IR NANO-ANTENNAS AND MOVING TOWARD SMALLER DEVICES FOR USE AT EVEN LONGER FIR WAVELENGTHS ARE SEEN AS THE NEXT DEVELOPMENT STEPS.

THIS RESEARCH WAS CARRIED OUT AT THE JET PROPULSION LABORATORY, CALIFORNIA INSTITUTE OF TECHNOLOGY, UNDER A CONTRACT WITH THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

2EA-02

98 % QUANTUM EFFICIENCY PHOTON NUMBER RESOLVING TES DETECTORS WITH MULTI-LAYERED OPTICAL RESONATOR ***D. FUKUDA***[1]*, G. FUJII*[1]*, T. NUMATA*[1]*, K. AMEMIYA*[1]*, A. YOSHIZAWA*[1]*, H. TSUCHIDA*[1]*, H. FUJINO*[1]*, H. ISHII*[1]*, T. ITATANI*[1]*, S. INOUE*[2]*;* [1]AIST, [2]NIHON UNIV.. — OPTICAL PHOTON DETECTORS WITH HIGH QUANTUM EFFICIENCY (QE) OPERATING AT HIGH COUNT RATE ARE INDISPENSABLE IN QUANTUM INFORMATION TECHNOLOGY. WE HAVE DEVELOPED HIGH PERFORMANCE PHOTON NUMBER RESOLVING DETECTORS WITH TITANIUM-BASED TRANSITION EDGE SENSORS (TI-TES). THE TI HAS THE TRANSITION TEMPERATURE AROUND 0.4 K, WHICH ENABLES THE HIGH COUNTING RATE UP TO 1 MHZ. IN ORDER TO ENHANCE QE, AN OPTICAL RESONANT STRUCTURE IS APPLIED TO TES, IN WHICH THE TES LAYER IS EMBEDDED IN ANTI-REFLECTION AND HIGH-REFLECTION LAYERS. WE HAVE FABRICATED THE RESONATOR WITH MULTI-LAYERED DIELECTRIC FILMS OF TA_2O_5 AND SIO_2 DEPOSITED BY ION BEAM ASSISTED SPUTTER (IBS). DURING THE DEPOSITION THICKNESS OF EACH LAYER IS MONITORED AND CONTROLLED IN SITU TO ACHIEVE THE DESIGNED VALUES. THE STRUCTURE OF RESONATOR IS DESIGNED FOR OPERATION AT 850 NM WAVELENGTH TAKING ACCOUNT OF COMPLEX REFRACTIVE INDEXES OF DIELECTRIC FILMS AND TI. TOTAL LAYER NUMBER OF THE RESONATOR IS 30 INCLUDING TI. THE ENERGY RESOLUTION AND DECAY TIME CONSTANT OF

THE FABRICATED TI-TES DEVICE IS MEASURED TO BE 0.46 EV (FWHM), AND 660 NS, RESPECTIVELY. THE DETECTION PROBABILITIES $P(M|M)$ OF M-PHOTONS TO THE INCIDENT PHOTON PULSES WITH AVERAGE PHOTON NUMBER M RANGING FROM 0.01 TO 2 ARE MEASURED AND COMPARED WITH POISSON DISTRIBUTION. FROM THESE RESULTS, WE OBTAINED QE OF 98 % WITH 2 % UNCERTAINTY, WHICH IS THE HIGHEST VALUE REPORTED SO FAR FOR ALL KINDS OF PHOTON DETECTORS.

THIS WORK IS SUPPORTED IN PART BY THE NATIONAL INSTITUTE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY (NICT). A PART OF THIS WORK WAS CONDUCTED AT THE AIST NANO-PROCESSING FACILITY.

2EA-03

HIGH EFFICIENCY PHOTON COUNTING TRANSITION EDGE SENSORS OPTIMIZED FOR ABSORPTION AT 810NM ***S. NAM***[1], *A. E. LITA*[1], *B. CALKINS*[2], *L. A. PELLOCHOUD*[1], *T. GERRITS*[1], *A. MIGDALL*[1]; [1]NIST, [2]UNIVERSITY OF COLORADO, BOULDER AND NIST. — A VARIETY OF QUANTUM OPTICS EXPERIMENTS AND QUANTUM INFORMATION PROCESSING PROTOCOLS REQUIRE OPTICAL-FIBER-COUPLED SINGLE PHOTON DETECTORS THAT CAN OPERATE WITH NEAR UNITY SYSTEM DETECTION EFFICIENCY WHILE RESOLVING PHOTON NUMBER AT A PARTICULAR WAVELENGTH. IN PREVIOUS WORK WE HAVE DEVELOPED SUCH DETECTORS BASED ON A TUNGSTEN TRANSITION EDGE SENSOR FABRICATED IN AN OPTICAL CAVITY TO MAXIMIZE ABSORPTION AT FIBER TELECOMMUNICATIONS WAVELENGTHS OF 1550 NM AND 860 NM. THE TUNABILITY OF THE OPTICAL CAVITY DESIGN ALLOWS FOR THE DEVELOPMENT OF HIGH-EFFICIENCY DETECTORS OPTIMIZED FOR ANY WAVELENGTH IN THE VISIBLE TO NEAR-IR SPECTRUM. HERE WE DESCRIBE OUR RECENT CREATION OF TUNGSTEN TESS TUNED TO 810 NM, A WAVELENGTH THAT IS USEFUL IN CERTAIN QUANTUM OPTICS EXPERIMENTS AS A PART OF CORRELATED PHOTON PAIRS PRODUCED BY PARAMETRIC DOWNCONVERSION. THESE DEVICES HAVE ACHIEVED HIGH SYSTEM DETECTION EFFICIENCY AT THE DESIRED WAVELENGTH AND EXHIBIT EXCELLENT PHOTON NUMBER RESOLUTION CAPABILITY.

2EA-04

AN 850 MICRON HIGH RESOLUTION, HIGH SENSITIVITY, PASSIVE VIDEO IMAGING SYSTEM USING TRANSITION EDGE SENSORS ***D. T. BECKER***[1], *J. A. BEALL*[1], *H. M. CHO*[1], *W. D. DUNCAN*[1], *G. C. HILTON*[1], *R. D. HORANSKY*[1], *K. D. IRWIN*[1], *P. LOWELL*[1], *M. D. NIEMACK*[1], *C. D. REINTSEMA*[1], *F. SCHIMA*[1], *R. E. SCHWALL*[1], *K. W. YOON*[1], *P. A. ADE*[2], *C. E. TUCKER*[1]; [1]NIST-BOULDER, [2]CARDIFF UNIVERSITY. — MILLIMETER WAVELENGTH RADIATION HOLDS PROMISE FOR IDENTIFICATION OF SECURITY THREATS AT A DISTANCE, SUCH AS IDENTIFYING SUICIDE BOMB BELTS. THE SENSITIVITY PROVIDED BY SUPERCONDUCTING TRANSITION-EDGE-SENSOR (TES) BOLOMETERS MAKES THEM IDEAL FOR HIGH SENSITIVITY PASSIVE IMAGING OF THERMAL SIGNALS AT MILLIMETER AND SUBMILLIMETER WAVELENGTHS. WE ARE DEVELOPING AN 850 UM VIDEO-IMAGING SYSTEM USING TES BOLOMETERS AS DETECTORS. THIS DEMONSTRATION SYSTEM WILL IMAGE A 1 M X 1 M TARGET AT A DISTANCE OF 16 M TO A RESOLUTION OF APPROXIMATELY 1 CM. VIDEO IMAGES WITH NOISE-EQUIVALENT TEMPERATURE DIFFERENCE OF 50 MK WILL BE GENERATED AT 10 FRAMES PER SECOND. LIGHT IS CAPTURED BY AN F/2.0 CASSEGRAIN OPTICAL SYSTEM WITH 1.3 M PRIMARY MIRROR. IN THE INITIAL DEMONSTRATION SYSTEM, THE FOCAL PLANE WILL CONSIST OF 800 TES BOLOMETERS COOLED TO .8K. THE PIXELS WILL INITIALLY BE READ OUT USING A TIME-DOMAIN MULTIPLEXED SQUID READOUT SYSTEM. WE WILL REPORT ON THE CURRENT STATUS OF DEVELOPMENT OF THIS SYSTEM.

2EA-05

LABOCA-2 - A MULTIPLEXED 300 CHANNEL BOLOMETER CAMERA FOR 870 MICROMETER WAVELENGTH ***T. MAY***[1], *V. ZAKOSARENKO*[1], *E. HEINZ*[1], *K. PEISELT*[1], *A. KRUEGER*[1], *S. ANDERS*[1], *H. MEYER*[1], *E. KREYSA*[2], *W. ESCH*[2], *G. LUNDERSHAUSEN*[2]; [1]INSTITUTE OF PHOTONIC TECHNOLOGY, [2]MAX-PLANCK INSTITUTE FOR RADIOASTRONOMY. — ONE OF THE BEST ACCESSIBLE SITES FOR SUBMILLIMETER OBSERVATIONS IS THE HIGH PLATEAU LLANO DE CHAJNANTOR IN CHILE'S ATACAMA DESERT. AT 5000 METER ALTITUDE APEX (ATACAMA PATHFINDER EXPERIMENT), A 12 METER RADIO TELESCOPE, HAS SEEN FIRST LIGHT IN 2005.THE LARGE ARRAY BOLOMETER CAMERA (LABOCA) IS SCHEDULED TO SUCCEED TO ITS SEMICONDUCTING PREDECESSOR AT APEX IN AUTUMN 2010. IT IS AN ARRAY OF 300 TRANSITION EDGE SENSORS OPERATED AT A TEMPERATURE OF 260 MK, PROVIDED BY A MULTI-STAGE [3]HE SORPTION COOLER MOUNTED ON A PULSE TUBE COOLER. THE INSTRUMENT IS READ OUT BY SQUID CURRENT SENSORS IN A TIME DOMAIN MULTIPLEXING SCHEME. 30 INTEGRATED MULTIPLEXER CHIPS, 10 FIRST STAGE SQUIDS EACH, ARE PLACED NEXT TO THE DETECTOR CHIP, OPERATING AT THE SAME TEMPERATURE. EVERY MULTIPLEXER CHIP IS COUPLED TO ONE SUPERCONDUCTING QUANTUM INTERFERENCE FILTER (SQIF) FOR PREAMPLIFICATION. THE SQIFS OPERATE AT A TEMPERATURE OF ABOUT 2K.THE SIGNALS ARE ACQUIRED BY ROOM TEMPERATURE ELECTRONICS AND DIGITIZED BY 18BIT A/D CONVERTERS. THE DATA ACQUISITION SYSTEM LIMITS THE SYSTEM CLOCK TO 20KHZ, RESULTING IN AN EFFECTIVE DATA RATE OF 2KHZ PER CHANNEL.

2EA-06

DEVELOPMENT OF MULTILAYER READOUT WIRING FOR LARGE-FORMAT TES X-RAY MICROCALORIMETER ARRAYS ***Y. EZOE***[1], *Y. ISHISAKI*[1], *H. YOSHITAKE*[2], *N. SEKIYA*[2], *S. OISHI*[1], *Y. ABE*[1], *H. AKAMATSU*[1], *Y. TAKEI*[2], *N. Y. YAMASAKI*[2], *K. MITSUDA*[2], *T. OHASHI*[1], *T. MOROOKA*[3], *K. TANAKA*[4]; [1]TOKYO METROPOLITAN UNIVERSITY, [2]ISAS/JAXA, [3]SEIKO INSTRUMENTS INC., [4]SEIKO NANOTECHNOLOGY INC.. — WE HAVE BEEN DEVELOPING ARRAYS OF TRANSITION-EDGE SENSOR (TES) X-RAY MICROCALORIMETER FOR FUTURE ASTRONOMICAL MISSIONS. A PIXEL ARRAY IS COMPOSED OF A TI/AU TES BILAYER, SINX MEMBRANE, AND A GOLD ABSORBER. WE HAVE ACHIEVED AN ENERGY RESOLUTION OF 2.8 EV (FWHM) AT 5.9 KEV FOR A SMALL 4X4 ARRAY (AKAMATSU ET

AL. 2009 LTD11) AND 4.4 EV FOR A 16X16 ARRAY (EZOE ET AL. 2009 LTD11). NOW WE ARE DIRECTING OUR EFFORTS TOWARDS REPRODUCIBLE, HIGH ENERGY-RESOLUTION AND HIGH FILLING-FACTOR ARRAYS. REDUCTION OF WIRING SPACE AND ELECTRICAL INTERFERENCE AMONG PIXELS ARE IMPORTANT ISSUES. IN THIS PAPER, WE PRESENT OUR DEVELOPMENT OF MULTILAYER READOUT WIRING CONSISTING OF SUPERCONDUCTING HOT AND RETURN WIRES (AL OR NB) THAT SANDWICH AN INSULATION FILM (SIO2). THE NECESSARY AREA FOR WIRING BECOMES HALF COMPARED TO A NORMAL WIRING. ALSO, A MUTUAL INDUCTANCE BETWEEN HOT AND RETURN WIRES IS MINIMIZED, WHICH IS IDEAL FOR A FREQUENCY-DIVISION SQUID MULTIPLEXER SYSTEM. WE FABRICATED WIRING SAMPLES WITHOUT TES FOR 4X4, 8X8, AND 20X20 ARRAYS. WIDTHS OF UPPER AND LOWER WIRES ARE AT MINIMUM 10 AND 15 UM. WE PRESENT FABRICATION PROCESS, CHARACTERISTICS AND OUR DEVELOPMENT OF TES ARRAYS USING THIS METHOD.

2EA-07

HIGH POWER ELECTRON TUNNELING REFRIGERATORS OPTIMIZED FOR MAXIMAL COOLING ***P. J. LOWELL****, G. C. O'NEIL, J. M. UNDERWOOD, J. N. ULLOM;* NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY. — NORMAL METAL INSULATOR SUPERCONDUCTOR (NIS) TUNNEL JUNCTIONS CAN BE USED AS REFRIGERATORS TO COOL SENSORS AND OTHER LOW-POWER PAYLOADS. IN PREVIOUS WORK, WE USED NIS JUNCTIONS TO COOL A TRANSITION EDGE X-RAY SENSOR (TES) FROM 300 TO 190 MK AND SUCCESSFULLY OPERATED THE SENSOR WITH AN ENERGY RESOLUTION OF 9.5 EV FWHM AT 5.9 KEV. IN ORDER TO ACHIEVE BETTER TES PERFORMANCE, LOWER NIS BASE TEMPERATURES ARE REQUIRED. TO ACHIEVE LOWER TEMPERATURES, WE HAVE DEVELOPED NIS REFRIGERATORS WITH THINNER BASE ELECTRODES AND IMPROVED NORMAL METAL QUASIPARTICLE TRAPS. IN PARTICULAR, WE HAVE OPTIMIZED THE TRANSPARENCY OF THE TRAP INTERFACE TO BALANCE COMPETING NEEDS FOR RAPID QUASIPARTICLE TUNNELING INTO THE TRAPS AND A DENSITY OF STATES IN THE COUNTERELECTRODE OF THE REFRIGERATOR THAT IS UNPERTURBED BY THE TRAPS. WE HAVE DESIGNED AND FABRICATED NIS REFRIGERATORS INCORPORATING THESE IMPROVEMENTS TO COOL FROM 300 TO 100 MK. WE PRESENT DATA ON THESE OPTIMIZED NIS REFRIGERATORS.

THIS WORK IS SUPPORTED BY THE NASA APRA PROGRAM.

2EB-01

(INVITED) **DESIGN AND DEMONSTRATION OF A 4-BIT FLASH-TYPE SFQ A/D CONVERTER INTEGRATED WITH ERROR CORRECTION AND INTERLEAVE CIRCUITS** ***H. SUZUKI****[1], M. OIKAWA[1], K. NISHII[1], K. ISHIHARA[2], K. FUJIWARA[3], M. MARUYAMA[4], M. HIDAKA[1];* [1]ISTEC/SRL, [2]TOKYO DENKI UNIVERSITY, [3]ISTEC/SRL, SANDISK LIMITED JAPAN (CURRENT AFFILIATION), [4]ISTEC/SRL, AIST (CURRENT AFFILIATION). — WE HAVE DESIGNED A FULLY INTEGRATED 4-BIT FLASH-TYPE SFQ ANALOG TO DIGITAL CONVERTER IN WHICH ERROR CORRECTION AND INTERLEAVE CIRCUITS ARE COMBINED WITH COMPARATORS AND CONFIRMED ITS PROPER OPERATION [1]. A COMPLEMENTARY QUASI-ONE-JUNCTION SQUID (CQOS) COMPARATOR COMBINED TWO SQUIDS ARE USED FOR INCREASING THE MAXIMUM OPERATING FREQUENCY [2]. MORE THAN 30 GHZ SAMPLING OPERATION WAS EXPERIMENTALLY CONFIRMED FOR A 4BIT COMPARATOR FABRICATED WITH JC OF 2.5KA/CM2 SRL'S NB STANDARD PROCESS (STD2). THE INTERLEAVE CIRCUIT CAN ADD ONE MORE BIT. IN TOTAL, THE A/D CONVERTER OUTPUT A BINARY 4-BIT AND A POLARITY BIT DATA. REDUNDANT COMPARATORS AND A DIGITAL CIRCUIT BASED ON LOOK-BACK LOGIC WERE ABLE TO AVOID GRAY ZONE IN COMPARATORS, ENABLING THE ERROR CORRECTED OPERATION IN THE CHIP. THEN, INPUT WAVEFORMS AT LOW FREQUENCIES WERE SUCCESSFULLY RETRIEVED FROM THE BINARY DATA OF THE A/D CONVERTER. THE A/D CONVERTER WAS ALSO CONFIRMED ITS OPERATION IN A CRYOCOOLING SYSTEM USING A 4K-GM-CRYOCOOLER AFTER THE CHIP WAS FLIP-CHIP BONDED ON MULTI-CHIP-MODULE (MCM) CARRIER.

THIS WORK WAS SUPPORTED BY THE NEW ENERGY AND INDUSTRIAL TECHNOLOGY DEVELOPMENT ORGANIZATION (NEDO) AS DEVELOPMENT OF NEXT-GENERATION HIGH-EFFICIENCY NETWORK DEVICE PROJECT.

2EB-02

(INVITED) **MULTI-BAND DIGITAL RF RECEIVER** ***S. SARWANA****, D. KIRICHENKO, V. DOTSENKO, A. F. KIRICHENKO, S. B. KAPLAN, D. GUPTA;* HYPRES INC.. — A SOFTWARE RADIO RECEIVER THAT CAN BE PROGRAMMED TO OPERATE IN MULTIPLE WIDE FREQUENCY BANDS IS REQUIRED FOR MANY COMMUNICATION AND INTELLIGENCE APPLICATIONS. WE HAVE DESIGNED A VARIETY OF MULTI-BAND RECEIVERS, COMPRISING A SET OF BAND-SPECIFIC ANALOG-TO-DIGITAL CONVERTERS (ADCS) FOR DIRECT DIGITIZATION OF RF BANDS AND A DIGITAL SWITCH MATRIX FOR BAND SELECTION, IN TWO FLAVORS: AS A SINGLE SUPERCONDUCTOR INTEGRATED CIRCUIT CHIP AND ALSO AS A MULTI-CHIP MODULE. IN ADDITION TO THE ADCS AND THE SWITCH, THESE INCLUDE A 1:16 DESERIALIZER AND OUTPUT DRIVERS TO FACILITATE TRANSPORT OF THE DIGITIZED RF DATA TO ROOM TEMPERATURE ELECTRONICS FOR FURTHER PROCESSING AND ANALYSIS. IN THE SINGLE IC FLAVOR, UP TO FOUR BANDPASS DELTA-SIGMA ADCS MINIMIZING QUANTIZATION NOISE IN THEIR RESPECTIVE BANDS WERE INTEGRATED ON THE SAME CHIP AND OPERATED AT CLOCK RATES UP TO 16 GHZ. IN THE MULTI-CHIP MODULE (MCM) IMPLEMENTATION, A 1-CM × 1-CM UNIVERSAL ACTIVE CARRIER WAS DESIGNED TO ACCOMMODATE ANY TWO 2.5-MM × 2.5-MM FLIPPED CHIPS, EACH CONTAINING A SINGLE ADC FRONT-END. THIS STANDARDIZED APPROACH FACILITATES CUSTOMIZATION OF TWO-BAND ADCS BY SELECTING FROM A GROWING LIBRARY OF ADC FRONT-ENDS, WHICH CURRENTLY COVER BANDS RANGING FROM HF (0-30 MHZ) TO KA-BAND (20-21 GHZ). MULTI-BAND MCMS WERE FABRICATED, ASSEMBLED AND TESTED, WITH NO SIGNIFICANT DEGRADATION IN PERFORMANCE FOR THE MULTI-BAND CHIPS VERSUS SINGLE CHIPS.

THIS WORK WAS SUPPORTED IN PART BY SPAWAR CONTRACT # N00039-08-C-0058

2EB-03

MULTITONE WAVEFORM SYNTHESIS WITH A QUANTUM VOLTAGE NOISE SOURCE ***S. BENZ****, P. DRESSELHAUS, C. BURROUGHS;* NIST. — WE HAVE DEVELOPED A QUANTUM VOLTAGE NOISE SOURCE (QVNS) BASED ON PULSE-DRIVEN JOSEPHSON ARRAYS AND OPTIMIZED ITS WAVEFORM SYNTHESIS FOR USE WITH JOHNSON NOISE THERMOMETRY (JNT). THE QVNS SYNTHESIZES MULTITONE WAVEFORMS WITH EQUAL AMPLITUDE HARMONIC TONES AND RANDOM RELATIVE PHASES IN ORDER TO CHARACTERIZE THE AMPLITUDE AND FREQUENCY RESPONSE OF THE ANALOG AND DIGITAL ELECTRONICS OF THE JNT SYSTEM. THIS PAPER DESCRIBES THE QVNS CIRCUIT DESIGN AND OPERATION, INCLUDING THE LUMPED-ARRAY JOSEPHSON-JUNCTION CIRCUIT AND BOTH UNIPOLAR AND BIPOLAR BIAS TECHNIQUES. WE ALSO DESCRIBE THE MODULATOR ALGORITHM THAT GENERATES THE DIGITAL CODE FOR THE SYNTHESIZED WAVEFORMS. WE DESCRIBE HOW THE MODULATOR ALGORITHM PARAMETERS ARE ADJUSTED TO OPTIMIZE THE AMPLITUDE UNIFORMITY OF THE SYNTHESIZED HARMONIC TONES AND WE DESCRIBE A METHOD TO MINIMIZE THE PEAK AMPLITUDE OF THE TIME-DEPENDENT WAVEFORM. ALL THESE IMPROVEMENTS CONTRIBUTED TO DOUBLING THE MEASUREMENT BANDWIDTH OF THE JNT SYSTEM.

2EB-04

OPTIMIZATION OF JOSEPHSON JUNCTION COMPARATORS IN TERMS OF SPEED AND ACCURACY *B. EBERT,* ***T. ORTLEPP****;* ILMENAU UNIVERSITY OF TECHNOLOGY. — THE BASIC DECISION MAKING ELEMENT OF RAPID SINGLE FLUX QUANTUM (RSFQ) LOGIC IS THE JOSEPHSON COMPARATOR COMPOSED OF TWO JOSEPHSON JUNCTIONS IN SERIES. IT COMPARES A SIGNAL CURRENT WITH A THRESHOLD CURRENT WHENEVER A PULSE OCCURS AT ITS CLOCK INPUT. THE PERFORMANCE OF THIS COMPARATOR IS LIMITED BY THE DECISION UNCERTAINTY AND THE SWITCHING TIME. THE DECISION UNCERTAINTY IS CAUSED BY THE PRESENCE OF THERMAL NOISE AND CAN BE QUANTIFIED BY THE GRAY ZONE WIDTH. THE TIME NEEDED BY THE COMPARATOR TO QUANTIZE THE SIGNAL CURRENT IS NAMED SWITCHING TIME. FINALLY, IT LIMITS THE CONVERSION SPEED OF AN ANALOG-TO-DIGITAL CONVERTER, BUT ALSO THE MAXIMUM OPERATING SPEED OF LOGIC CELLS. WE INVESTIGATED BOTH LIMITATIONS BY CIRCUIT SIMULATIONS AND REVEALED AN INHERENT TRADE-OFF BETWEEN SPEED AND ACCURACY WHICH IS ROBUST AGAINST MODIFICATIONS OF CIRCUIT PARAMETERS. WE INTRODUCED THE PRODUCT OF GRAY ZONE WIDTH AND SWITCHING TIME AS A FIGURE OF MERIT FOR COMPARATORS AND ANALYZE ITS DEPENDENCE ON THE CRITICAL CURRENT DENSITY. ITS VALUE WAS ALMOST CONSTANT DURING THE ANALYSIS OF DIFFERENT TOPOLOGIES FOR A FIXED TECHNOLOGY. ONLY A NEW TOPOLOGY WILL PROBABLY ALLOW TO IMPROVE ITS VALUE SIGNIFICANTLY.

2EB-05

EVENT-DRIVEN DUAL CHANNEL OVERSAMPLED ANALOG-TO-DIGITAL CONVERTER FOR A DETECTOR SYSTEM ***A. FUJIMAKI****, Y. HOGASHI, S. MIYAJIMA, T. KUSUMOTO;* NAGOYA UNIVERSITY. — WE HAVE SUCCESSFULLY DEMONSTRATED A DUAL CHANNEL OVERSAMPLED DELTA ANALOG-TO-DIGITAL CONVERTER (ADC) WITH AN EVENT-DRIVEN DECIMATION FILTER BASED ON THE SINGLE-FLUX-QUANTUM (SFQ) CIRCUITS FOR AN ARRAYED SYSTEM COMPOSED OF MULTIPLE SUPERCONDUCTIVE PARTICLE DETECTORS. EACH DETECTOR WILL BE CONNECTED BOTH TO A COMPARATOR AND TO A MODULATOR OF THE ADC, WHILE THE ADC TESTED HERE CAN HANDLE ONLY TWO INPUTS. ALL THE OUTPUTS OF THE MODULATORS ARE CONNECTED TO A SINGLE DECIMATION FILTER THROUGH A SELECTOR CONTROLLED BY THE OUTPUTS OF THE CORRESPONDING COMPARATORS MADE OF QUASI-ONE-JUNCTION SQUIDS. WHEN A CURRENT FROM A DETECTOR EXCEEDS A PREDETERMINED LEVEL, THE SELECTOR BECOMES 'ON' AND THE OUTPUT DATA OF THE CORRESPONDING MODULATOR ARE SENT TO THE DECIMATION FILTER. THIS PROVIDES AN EVENT-DRIVEN OPERATION AND ENABLES TIME-DIVISION MULTIPLEXING. WE CAN ACHIEVE A REMARKABLE REDUCTION BOTH IN OCCUPIED AREA AND IN HEAT INFLOW FROM ROOM TEMPERATURE ELECTRONICS THROUGH CABLES. WE EXAMINED THE ADC BY INPUTTING ANALOG SIGNALS FROM AN EXTERNAL FUNCTION GENERATOR INTO THE MODULATORS AND THE COMPARATORS. WE CONFIRMED EVENT-DRIVEN OPERATION AND TIME-DIVISION MULTIPLEXING OF THE DUAL ADC AT 15 GHZ.

THIS STUDY WAS SUPPORTED BY SENTAN, JST.

2EB-06

10 VOLT PROGRAMMABLE JOSEPHSON VOLTAGE STANDARD CIRCUITS USING NBSI-BARRIER JUNCTIONS ***P. D. DRESSELHAUS****, M. M. ELSBURY, D. OLAYA, C. J. BURROUGHS, S. P. BENZ;* NIST. — PROGRAMMABLE JOSEPHSON VOLTAGE STANDARD (PJVS) CIRCUITS WERE DEVELOPED THAT OPERATE AT 16-20 GHZ WITH OPERATING MARGINS LARGER THAN 1 MA. TWO CIRCUIT DESIGNS WERE DEMONSTRATED EACH HAVING A TOTAL OF ~ 300,000 JUNCTIONS, WHICH WERE DIVIDED INTO EITHER 16 OR 32 SUB-ARRAYS. IN ORDER TO YIELD THE ~300,000 JUNCTIONS ON EACH CIRCUIT, A NBSIX-BARRIER JUNCTION TECHNOLOGY WAS UTILIZED BECAUSE IT PROVIDED THE HIGHEST DEGREE OF UNIFORMITY OF THE BARRIER AND THE CORRESPONDING JUNCTION ELECTRICAL PROPERTIES. ALTHOUGH THE MARGINS ON BOTH THE 16-ARRAY AND 32-ARRAY CIRCUITS WERE MUCH GREATER THAN 1 MA, THE CIRCUIT YIELD FOR THE 16-ARRAY DESIGN WAS LOWER BECAUSE THE LONGER ARRAYS ARE MORE SENSITIVE TO DEFECTS. THE USE OF LUMPED-ELEMENT MICROWAVE SPLITTERS AND TAPERED ARRAYS SIGNIFICANTLY REDUCED THE MICROWAVE INPUT POWER AND INCREASED THE OPERATING MARGINS OF THESE DESIGNS. IN ADDITION, THE BROADBAND MICROWAVE RESPONSE OF THE DESIGN ALLOWED THE PJVS OUTPUT VOLTAGE TO BE CONTINUOUSLY ADJUSTED USING THE MICROWAVE FREQUENCY.

2EC-01

(INVITED) **CO-REGISTRATION OF MEG AND ULF MRI USING A 7 CHANNEL LOW-TC SQUID SYSTEM** ***P. MAGNELIND****, H. SANDIN, P. VOLEGOV, A. MATLASHOV, T. OWENS, J. GOMEZ, M. ESPY;* LOS ALAMOS NATIONAL LABORATORY. — IN HUMAN BRAIN IMAGING FOR, E.G., PRE-SURGICAL MAPPING IT IS HIGHLY DESIRED TO OBTAIN IMAGES WITH HIGH SPATIAL AND TEMPORAL RESOLUTION. HOWEVER, NO SINGLE IMAGING DEVICE IS ABLE TO PROVIDE BOTH A HIGH SPATIAL RESOLUTION ANATOMICAL IMAGE AND A HIGH TEMPORAL RESOLUTION FUNCTIONAL IMAGE. BY USING A 7 CHANNEL SQUID SYSTEM WHICH IS ABLE TO PERFORM BOTH ULTRA-LOW FIELD (ULF) MRI AND MEG IT IS POSSIBLE TO CO-REGISTER A LOWER RESOLUTION ULF MR IMAGE AND AN MEG IMAGE IN THE SAME RUN TO GET ANATOMICAL LANDMARKS FOR ALIGNING THE MEG DATA. RECENTLY, OUR GROUP PRESENTED THE FIRST BRAIN IMAGES OBTAIN BY ULF MRI WHERE AN MEG SESSION WAS PERFORMED A POSTERIORI. IN THIS PRESENT WORK WE SHOW INTERLEAVED ULF MRI AND MEG MEASUREMENTS, WHERE THE ULF MR AND THE MEG IMAGES ARE OVERLAID ON A HIGH RESOLUTION 3 T MR IMAGE. WITH THIS APPROACH WE OBTAINED A CO-REGISTRATION ERROR ON THE MILLIMETER SCALE. IN PRINCIPLE, THE TECHNIQUE SHOULD BE APPLICABLE TO A CUSTOM EQUIPPED WHOLE-HEAD MEG SYSTEM WITH ADDED ULF MRI CAPABILITY.

THE AUTHORS GRATEFULLY ACKNOWLEDGE THE SUPPORT OF THE U.S. NATIONAL INSTITUTES OF HEALTH.

2EC-02

FIELD-TOLERANT SQUID SENSORS FOR A COMBINED MEG-MRI SYSTEM ***J. LUOMAHAARA****[1], J. HASSEL[1], J. PENTTILÄ[2], M. KIVIRANTA[1], L. GRÖNBERG[1];* [1]TECHNICAL RESEARCH CENTER OF FINLAND, [2]AIVON OY. — LOW-TEMPERATURE SQUID SENSORS COUPLED TO LARGE PICKUP COILS ARE A STRONG CANDIDATE FOR THE HYBRID MEG-MRI DEVICE PRESENTLY UNDER DEVELOPMENT. THE MAJOR CHALLENGE IS TO ENHANCE THE FIELD TOLERANCE AGAINST LARGE POLARIZATION PULSES WITHOUT RISKING THE FIELD SENSITIVITY. WE HAVE STUDIED VARIOUS ASPECTS OF SENSOR OPTIMIZATION. THE FIELD TOLERANCE WAS MEASURED BY PLACING THE SQUID IN PERPENDICULAR MAGNETIC FIELD. EXPERIMENTS SHOW THAT OUR CURRENT SQUID MODULES BASED ON A PLANAR TECHNOLOGY AND CONFIGURED AS EITHER MAGNETOMETERS OR FIRST-ORDER GRADIOMETERS ARE ABLE TO FUNCTION IN A HOMOGENEOUS MAGNETIC FIELD OF SEVERAL HUNDREDS OF μT AND RECOVER COMPLETELY FROM PULSES OF AT LEAST 11 MT. THE RECOVERY WAS FOUND TO BE WELL EXPLAINED THROUGH THE THEORY OF THE GEOMETRICAL BARRIER. IN GENERAL, THE FIELD TOLERANCE CAN BE IMPROVED BY DECREASING LINEWIDTH WHICH CAN ALSO BE UTILIZED TO ACHIEVE BETTER CHARACTERISTICS IN OTHER RESPECTS SUCH AS NOISE AND DEVICE PACKING DENSITY IN FABRICATION. WE ALSO INTRODUCE OUR NEW FABRICATION PROCESS ENABLING REDUCED LINEWIDTHS BASED ON PROJECTION LITHOGRAPHY, AND SHOW CHARACTERIZATION RESULTS ON SQUID SENSORS FABRICATED WITH IT.

THIS WORK WAS SUPPORTED BY EU THROUGH FP7 PROJECT MEGMRI AND BY THE ACADEMY OF FINLAND.

2EC-03

ULTRALOW FIELD MRI AT 132 μT FOR THE DETECTION OF TUMORS ***S. BUSCH****[1], M. HATRIDGE[1], T. WONG[1], M. MOESSLE[1], K. CHEW[2], J. SIMKO[2], A. PINES[1], J. CLARKE[1];* [1]UC BERKELEY/LBNL, [2]UC SAN FRANCISCO. — WE ARE INVESTIGATING THE USE OF MAGNETIC RESONANCE IMAGING (MRI) AT ULTRALOW FIELDS OF AROUND 100 μT, WHERE INTRINSIC LONGITUDINAL-RELAXATION-TIME (T1)-WEIGHTED CONTRAST IS ENHANCED, TO DETECT TUMORS. WE HAVE MEASURED T1 OF PAIRS OF NORMAL AND CANCEROUS PROSTATE TISSUE SPECIMENS--WITHIN A FEW HOURS OF THEIR SURGICAL REMOVAL--FROM APPROXIMATELY 20 PATIENTS. THE MEASUREMENTS INVOLVE A FIELD-CYCLING IMAGING TECHNIQUE IN WHICH WE PREPOLARIZE THE PROTONS IN EACH PAIR OF SAMPLES IN A FIELD OF 150 MT, RAMP THIS FIELD DOWN TO 132 μT, ENCODE THE LOW FIELD IMAGE USING MAGNETIC FIELD GRADIENTS, AND MEASURE THE PROTON NMR SIGNAL WITH A SQUID COUPLED TO AN UNTUNED, SECOND-DERIVATIVE GRADIOMETER. THE OBSERVED T1 CONTRAST IS SIGNIFICANTLY GREATER THAN THAT AT TESLA FIELDS, SUGGESTING THAT ONE MAY BE ABLE TO DISTINGUISH TUMORS FROM NORMAL TISSUE IN VIVO WITHOUT A CONTRAST AGENT: AVERAGE T1 VALUES AT 132 μT FOR NORMAL AND CANCEROUS TISSUE ARE 60 AND 46 MS. WE PRESENT DATA SHOWING THE SCALING OF IMAGE CONTRAST WITH DIFFERENCE IN PERCENTAGE TUMOR OF EACH SPECIMEN PAIR. WE DESCRIBE A 150-MT PREPOLARIZING COIL THAT WILL ALLOW THE SYSTEM TO BE RECONFIGURED IN A GEOMETRY SUITABLE FOR IN VIVO IMAGING.

WORK SUPPORTED BY THE NATIONAL INSTITUTES OF HEALTH.

2EC-04

LOW-FIELD NUCLEAR MAGNETIC RESONANCE AND MAGNETIC RESONANCE IMAGING USING HIGH-T_C SQUID FOR TUMOR DETECTION ***H. C. YANG****[1], S. H. LIAO[1], H. H. CHEN[2], H. E. HORNG[2], S. Y. YANG[3], K. W. HUANG[4], L. M. WANG[1], M. J. CHEN[1], K. L. CHEN[1];* [1]DEPARTMENT OF PHYSICS, NATIONAL TAIWAN UNIVERSITY, [2]INSTITUTE OF ELECTRO-OPTICAL SCIENCE AND TECHNOLOGY, NATIONAL TAIWAN NORMAL UNIVERSITY, [3]MAGQU CO., LTD., [4]DEPARTMENT OF SURGERY AND ANGIOGENESIS CENTER, NATIONAL TAIWAN UNIVERSITY HOSPITAL AND NATIONAL TAIWAN UNIVERSITY COLLEGE OF MEDICINE. — IN THIS WORK, WE DEVELOP A HIGH-T_C SQUID BASED NUCLEAR MAGNETIC RESONANCE AND MAGNETIC RESONANCE IMAGING (NMR/MRI) WITH PRE-POLARIZATION TECHNIQUE IN MICROTESLA MAGNETIC FIELD FOR LIVER TUMOR DETECTION IN RATS. A TUNED COPPER-MADE FLUX TRANSFORMER COUPLED THE SIGNAL FROM SPECIMENS AT 300 K TO THE SQUID-DETECTOR. FOR WATER PHANTOM OF 1 ML IN VOLUME, THE SIGNAL-TO NOISE OF NMR SIGNAL IS 60

IN ONE SHOT AND THE SPECTRAL LINEWIDTH IS 1.4 HZ. FOR LIVER TUMOR DETECTION, THE LONGITUDINAL RELAXATION TIME T_1 OF CONTROLLED AND TUMOR LIVERS HAVE BEEN CHARACTERIZED. WE FIT THE CURVE OF SIGNAL INTENSITY OF NMR VERSUS PRE-POLARIZATION TIME T_P TO THE FUNCTION OF 1-EXP(-T_P/T_1). THE T_1 OF CONTROLLED AND CANCEROUS TISSUES IS 0.13 AND 0.3 SEC RESPECTIVELY IN A MAGNETIC FIELD OF 100 MT. THE FEASIBILITY OF USING T_1-PARAMETER TO DIFFERENTIATE CANCEROUS TISSUES FROM CONTROLLED TISSUES IS DEMONSTRATED. FURTHERMORE WE PRESENT THE T_1-WEIGHTED IMAGE IN PHANTOMS COMPOSED OF CONTROLLED AND TUMOR LIVERS TO DIFFERENTIATE THE CANCEROUS TISSUE FROM CONTROLLED TISSUES. THE RESULTS ARE DISCUSSED.

2EC-06

SQUIDS VS FARADAY COILS FOR ULTRA-LOW FIELD NUCLEAR MAGNETIC RESONANCE: EXPERIMENTAL AND SIMULATION COMPARISON ***A. N. MATLASHOV****, M. A. ESPY, R. H. KRAUS, I. M. SAVUKOV, L. J. SCHULTZ, A. V. URBAITIS, P. L. VOLEGOV;* LOS ALAMOS NATIONAL LABORATORY. — NUCLEAR MAGNETIC RESONANCE (NMR) METHODS ARE WIDELY USED IN MEDICINE, CHEMISTRY AND INDUSTRY. ONE APPLICATION AREA IS MAGNETIC RESONANCE IMAGING OR MRI. RECENTLY IT HAS BECOME POSSIBLE TO PERFORM NMR AND MRI IN ULTRA-LOW FIELD (ULF) REGIME THAT REQUIRES MEASUREMENT FIELD STRENGTHS ONLY OF THE ORDER OF 1 GAUSS. THESE TECHNIQUES EXPLOIT THE ADVANTAGES OFFERED BY SUPERCONDUCTING QUANTUM INTERFERENCE DEVICES OR SQUIDS. OUR GROUP AT LANL HAS BUILT SQUID BASED MRI SYSTEMS FOR BRAIN IMAGING AND FOR LIQUID EXPLOSIVES DETECTION AT AIRPORTS SECURITY CHECKPOINTS. THE REQUIREMENT FOR LIQUID HELIUM COOLING LIMITS POTENTIAL APPLICATIONS OF ULF MRI FOR LIQUID IDENTIFICATION AND SECURITY PURPOSES. OUR EXPERIMENTAL COMPARATIVE INVESTIGATION SHOWS THAT ROOM TEMPERATURE INDUCTIVE MAGNETOMETERS PROVIDE ENOUGH SENSITIVITY IN THE 3-10 KHZ RANGE AND CAN BE USED FOR FAST LIQUID EXPLOSIVES DETECTION BASED ON ULF NMR/MRI TECHNIQUE. WE DESCRIBE AN EXPERIMENTAL AND COMPUTER SIMULATION COMPARISON OF THE WORLD'S FIRST MULTICHANNEL SQUID BASED AND FARADAY COILS BASED INSTRUMENTS THAT ARE CAPABLE OF PERFORMING ULF MRI FOR LIQUIDS IDENTIFICATION.

THE AUTHORS GRATEFULLY ACKNOWLEDGE THE SUPPORT OF THE U.S. DEPARTMENT OF ENERGY, THE U.S. NATIONAL INSTITUTES OF HEALTH AND THE U.S. DEPARTMENT OF HOMELAND SECURITY FOR THIS WORK.

2EC-07

HTS COILS FOR MRI APPLICATIONS; ASSESSMENT OF SPLIT-RING AND COUNTER ROTATING CURRENTS DESIGNS ***J. WOSIK****[1], K. NESTERUK[2], L. XIE[3], F. IP[4];* [1]UNIVERSITY OF HOUSTON, ELECTRICAL AND COMPUTER ENGINEERING DEPARTMENT AND TEXAS CTR. FOR SUPERCONDUCTIVITY, [2]INSTITUTE OF PHYSICS, POLISH ACADEMY OF SCIENCES, WARSAW, POLAND, [3]UNIVERSITY OF HOUSTON, [4]UNIVERSITY OF TEXAS, HEALTH SCIENCES CENTER, SAN ANTONIO, TEXAS, USA. — SEVERAL STUDIES HAVE SHOWN THAT FOR SELECTED APPLICATIONS HTS MRI RECEIVER COILS PERFORM SIGNIFICANTLY BETTER THAN COMPARABLE COPPER COILS. WE REPORT ON THE DEVELOPMENT OF HTS COILS AND ARRAYS USING A NOVEL COUNTER-ROTATING CURRENTS (CRC) COIL DESIGN. SUCH COIL, IN A UNIFORM RF FIELD, IS INTRINSICALLY ISOLATED FROM THE TRANSMIT COIL (NO NEED FOR DETUNING CIRCUITRY) AND, IN ADDITION, IT PROVIDES RELATIVELY SMALLER BODY LOSSES COMPARED WITH COILS OF THE SAME FIELD-OF-VIEW. THE DESIGN CONSISTS OF TWO DOUBLE-SIDED (DISTRIBUTED CAPACITANCE MINIMIZING STRAY FIELDS) CONNECTED SPLIT-RING RESONATORS. THE HTS COIL WAS PATTERNED ON 2 YBCO FILMS DEPOSITED ON BOTH SIDES OF A 2-INCH LAO SUBSTRATE. EACH SPLIT-RING HAS A 22-MM OUTER DIAMETER AND 16-MM INNER DIAMETER. UNLOADED QS WERE MEASURED 128 MHZ AS 380 AND 15,000 FOR COPPER AND HTS COILS, RESPECTIVELY. SNR GAIN BY 100% OVER 295 K CU COIL/ARRAYS WAS ROUTINELY OBTAINED AT 77 K. BOTH 3 T AND 7 T TUNED HTS AND CU CRC COILS WERE TESTED IN SCANNERS IN SINGLE AND TWO-ELEMENT ARRAY CONFIGURATIONS (-20 DB ISOLATION WAS ACHIEVED USING THE CAPACITIVE ONLY DECOUPLING TECHNIQUE). THE CRC CRYO-COIL ALLOWED FOR A MULTIPLE REDUCTION OF THE IMAGE ACQUISITION TIME IN COMPARISON WITH CU COILS. IMAGES OF INFANT RESUS MONKEY'S EYES AND OF A HUMAN TRABECULAR BONE STRUCTURE FOLLOWED BY DISCUSSION OF THE DESIGN ADVANTAGES OVER THE STATE-OF-THE ART STANDARD COILS WILL BE PRESENTED.

THIS WORK WAS SUPPORTED BY NIH GRANTS AR053156, EY-03611 AND TEXAS CENTER FOR SUPERCONDUCTIVITY

2EX-01

(INVITED) **READ-OUT OF TES BOLOMETERS AND CALORIMETERS** *J. BEYER,* ***D. DRUNG****;* PHYSIKALISCH-TECHNISCHE BUNDESANSTALT. — SQUIDS ARE UBIQUITOUS TO READ OUT TRANSITION EDGE SENSORS (TESS): THEY ARE COMPATIBLE WITH THE LOW OPERATING TEMPERATURES OF TESS AND CAN BE DESIGNED INTO SENSITIVE AND FAST LOW-INPUT IMPEDANCE CURRENT SENSORS. THE REQUIRED PERFORMANCE IN TERMS OF INPUT REFERRED CURRENT NOISE, DYNAMIC RANGE, BANDWIDTH AND ACCEPTABLE POWER DISSIPATION VARIES FOR DIFFERENT TES APPLICATIONS. FOR INSTANCE, OPTICAL-PHOTON TES CALORIMETERS PRODUCE CURRENT PULSES OF ABOUT 100NA AMPLITUDE ON A MICROSECOND TIMESCALE THAT NEED TO BE DETECTED WITH LOW JITTER, WHEREAS HIGHLY SENSITIVE FAR-INFRARED BOLOMETERS REQUIRE EXCELLENT LOW-FREQUENCY CURRENT SENSOR NOISE PERFORMANCE AND NO BACK-ACTION OF THE SQUID ON THE TES. THE DEVELOPMENT OF ARRAYS WITH UP TO TENS OF THOUSANDS OF TES PIXELS FOR GROUND- AND SATELLITE-BASED ASTRONOMICAL INSTRUMENTS SETS PARTICULARLY STRINGENT REQUIREMENTS ON THE READOUT PERFORMANCE, BOTH WITH RESPECT TO THE SQUID CURRENT SENSORS AND THE SQUID READOUT ELECTRONICS. WE WILL REVIEW THE STATE-OF-THE-ART OF DEMANDING SINGLE TES SQUID-READOUT AS

WELL AS MULTIPLEXING TECHNIQUES NECESSARY TO INSTRUMENT LARGE-SCALE TES ARRAYS.

2EX-02

CODE-DIVISION SQUID MULTIPLEXING ARCHITECTURES, SIMULATIONS, AND MEASUREMENT RESULTS ***M. D. NIEMACK***[1]*, J. BEYER*[2]*, H. CHO*[1]*, W. DORIESE*[1]*, G. C. HILTON*[1]*, K. D. IRWIN*[1]*, C. D. REINTSEMA*[1]*, D. R. SCHMIDT*[1]*, J. N. ULLOM*[1]*, L. R. VALE*[1]*;* [1]NIST, [2]PHYSIKALISCH-TECHNISCHE BUNDESANSTALT (GERMANY). — WE ARE DEVELOPING CODE-DIVISION SQUID MULTIPLEXING (CDM) FOR READOUT OF SUPERCONDUCTING TRANSITION-EDGE SENSOR (TES) DETECTOR ARRAYS. CDM HAS BEEN SHOWN TO STRONGLY SUPPRESS PARASITIC NOISE (HARMONICS AND 1/F) IN THE READOUT CIRCUIT, WHICH SUGGESTS THAT IT MAY ALSO BE USEFUL FOR MORE GENERAL SQUID MEASUREMENT APPLICATIONS. WE PRESENT THE CDM ARCHITECTURES UNDER DEVELOPMENT AS WELL AS THE RESULTS OF NOISE, CROSSTALK, AND PARASITIC PICKUP MEASUREMENTS AND SIMULATIONS. WE ALSO DISCUSS THE ADVANTAGES OF CDM READOUT COMPARED TO EXISTING TES ARRAY READOUT METHODS IN TERMS OF PERFORMANCE AND SCALABILITY.

2EX-03

MICROWAVE SQUID MULTIPLEXER READOUT OF AN ARRAY OF CMB POLARIMETERS ***J. A. MATES***[1]*, K. D. IRWIN*[1]*, L. R. VALE*[1]*, G. C. HILTON*[1]*, J. GAO*[1]*, K. W. LEHNERT*[2]*;* [1]NIST, [2]JILA. — THE MICROWAVE SQUID MULTIPLEXER ENABLES FREQUENCY-DIVISION MULTIPLEXING OF LOW-TEMPERATURE BOLOMETERS AND CALORIMETERS, INCLUDING THE TRANSITION-EDGE SENSOR (TES), WITH MULTIPLE GIGAHERTZ OF BANDWIDTH. THE SIGNAL FROM A TES INDUCTIVELY COUPLES MAGNETIC FLUX INTO AN UNSHUNTED SQUID, SHIFTING THE RESONANCE FREQUENCY OF A SUPERCONDUCTING MICROWAVE RESONATOR. USING THE MICROWAVE SQUID MULTIPLEXER, LARGE ARRAYS OF TES DETECTORS CAN BE READ OUT USING A SINGLE COAXIAL CABLE AND ONE LOW-FREQUENCY FLUX MODULATION LINE, WITH LOW POWER DISSIPATION IN THE FOCAL PLANE. WE PRESENT DATA FROM READOUT OF A TES-BASED CMB POLARIMETER ARRAY USING A MICROWAVE SQUID MULTIPLEXER AND A SINGLE OUTPUT CHANNEL.

2EX-04

SINGLE PIXEL CHARACTERIZATION OF TRANSITION-EDGE SENSORS MICROCALORIMETER AND BOLOMETER UNDER AC BIAS. ***L. GOTTARDI***[1]*, J. VAN DER KUUR*[1]*, S. BANDLER*[2]*, M. BRUIJN*[1]*, P. DE KORTE*[1]*, J. R. GAO*[3]*, R. DEN HARTOG*[1]*, R. A. HIJMERING*[1]*, H. HOEVERS*[1]*, P. KHOSROPANAH*[1]*, C. KILBOURNE*[2]*, M. A. LINDEMAN*[1]*, M. PARRAS BORDERIAS*[4]*, M. RIDDER*[1]*;* [1]SRON NATIONAL INSTITUTE FOR SPACE RESEARCH, [2]NASA-GODDARD SPACE FLIGHT CENTER, [3]SRON NATIONAL INSTITUTE FOR SPACE RESEARCH/TU DELFT, [4]INSTITUTO DE CIENCIA DE MATERIALES DE ARAGÓN (CSIC-UNIVERSIDAD DE ZARAGOZA). — SRON IS DEVELOPING FREQUENCY DOMAIN MULTIPLEXING (FDM) FOR THE READ-OUT OF TRANSITION EDGE SENSOR (TES) SOFT X-RAY MICROCALORIMETERS FOR THE XMS INSTRUMENT OF THE INTERNATIONAL X-RAY OBSERVATORY AND FAR-INFRARED BOLOMETERS FOR THE SAFARI INSTRUMENT ON THE JAPANESE MISSION SPICA.IN FDM THE TESS ARE AC VOLTAGE BIASED AT FREQUENCIES FROM 0.5 TO 6 MHZ IN A SUPERCONDUCTING LC RESONANT CIRCUIT AND THE SIGNAL IS READ-OUT BY LOW NOISE AND HIGH DYNAMIC RANGE SQUIDS AMPLIFIERS. THE TES WORKS AS AN AMPLITUDE MODULATOR.WE REVIEW SEVERAL AC BIAS EXPERIMENTS PERFORMED ON DIFFERENT DETECTORS. IN PARTICULAR, WE DISCUSS THE RESULTS ON THE CHARACTERIZATION OF SRON AND GODDARD SPACE FLIGHT CENTER X-RAY PIXELS AND SRON BOLOMETERS. THE PAPER FOCUS ON THE ANALYSIS OF DIFFERENT READ-OUT CONFIGURATIONS DEVELOPED TO OPTIMIZE THE NOISE AND THE IMPEDANCE MATCHING BETWEEN THE DETECTORS AND THE SQUID AMPLIFIER. A NOVEL FEEDBACK NETWORK ELECTRONICS HAS BEEN DEVELOPED TO KEEP THE SQUID IN FLUX LOCKED LOOP, WHEN COUPLED TO SUPERCONDUCTING HIGH Q CIRCUITS, AND TO OPTIMALLY TUNE THE RESONANT BIAS CIRCUIT. THE EFFECT OF THE BIAS FREQUENCY ON THE DETECTOR SENSITIVITY IS EXPERIMENTALLY INVESTIGATED AS WELL.THE ACHIEVED DETECTORS PERFORMANCES ARE DISCUSSED IN VIEW OF THE INSTRUMENTS REQUIREMENT FOR THE TWO SPACE MISSIONS.

2EX-05

DEVELOPMENT OF A REAL-TIME PULSE PROCESSING ALGORITHM FOR TES-BASED X-RAY MICROCALORIMETERS ***H. TAN***[1]*, W. HENNIG*[1]*, W. K. WARBURTON*[1]*, W. B. DORIESE*[2]*, C. A. KILBOURNE*[3]*;* [1]XIA LLC, [2]NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY, [3]NASA/GODDARD SPACE FLIGHT CENTER. — WE REPORT HERE A REAL-TIME PULSE PROCESSING ALGORITHM FOR SUPERCONDUCTING TRANSITION-EDGE-SENSOR (TES) BASED X-RAY MICROCALORIMETERS. TES-BASED MICROCALORIMETERS OFFER ULTRA-HIGH ENERGY RESOLUTIONS, BUT THE SMALL VOLUME OF EACH PIXEL REQUIRES LARGE ARRAYS OF IDENTICAL MICROCALORIMETER PIXELS BE BUILT TO ACHIEVE SUFFICIENT DETECTION EFFICIENCY. THAT IN TURN REQUIRES AS MUCH PULSE PROCESSING AS POSSIBLE MUST BE PERFORMED AT THE FRONT END OF READOUT ELECTRONICS TO AVOID TRANSFERRING LARGE AMOUNTS OF DATA TO A HOST COMPUTER FOR PROCESSING. THEREFORE, A REAL-TIME PULSE PROCESSING ALGORITHM THAT CAN NOT ONLY BE IMPLEMENTABLE IN THE READOUT ELECTRONICS BUT ALSO ACHIEVE SATISFACTORY ENERGY RESOLUTIONS IS DESIRED. WE HAVE DEVELOPED AN ALGORITHM THAT CAN BE EASILY IMPLEMENTED IN HARDWARE (E.G. A FIELD PROGRAMMABLE GATE ARRAY (FPGA)). WE THEN TESTED THE ALGORITHM OFFLINE USING SEVERAL DATA SETS ACQUIRED WITH AN 8X8 GODDARD TES X-RAY CALORIMETER ARRAY AND 2X16 NIST TIME-DIVISION SQUID MULTIPLEXER. WE OBTAINED AN AVERAGE ENERGY RESOLUTION OF 3.2 EV AT 6 KEV FOR THE 16 MULTIPLEXED PIXELS. WE INTEND TO IMPLEMENT THE ALGORITHM IN THE READOUT ELECTRONICS THAT WE ARE CURRENTLY DEVELOPING AND WILL REPORT ANY REAL-TIME PROCESSING RESULTS THAT MIGHT BECOME AVAILABLE BY THE TIME OF THE CONFERENCE.

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2EX-06

ANALYSIS OF SATURATING SIGNALS OF TRASITION-EDGE SENSORS ***N. IYOMOTO;*** THE UNIVERSITY OF TOKYO. — WE ARE DEVELOPING IRIDIUM-BASED TRANSITION-EDGE-SENSOR (TES) MICROCALORIMETERS. SINCE OUR DEVICES HAVE A SMALL HEAT CAPACITY TO MAKE THE RESPONCE FAST, THE DEVICES HAVE SATURATING SIGNALS EVEN WITH A LOW-ENERGY X-RAYS. IN THE USUAL OPTIMAL-FILTERING METHOD, NON-LINEARIY DUE TO THE SATURATION STRONGLY DEGRADES THE ENERGY RESOLUTION. INSTEAD, WE INTEGRATE EACH PULSE AND MAKE AN OPTIMAL FILTER FROM THE INTEGRATED PULSES. APPLYING THE OPTIMAL FILTER TO THE INTEGRATED SIGNALS, WE OBTAIN A LINEAR RESPONSE WITH AN OFFSET AND IMPROVED ENERGY RESOLUTION OVER A WIDE ENERGY RANGE OF INCIDENT X-RAY PHOTON.

2EX-07

SMALL-SIGNAL BEHAVIOR OF A TES UNDER AC BIAS ***J. VAN DER KUUR[1], L. GOTTARDI[1], M. PARRA BORDERIAS[2], B. DIRKS[1], P. DE KORTE[1], M. LINDEMAN[1], P. KHOSROPANAH[1], R. DEN HARTOG[1], H. HOEVERS[1];*** [1]SRON NATIONAL INSTITUTE FOR SPACE RESEARCH, [2]CSIC - UNIVERSIDAD DE ZARAGOZA. — FREQUENCY DOMAIN MULTIPLEXING (FDM) IS ONE OF THE CANDIDATES FOR THE SQUID BASED READOUT OF TES-BASED IMAGING MICROCALORIMETER ARRAYS FOR APPLICATIONS SUCH AS IXO, AND IMAGING BOLOMETER ARRAYS FOR THE SAFARI INSTRUMENT ON THE JAPANSE SPICA SPACE TELESCOPE.USAGE OF THE TES AS MODULATING ELEMENT BY APPLYING AN AC BIAS IS AN ESSENTIAL PART OF FDM. WITHIN THIS FRAMEWORK THE SMALL SIGNAL CHARACTERISTICS OF ARRAY PIXELS UNDER BOTH AC AND DC BIAS HAVE BEEN PERFORMED. WE WILL PRESENT A SMALL SIGNAL MODEL OF THE TES UNDER AC BIAS, AND APPLY THE RESULTS TO THE MEASUREMENTS ON A BOLOMETER PIXEL AND AN X-RAY MICROCALORIMETER.

2EY-01**QUANTUM NOISE LIMITED PARAMETRIC AMPLIFICATION IN A LUMPED ELEMENT, LOW-Q JOSEPHSON RESONATOR** ***R. VIJAY[1], M. HATRIDGE[2], D. H. SLICHTER[1], J. CLARKE[2], I. SIDDIQI[1];*** [1]QUANTUM NANOELECTRONICS LABORATORY, UNIVERSITY OF CALIFORNIA, BERKELEY, [2]UNIVERSITY OF CALIFORNIA, BERKELEY / LAWRENCE BERKELEY NATIONAL LABORATORY. — LOW NOISE MICROWAVE AMPLIFIERS ARE A KEY COMPONENT IN HIGH FIDELITY MEASUREMENTS OF QUANTUM COHERENT CIRCUITS. WE PRESENT A SIMPLE, FLUX TUNABLE, PARAMETRIC AMPLIFIER COMPRISED OF AN UNSHUNTED TWO-JUNCTION SQUID IN PARALLEL WITH AN ON-CHIP CAPACITOR. THIS RESONATOR IS DIRECTLY COUPLED TO A $Z_{0}=50\ \OMEGA $ TRANSMISSION LINE, RESULTING IN A QUALITY FACTOR $% Q\SIM 10-20$ FOR A PLASMA FREQUENCY $\OMEGA _{P}/2\PI \SIM 4-8$ GHZ. FOR A SUFFICIENTLY STRONG MICROWAVE DRIVE AT FREQUENCY $\OMEGA _{D}\LESSSIM \OMEGA _{P}$, THE NONLINEAR RESONATOR AMPLIFIES ANY ADDITIONAL WEAK SIGNAL AT FREQUENCY $\OMEGA _{RF}\SIM \OMEGA _{D}$. WE HAVE ACHIEVED A PARAMETRIC GAIN OF 32 DB AT $\OMEGA _{D}/2\PI =5.56$ GHZ WITH A NEAR QUANTUM LIMITED SYSTEM NOISE TEMPERATURE $T_{\TEXT{SYS}}=$ $(0.64\PM 0.14)$ $\HBAR \OMEGA _{D}/K_{B} $ AND A 600 KHZ INSTANTANEOUS BANDWIDTH. REDUCING THE GAIN TO 20 DB INCREASES THE BANDWIDTH TO 10 MHZ BUT DEGRADES THE SYSTEM NOISE $T_{\TEXT{SYS% }}=$ $(1.78\PM 0.29)$ $\HBAR \OMEGA _{D}/K_{B}$. WE WILL DISCUSS THE OPTIMIZATION OF THIS AMPLIFIER FOR GAIN, BANDWIDTH AND DYNAMIC RANGE. ADDITIONALLY, WE DESCRIBE THE PERFORMANCE OF THIS DEVICE AS A DISPERSIVE MAGNETOMETER WHICH EXPLOITS THE PHASE SENSITIVE MODE OF OPERATION.

WE ACKNOWLEDGE SUPPORT FROM THE AFOSR(RV, IS), THE HERTZ FOUNDATION (DHS), AND THE DOE (MH, JC).

2EY-02

SQUID AMPLIFIERS AND QUANTUM NOISE ***L. SPIETZ**, M. LEE, J. AUMENTADO;* NIST. — WE DESCRIBE MEASUREMENTS OF NOISE IN THE DC-SQUID AMPLIFIER USING BOTH A HEATED LOAD AND A SHOT NOISE SOURCE. WE SHOW NOISE TEMPERATURES BELOW 1 K AT SEVERAL FREQUENCIES IN THE 4-8 GHZ RANGE, WITH USEFUL GAINS. DATA ARE SHOWN CHARACTERIZING THE NOISE PROPERTIES IN DETAIL, AND THE MECHANISMS FOR THAT NOISE ARE DISCUSSED. USE OF QUANTUM NOISE FROM A TUNNEL JUNCTION TO CALIBRATE AMPLIFIERS IS DESCRIBED. FURTHERMORE, WE COMMENT ON THE UNIQUE CHALLENGES ASSOCIATED WITH DEFINING AND MEASURING NOISE TEMPERATURE OF AMPLIFIERS IN THE RANGE OF THE STANDARD QUANTUM LIMIT IN AN ATTEMPT TO SET A STANDARD OF PRACTICE FOR SUCH MEASUREMENTS.

2EY-03

PARAMETRIC RESONATORS FOR MICROWAVE APPLICATIONS ***C. WILSON;*** CHALMERS UNIVERSITY. — WE HAVE FABRICATED AND CHARACTERIZED TUNABLE SUPERCONDUCTING TRANSMISSION LINE RESONATORS. TO CHANGE THE RESONANCE FREQUENCY, WE MODIFY THE BOUNDARY CONDITION AT ONE END OF THE RESONATOR THROUGH THE TUNABLE JOSEPHSON INDUCTANCE OF A SQUID. WE DEMONSTRATE A LARGE TUNING RANGE, HIGH QUALITY FACTORS AND THAT WE CAN CHANGE THE FREQUENCY OF A FEW-PHOTON FIELD ON A TIME SCALE ORDERS OF MAGNITUDE FASTER THAN THE PHOTON LIFETIME. WHEN PARAMETRICALLY PUMPED AT TWICE THEIR RESONANCE FREQUENCY, THE DEVICES CAN ACT AS PARAMETRIC AMPLIFIERS. WE HAVE DEMONSTRATED GAINS GREATER THAN 20 DB WITH NOISE TEMPERATURES AN ORDER OF MAGNITUDE LESS THAN BEST COMMERCIAL SEMICONDUCTOR AMPLIFIERS. WHEN PUMPED STRONGLY, A THRESHOLD IS CROSSED WHERE THE RESONATORS OSCILLATE SPONTANEOUSLY. WITHIN THIS REGIME OF PARAMETRIC OSCILLATIONS, THE DEVICES CAN EXIST IN A VARIETY OF DYNAMICAL STATES. WE OBSERVE A RICH PATTERN IN THE

DYNAMICS OF SWITCHING BETWEEN THESE STATES. IT SHOULD ALSO BE POSSIBLE TO USE THIS DYNAMICAL BIFURCATION AS A LATCHING MICROWAVE DETECTOR.

2EY-04

ON-CHIP QUANTUM AMPLIFIER ***A. A. ABDUMALIKOV***[1]*, O. ASTAFIEV*[2]*, A. M. ZAGOSKIN*[3]*, Y. A. PASHKIN*[2]*, Y. NAKAMURA*[2]*, J. TSAI*[2]*;* [1]THE INSTITUTE OF PHYSICAL AND CHEMICAL RESEARCH (RIKEN), TSUKUBA, JAPAN, [2]NEC NANO ELECTRONICS RESEARCH LABORATORIES, TSUKUBA, JAPAN, [3]DEPARTMENT OF PHYSICS, LOUGHBOROUGH UNIVERSITY, LOUGHBOROUGH, UK. — QUANTUM AMPLIFIERS WHICH ARE ROUTINELY USED IN OPTICS RELY ON INTRA-ATOMIC(MOLECULAR) TRANSITIONS OF AVAILABLE MATERIALS. STATE-OF-THE-ART NANOTECHNOLOGY MAKES IT POSSIBLE TO FABRICATE ARTIFICIAL ON-CHIP QUANTUM SYSTEMS, PARTICULARY THE ONES BASED ON JOSEPHSON STRUCTURES, WITH DESIRED PROPERTIES, SUCH AS ENERGY SPECTRA, COUPLING CONSTANTS ETC. THIS OPENS THE WAY TO THE DEVELOPMENT OF NOVEL QUANTUM DEVICES BASED ON FULLY CONTROLLABLE ARTIFICIAL QUANTUM SYSTEMS (``ARTIFICIAL ATOMS''). HERE WE REPORT AMPLIFICATION OF ELECTROMAGNETIC WAVES BY A SINGLE THREE-LEVEL ARTIFICIAL ATOM IN OPEN 1D-SPACE. THE OBSERVED SPONTANEOUS AND STIMULATED EMISSION IS DUE TO THE STRONG INTERACTION OF THE SYSTEM WITH ELECTROMAGNETIC WAVES IN AN OPEN 1D CHANNEL. COHERENT EMISSION BY THE ATOM IN THE DRIVING FIELD OF THE PROPAGATING WAVE, KNOWN AS STIMULATED EMISSION, WHICH WE DEMONSTRATE IN OUR SOLID-STATE ARTIFICIAL SYSTEM, IS ONE OF THE MOST FUNDAMENTAL PHENOMENA OF QUANTUM OPTICS. THUS, OUR RESULTS BRING TOGETHER QUANTUM OPTICS AND MESOSCOPIC SOLID STATE PHYSICS.

2EY-05

TOMOGRAPHIC RECONSTRUCTION OF THE WIGNER FUNCTION OF AN ITINERANT MICROWAVE FIELD. ***F. MALLET***[1]*, M. CASTELLANOS-BELTRAN*[1]*, H. KU*[1]*, K. IRWIN*[2]*, L. VALE*[2]*, G. HILTON*[1]*, K. LEHNERT*[1]*;* [1]JILA, [2]NIST. — IN AN INCREASING NUMBER OF EXPERIMENTS, THE DESIRED INFORMATION, BY EXAMPLE THE STATE OF NANOMECHANICAL RESONATORS OR OF SUPERCONDUCTING QUBITS, IS SUCCESSFULLY ENCODED ONTO THE STATE OF A COHERENT MICROWAVE FIELD. HOWEVER MOST THE INFORMATION IS LOST DUE TO THE POOR QUANTUM EFFICIENCY OF THE BEST COMMERCIALLY AVAILABLE MICROWAVE AMPLIFIERS: THE BEST COMMERCIALLY AVAILABLE AMPLIFIERS ADD TWENTY TIMES MORE NOISE THAN THE INTRINSIC QUANTUM FLUCTUATIONS OF THE FIELD. TO CIRCUMVENT THIS LIMITATION OUR LAB HAS BEEN DEVELOPING QUANTUM LIMITED JOSEPHSON PARAMETRIC AMPLIFIERS (JPAS) [1]. IN THIS TALK WE WILL PRESENT AN APPLICATION OF THE JPA LEADING TO A DRAMATIC INCREASE OF THE PERFORMANCE OF THE QUANTUM STATE TOMOGRAPHY. IT HAS ENABLED US TO RECONSTRUCT THE WIGNER FUNCTION OF A SQUEEZED STATE OF THE MICROWAVE FIELD. THE ACHIEVED DEGREE OF SQUEEZING AND THE QUANTUM EFFICIENCY OF THE STATE TOMOGRAPHY WILL BE PRESENTED FROM THE POINT OF VIEW OF USING THESE SQUEEZED STATES AS BUILDING BLOCKS OF A MORE GLOBAL STRATEGY TO PERFORM QUANTUM INFORMATION EXPERIMENTS. INDEED THESE STATES, WHICH ARE HIGHLY NON-CLASSICAL AND ARE EASILY GENERATED BY JPAS, FORM EPR LIKE STATES WHEN COMBINED TOGETHER AND THUS ARE THE BASIS OF A COMPLETE QUANTUM.[1]: AMPLIFICATION AND SQUEEZING OF QUANTUM NOISE WITH A TUNABLE JOSEPHSON METAMATERIAL, M. CASTELLANOS-BELTRAN ET AL., NAT. PHYS. 4, 929-931 (2008).

2EY-06

TWO-PORT DIRECTIONAL PARAMETRIC AMPLIFIER ***A. KAMAL***[1]*, M. DEVORET*[1]*, J. CLARKE*[2]*;* [1]DEPARTMENTS OF PHYSICS AND APPLIED PHYSICS, YALE UNIVERSITY, [2]DEPARTMENT OF PHYSICS, UNIVERSITY OF CALIFORNIA, BERKELEY AND MATERIALS SCIENCES DIVISION, LAWRENCE BERKELEY NATIONAL LABORATORY. — NEW APPLICATIONS OF LOW NOISE JOSEPHSON MICROWAVE AMPLIFIERS HAVE EMERGED RECENTLY, RANGING FROM MEASUREMENTS ON SUPERCONDUCTING QUBITS TO DARK MATTER DETECTORS. CONVENTIONAL MICROWAVE PARAMETRIC AMPLIFIERS OPERATE AS ONE-PORT REFLECTION DEVICES, AND RELY ON NON-RECIPROCAL COMPONENTS LIKE CIRCULATORS FOR SEPARATION OF INPUT AND OUTPUT CHANNELS. THIS SEPARATION IS AUTOMATICALLY ACHIEVED IN THE MICROWAVE DC SQUID AMPLIFIER; HOWEVER A PHYSICAL UNDERSTANDING OF ITS AMPLIFYING DYNAMICS REMAINS INCOMPLETE. WE WILL PRESENT THE RESULTS OF A THEORETICAL ANALYSIS OF A MINIMAL-NOISE DIRECTIONAL AMPLIFIER BASED ON PARAMETRIC JOSEPHSON DEVICES, WHICH CAN EMULATE THE NON-RECIPROCAL ACTION OF THE DC SQUID. THE NON-RECIPROCITY IS ACHIEVED FROM THE COMBINATION OF NON-COMMUTING PHASE SHIFTS AT DIFFERENT STAGES IN THE DEVICE, LEADING TO A VALVE-LIKE EFFECT. THE GAIN AND NOISE CHARACTERISTICS OF THIS DEVICE AND ITS PARALLEL WITH THE DC SQUID WILL ALSO BE DISCUSSED.

WORK SUPPORTED BY ARO AND NSF (AK AND MHD) AND DOE BES (JC)

2EZ-01

(INVITED) **CLINICAL APPLICATION OF AUDITORY EVOKED FIELD FOR DEMENTIA USING UNSHIELDED MEG SYSTEM WITH TWO-DIMENSIONAL GRADIOMETERS** ***Y. SEKI***[1]*, A. KANDORI*[1]*, K. OGATA*[1]*, T. MIYASHITA*[1]*, A. MAKI*[1]*, Y. KUMAGAI*[2]*, M. OHNUMA*[3]*, K. KONAKA*[4]*, H. NARITOMI*[4]*;* [1]HITACHI ADVANCED RESEARCH LABORATORY, [2]HITACHI CENTRAL RESEARCH LABORATORY, [3]HITACHI DESIGN DIVISION, [4]NATIONAL CARDIOVASCULAR CENTER. — WE MEASURED THE AUDITORY EVOKED FIELD (AEF) OF 18 DEMENTIA PATIENTS USING AN UNSHIELDED MAGNETOENCEPHALOGRAPHY (MEG) SYSTEM WITH FOUR CHANNELS OF TWO-DIMENSIONAL GRADIOMETERS BASED ON LOW-TC SUPERCONDUCTING QUANTUM INTERFERENCE DEVICES (SQUIDS) [1]. THIS MEG SYSTEM CONSISTS OF TWO SYMMETRIC CRYOSTATS IN WHICH

THE 2D GRADIOMETERS ARE INSTALLED IN EACH CRYOSTAT. AS A RESULT, N100M LATENCY, WHICH IS THOUGHT TO BE CORRELATED WITH COGNITIVE FUNCTION [2, 3], IN THE BOTH AUDITORY AREA OF THESE PATIENTS WERE OBTAINED. MOREOVER, THE AEF WAS MEASURED FOR 12 OF THE ABOVE PATIENTS BY USING A CONVENTIONAL BIOMAGNETIC MEASUREMENT SYSTEM WITH 64-CHANNEL SQUIDS IN A MAGNETICALLY SHIELDED ROOM FOR COMPARISON OF THE TWO SYSTEMS. ACCORDING TO THESE RESULTS, N100M LATENCY OBTAINED BY THE UNSHIELDED MEG SYSTEM WAS CORRELATED WITH THAT OBTAINED BY THE CONVENTIONAL SYSTEM. IN CONCLUSION, THE UNSHIELDED MEG SYSTEM IS POSSIBLE TO MEASURE THE N100M LATENCY OF DEMENTIA PATIENTS.[1] Y. SEKI AND A. KANDORI, JAPANESE JOURNAL OF APPLIED PHYSICS **46**, 3397 (2007).[2] E. PEKKONEN, ET AL., CLINICAL NEUROPHYSIOLOGY **110**, 1942 (1999).[3] H. OE, ET AL., NEUROSCIENCE RESEARCH **44**, 483 (2002).

2EZ-02

STUDIES ON HIGHER FUNCTION OF HUMAN BRAINS BY A SQUID SYSTEM IN A SUPERCONDUCTING MAGNETIC SHIELD ***H. OHTA***[1]*, T. MATSUI*[1]*, Y. UCHIKAWA*[2]*;* [1]NICT, [2]TOKYO TENKI UNIVERSITY. — ESSENTIAL ROLE OF A SUPERCONDUCTING MAGNETIC SHIELD IS DESCRIBED FOR STUDY OF HIGHER FUNCTION OF HUMAN BRAINS. THE PRESENT SQUID HAS A SENSITIVITY OF 0.9 FT/ (HZ) 1/ 2 AT 100HZ IN A SUPERCONDUCTING MAGNETIC SHIELD. SQUID SENSORS ARE MADE OF SNS (SUPERCONDUCTOR/NORMAL METAL/SUPERCONDUCTOR) JUNCTIONS. RECENT THEORIES OF BEAMFORMER AND MUSIC(MULTIPLE SIGNAL CLASSIFICATION) EMPHASIZE THE IMPORTANCE OF SNR(SIGNAL-TO-NOISE RATIO) OF DATA TO LOCATE EQUIVALENT CURRENT DIPOLES IN BRAINS. FOR INSTANCE, MUSIC USES NOISE SUBSPACE OF THE COVARIANT MATRIX PRACTICALLY CALCULATED BY MEASURED MAGNETIC FIELDS.DYNAMICAL RESPONSES OF HIPPOCAMPUS TO NOVELTY OR UNEXPECTEDNESS ARE MEASURED BY THE SQUID SYSTEM IN A SUPERCONDUCTIONG MAGNETIC SHIELD AND VISUALIZED BY A NEW EXTENSION OF SLORETA (STANDARDIZED LOW-RESOLUTION ELECTROMAGNETIC TOMOGRAPHY). RESPONSES OF BRAINS TO NOVELTY DO NOT DEPEND ON MODALITIES VERY MUCH BECAUSE THEY ARE OF HIGHER FUNCTION OF BRAINS IN LONGER LATENCIES. THE SQUID SYSTEM IN A MAGNETIC SHIELD OF HIGH-TC SUPERCONDUCTOR IS YIELDING NEW INFORMATION OF DEEP AREA OF HUMAN BRAINS TO BE ONE OF THE MOST IMPORTANT APPLICATIONS OF HIGH-TC AND LOW-TC SUPERCONDUCTORS.

2EZ-03

A PORTABLE AND FLEXIBLE HAND-HELD MAGNETIC PROBE SYSTEM BASED ON HTS SQUID FOR STAGING NODAL CANCERS ***A. BRAZDEIKIS****, S. SARANGI;* TEXAS CENTER FOR SUPERCONDUCTIVITY, UNIVERSITY OF HOUSTON, HOUSTON, TX 77204. — THE SENTINEL LYMPH NODE (SLN) LOCALIZATION USING LYMPHOSCINTIGRAPHY AND GAMMA PROBES IS NOW A ROUTINE PART OF THE SURGICAL TREATMENT OF PATIENTS WITH BREAST CANCER. AN HTS SQUID TECHNOLOGY IS BEING EXPLORED FOR DEVELOPING NOVEL MEDICAL DEVICES FOR INTRAOPERATIVE LOCALIZATION OF THE SLN IN CANCER PATIENTS USING CLINICAL MRI CONTRAST AGENTS.A PORTABLE AND FLEXIBLE HAND-HELD MAGNETIC PROBE SYSTEM BASED ON HTS SQUID IS DEVELOPED IN OUR LABORATORY. THE UNIQUE FEATURE OF THIS SYSTEM IS ITS ABILITY TO PROVIDE MAGNETICALLY GUIDED LOCALIZATION AND DISSECTION OF THE SLN IN CANCER SURGERY WITHOUT REQUIRING EXPOSURE TO IONIZING RADIATION. THE MAJOR COMPONENTS OF THE SYSTEM ARE THE HAND-HELD MAGNETIC PROBE WHICH INCORPORATES A SPECIALIZED AC DRIVE-FIELD COIL AND PICKUP COIL ASSEMBLY AT ROOM TEMPERATURE, A LONG FLEXIBLE CABLE, AN LN2 CRYOGENIC INSERT WHICH HOUSES AN HTS SQUID MAGNETOMETER, AN ELECTRONICS ENCLOSURE, AND A LAPTOP FOR SIGNAL ACQUISITION AND CONTROL.WE WILL DISCUSS PROCEDURES WHICH ALLOWED US TO IMPROVE SMALL SIGNAL DETECTION AND MAGNETIC FLUX TRANSFER FROM THE PICKUP TO THE REMOTELY LOCATED SQUID, AND TO AVOID SOME OF THE PROBLEMS ASSOCIATED WITH NOISY CLINICAL ENVIRONMENTS. WE WILL ALSO DISCUSS OUR RESULTS OF USING THE SYSTEM FOR THE SLN LOCALIZATION IN BREAST CANCER SURGERY AND OUR PROGRESS TOWARDS DEVELOPING NEW SPECIALIZED PROBES FOR ASSESSMENT OF THE METASTATIC STATUS OF LYMPH NODES.

2EZ-04

LIQUID-PHASE DETECTION OF BIOLOGICAL TARGETS WITH MAGNETIC MARKER AND SQUID ***K. ENPUKU****, S. CHOSOKABE, H. WATANABE, M. MATSUO, T. YOSHIDA;* KYUSHU UNIVERSITY. — WE HAVE BEEN DEVELOPING A SQUID SYSTEM FOR THE LIQUID-PHASE DETECTION OF BIOLOGICAL TARGETS. IN THIS SYSTEM, BIOLOGICAL TARGETS ARE FIXED ON THE SURFACE OF LARGE POLYMER BEADS. WHEN MAGNETIC MARKERS ARE BOUND TO THE TARGETS, THEIR BROWNIAN RELAXATION TIME BECOMES MUCH LONGER THAN THAT OF UNBOUND (FREE) MARKERS. THIS DIFFERENCE ENABLES US TO MAGNETICALLY DISTINGUISH THE BOUND MARKERS FROM THE FREE ONES WITHOUT USING THE WASHING PROCESS CALLED BOUND/FREE SEPARATION. USING THIS PROCEDURE, WE PERFORMED THE DETECTION OF BIOTIN-COATED POLYMER BEADS IN SUSPENSION. THE DETECTION WAS DONE BY MEASURING RELAXATION SIGNAL OR AC SUSCEPTIBILITY OF SAMPLES. GOOD RELATIONSHIP WAS OBTAINED BETWEEN THE NUMBER OF BIOTINS AND THE MAGNETIC SIGNAL. WE COULD DETECT BIOTINS AS SMALL AS 1.5E+5, WHICH CORRESPONDS TO HIGH SENSITIVITY OF 6 ATTO-MOL/ML IN TERMS OF MOLECULAR CONCENTRATION. BINDING PROCESS BETWEEN THE TARGETS AND THE MARKERS WAS ALSO CLARIFIED FROM THE DEPENDENCE OF THE MAGNETIC SIGNAL ON THE INCUBATION TIME. TYPICAL REACTION TIME WAS BETWEEN 10 TO 30 MIN. WE ALSO STUDY A METHOD TO FASTEN THE REACTION TIME.

2EZ-05

MAGNETORELAXATION (MRX) MEASUREMENTS WITH DC-SQUID GRADIOMETERS *M. BÜTTNER, F. SCHMIDL, M. SCHIFFLER,* ***P. SEIDEL****;* FRIEDRICH-SCHILLER-UNIVERSITÄT JENA.

— MAGNETIC NANOPARTICLES (MNP) SHOW DIFFERENT RELAXATION MECHANISMS AFTER SWITCHING OFF AN EXTERNAL FIELD. THE BROWNIAN RELAXATION (BR) OF THE FREE ROTATION OF THE WHOLE PARTICLES AND THE NÉEL RELAXATION (NR) OF THE MAGNETISATION VECTOR INSIDE A FIXED PARTICLE HAVE DIFFERENT TIME SCALES. WHILE THE BR TIME IS IN THE ORDER OF MILLISECONDS THE NR TIME IS IN THE SECOND RANGE. THUS A CLEAR SEPARATION OF FREE AND FIXED MNP IS POSSIBLE. TO MEASURE THE VERY SMALL MAGNETIC RELAXATION FIELDS WE HAVE DEVELOPED MRX SYSTEMS USING LOW TEMPERATURE SUPERCONDUCTOR THIN FILM SECOND ORDER SQUID GRADIOMETERS WORKING IN UNSHIELDED ENVIRONMENT. BY STANDARD MRX WE ARE ABLE TO SEPARATE BOTH RELAXATION PROCESSES TO DETERMINE THE AMOUNT OF BOUNDED MNP AS RESULTS OF BINDING REACTIONS. BY NÉEL MEASUREMENTS WITH A X-Y SCANNING MRX SYSTEM A SPATIAL RESOLVED IMAGING OF THE BOUNDED PARTICLES IS POSSIBLE EVEN FOR LIVING OBJECTS. WITHIN AN ANTI-CRYOSTAT WE CAN MEASURE THE TEMPERATURE DEPENDENCE OF SMALL SAMPLES (T-MRX) BETWEEN 4 K AND 320 K. FROM NÉEL SIGNALS USING SOME THEORETICAL MODELLING IMPORTANT PARAMETERS OF THE MNP SUCH AS ENERGY BARRIER DISTRIBUTION, ACTIVATION ENERGY AND DIAMETER OF THE MAGNETIC CORE WERE OBTAINED. THE RESULTS WERE COMPARED TO OTHER METHODS LIKE TEM, AFM OR MAGNETO-OPTICAL RELAXATION MEASUREMENTS. MEASUREMENTS FOR DIFFERENT TYPES OF MNP AND BIOLOGICAL OR MEDICAL OBJECTS WERE SHOWN.

WE LIKE TO THANK P. WEBER, E. ROMANUS AND S. PRASS FOR THEIR CONTRIBUTIONS.

2EZ-06

MULTI-CHANNEL SQUID-BASED ULTRA-HIGH-SENSITIVITY AND HIGH-SPECIFICITY IN-VITRO DETECTIONS FOR BIOMARKERS VIA IMMUNOMAGNETIC REDUCTION ***H. HORNG***[1]*, S. YANG*[2]*, K. HUANG*[3]*, M. CHIU*[3]*, C. HONG*[4]*, H. YANG*[5]*;* [1]NATIONAL TAIWAN NORMAL UNIVERSITY, [2]MAGQU CO., LTD., [3]NATIONAL TAIWAN UNIVERSITY HOSPITAL, [4]NATIONAL CHUNG HSING UNIVERSITY, [5]NATIONAL TAIWAN UNIVERSITY. — VIA IMMUNOMAGNETIC REDUCTION ASSAY, BIO-MOLECULES CAN BE QUANTITATIVELY DETECTED WITH AID OF BIO-FUNCTIONALIZED MAGNETIC NANOPARTICLES, WHICH ARE USED AS LABELING MARKERS FOR SPECIFIC BIO-MOLECULES. TO ACHIEVE AN ULTRA-HIGH SENSITIVITY IN DETECTING BIO-MOLECULES, SUPERCONDUCTING QUANTUM INTERFERENCE DEVICE (SQUID) IS A PROMISING CANDIDATE TO ACT AS A SENSOR TO THE MAGNETIC SIGNAL RELATED TO THE CONCENTRATION OF DETECTED BIO-MOLECULES. IN THE PAST, WE HAVE DEVELOPED A SINGLE CHANNEL SQUID-BASED MAGNETOSUSCEPTOMETRY. IN ORDER TO INCREASE THE DETECTION THROUGH-PUT, MULTI-CHANNEL SQUID-BASED MAGNETOSUSCEPTOMETRY IS DEVELOPED. IN THIS WORK, THE DESIGN AND WORKING PRINCIPLE OF 4-CHANNEL SQUID-BASED MAGNETOSUSCEPTOMETRY ARE INTRODUCED. USING UTILIZING SCANNING TECHNOLOGY, 4 SAMPLES CAN BE SIMULTANEOUSLY LOGGED INTO THE SQUID-BASED MAGNETOSUSCEPTOMETRY. NOTABLY, ONLY SINGLE SQUID MAGNETOMETER IS USED IN THE MAGNETOSUSCEPTOMETRY. THE PRECISION AND SENSITIVITY IN DETECTING BIO-MOLECULES USING THE 4-CHANNEL SQUID-BASED MAGNETOSUSCEPTOMETRY ARE INVESTIGATED. THE DETECTED BIO-MOLECULES INCLUDE BIOMARKERS FOR TUMOR DEVELOPMENT, ALZHEIMER'S DISEASE, ETC.

2EZ-07

SQUID-BASED HARMONIC SPECTROSCOPY OF LIVING CELLS USING NONLINEAR FIELDS ***J. R. CLAYCOMB***[1]*, J. FANG*[2]*, J. H. MILLER, JR.*[2]*;* [1]HOUSTON BAPTIST UNIVERSITY, DEPARTMENT OF MATHEMATICS AND PHYSICS, [2]UNIVERSITY OF HOUSTON, DEPARTMENT OF PHYSICS AND TEXAS CENTER FOR SUPERCONDUCTIVITY. — THE HARMONIC RESPONSE OF LIVING CELLS TO REMOTE FIELD EXCITATION IS RECORDED USING SUPERCONDUCTING QUANTUM INTERFERENCE DEVICE MAGNETOMETERS. POLARIZATION EFFECTS USUALLY ASSOCIATED WITH THE ELECTRODE/ELECTROLYTE INTERFACE ARE ELIMINATED USING NONLINEAR EXCITATION FIELDS. THE TECHNIQUE IS DEMONSTRATED BOTH FOR CELL AND ORGANELLE SUSPENSIONS AND EXCITABLE TISSUE. FEATURES OF THE FREQUENCY-DEPENDENT SECOND AND THIRD HARMONICS APPEAR TO CORRELATE WITH ACTIVITY OF CATION PUMPS AND OTHER ENZYMES WITHIN THE PLASMA MEMBRANE, AS WELL AS INTERNAL MEMBRANE COMPLEXES SUCH AS THOSE WITHIN THE MITOCHONDRIAL RESPIRATORY CHAIN. POTENTIAL APPLICATIONS, IF FURTHER DEVELOPED, INCLUDE THE DIAGNOSIS OF METABOLIC DYSFUNCTION RELATED TO OBESITY, TYPE-2 DIABETES, AND THEIR CARDIOVASCULAR COMPLICATIONS, WHICH OFTEN CULMINATE IN HEART FAILURE.

2LA-01

STATISTICAL STUDY ON INHOMOGENEOUS CURRENT TRANSPORT PROPERTY OF COATED CONDUCTORS ALONG ITS LONGITUDINAL DIRECTION FOR POWER APPARATUS DEVELOPMENT ***Y. TAKAMURA***[1]*, T. NAKAMURA*[1]*, N. AMEMIYA*[1]*, K. NAKAO*[2]*, T. IZUMI*[2]*;* [1]KYOTO UNIVERSITY, [2]ISTEC-SRL. — RECENT ADVANCES IN PRODUCTION TECHNOLOGY OF COATED CONDUCTORS HAVE CONTINUOUSLY STIMULATED THE DEVELOPMENT OF THE POWER APPLICATIONS.IN ORDER TO PROMOTE SUCH DEVELOPMENT, IT IS IMPORTANT TO PRODUCE CONDUCTORS THOSE HAVE THE HOMOGENEOUS CURRENT TRANSPORT PROPERTY ALONG THE LONGITUDINAL DIRECTION FOR THE PRACTICAL SYSTEMS.THEREFORE, CLARIFICATION OF RELATIONSHIP BETWEEN THE ABOVE-MENTIONED PROPERTY AND THE PERFORMANCE OF POWER APPARATUSES WILL BE EFFECTIVE APPROACH FOR THE ACCELERATION OF THE DEVELOPMENT.IN THIS STUDY, WE INVESTIGATE THE LONGITUDINAL CRITICAL CURRENT DISTRIBUTION ALONG A COATED CONDUCTOR, AND THEN ITS INFLUENCE ON THE CURRENT TRANSPORT CHARACTERISTICS OF POWER APPARATUSES SUCH AS POWER TRANSMISSION CABLE IS EXAMINED BASED ON THE ANALYSIS.THE LOCAL CRITICAL CURRENT DISTRIBUTION IS MEASURED BY MEAN OF TAPESTAR, AND THEN ITS INHOMOGENEITY IS CHARACTERIZED WITH THE AID OF THE GAUSSIAN DISTRIBUTION FUNCTION.AND THEN, AS AN EXAMPLE OF POWER APPARATUSES, THE CURRENT TRANSPORT CHARACTERISTICS

OF A SMALL PANCAKE COIL ARE ESTIMATED BY SUMMING UP THE MAGNETIC-FIELD-DEPENDENT CRITICAL CURRENT THAT TAKES INTO ACCOUNT THE INHOMOGENEITY.IT IS SHOWN BASED ON THE ANALYSIS THAT THE INHOMOGENEITY OF THE CURRENT TRANSPORT CHARACTERISTICS DRASTICALLY INFLUENCES THE MAXIMUM ELECTRIC FIELD AND THE TOTAL FLUX-FLOW LOSS.

THIS WORK IS SUPPORTED BY THE NEW ENERGY AND INDUSTRIAL TECHNOLOGY DEVELOPMENT ORGANIZATION AS MATERIALS AND POWER APPLICATIONS OF COATED CONDUCTORS.

2LA-02

A HYBRID, THREE-DIMENSIONAL FINITE ELEMENT MODEL OF QUENCH DYNAMICS IN AN YBA2CU3OX COATED-CONDUCTOR COIL BASED ON A MICROSCOPIC MIXED-DIMENSIONAL COATED CONDUCTOR TAPE MODEL ***W. CHAN***[1]*, J. SCHWARTZ*[2]*;* [1]DEPARTMENT OF MECHANICAL ENGINEERING, FAMU-FSU COLLEGE OF ENGINEERING AND DEPARTMENT OF MATERIALS SCIENCE & ENGINEERING, NORTH CAROLINA STATE UNIVERSITY, [2]DEPARTMENT OF MATERIALS SCIENCE & ENGINEERING, NORTH CAROLINA STATE UNIVERSITY. — THE DEVELOPMENT OF EFFECTIVE QUENCH DETECTION AND PROTECTION METHODS FOR YBA2CU3OX COATED CONDUCTOR (CC) BASED HTS COILS REQUIRES A THOROUGH UNDERSTANDING OF THE QUENCH BEHAVIOR ON MULTIPLE SCALE-LENGTHS. A FINITE ELEMENT (FE) THERMO-MAGNETOSTATIC COIL MODEL EMBEDDED WITH A LOCALIZED MULTILAYER TAPE MODEL IS DEVELOPED TO STUDY THE THREE-DIMENSIONAL (3D) QUENCH DYNAMICS. THE MULTILAYER TAPE MODEL IS COMPOSED OF MULTIPLE STACKS OF 3D SINGLE-LAYER CC TAPE MODELS SEPARATED BY INSULATION. THE SINGLE-LAYER TAPE MODEL IS BASED ON A VALIDATED, HIGHLY ACCURATE 3D FE CC TAPE MODEL WHICH USES A MIXED-DIMENSIONAL MODELING METHOD TO EFFECTIVELY AND EFFICIENTLY OVERCOME THE PROBLEMS IN MODELING HIGH ASPECT RATIO THIN FILMS. MAGNETIC FIELD AND TEMPERATURE DEPENDENT E-J RELATIONSHIPS ARE USED AND THE PHYSICS FROM ALL LAYERS IN THE CC ARE ACCOUNTED FOR IN ACTUAL DIMENSIONS. THE HTS COIL MODEL IS HOMOGENIZED OUTSIDE THE LOCALIZED MULTILAYER TAPE MODEL. THE BOUNDARY CONDITIONS COUPLING THE TWO SUB-MODELS ARE DETERMINED BY EXPERIMENTS. THIS MODEL REDUCES THE FE UNKNOWNS SIGNIFICANTLY AND ALLOWS VERY DETAIL QUENCH INFORMATION SUCH AS IN-LAYER, IN-TURN AND TURN-TO-TURN TEMPERATURE AND VOLTAGE PROFILES AND PROPAGATION VELOCITIES IN A HTS COIL TO BE OBTAINED. SIMULATION RESULTS ARE PRESENTED TO SHOW HOW THE CC TAPE STRUCTURE AND PROPERTIES OF INSULATION MATERIALS INFLUENCE THE QUENCH DYNAMICS IN A HTS COIL.

THIS WORK IS SUPPORTED BY THE AIR FORCE RESEARCH LABORATORY.

2LA-03**MULTI-PURPOSE FIBER OPTIC SENSORS FOR SUPERCONDUCTING MAGNETS: PROCESS MONITORING OF BI2SR2CACU2OX AND QUENCH DETECTION** ***M. TURENNE***[1]*, G. FLANAGAN*[1]*, R. JOHNSON*[1]*, F. HUNTE*[2]*, J. SCHWARTZ*[2]*;* [1]MUONS, INC., [2]NCSU. — HIGH TEMPERATURE SUPERCONDUCTING (HTS) MAGNETS CONSTRUCTED FROM BI2SR2CACU2OX (BI2212) AND YBA2CU3OX (YBCO) SHOW GREAT PROMISE FOR HIGH MAGNETIC FIELD APPLICATIONS. TO FURTHER ADVANCE THESE CONDUCTOR TECHNOLOGIES INTO MAGNET TECHNOLOGIES, ADVANCED SENSORS ARE NEEDED FOR BI2212 AND YBCO QUENCH DETECTION, AND FOR MONITORING THE HEAT TREATMENT OF BI2212 MAGNETS. HERE WE PRESENT THE APPLICATION OF FIBER OPTIC SENSORS TO BOTH OF THESE SENSING NEEDS. FOR MONITORING THE HEAT TREATMENT OF BI2212, IT HAS BEEN PREVIOUSLY SHOWN THAT CONVENTIONAL FIBER BRAGG GRATINGS (FBGS) DO NOT WITHSTAND THE HEAT TREATMENT, BUT THAT OTHERWISE THE OPTICAL FIBER AND BI2212 WIRE ARE COMPATIBLE. HERE WE PRESENT RESULTS USING A RAYLEIGH BACKSCATTERING (RB) TECHNIQUE THAT USES THE PRE-EXISTING DEFECTS WITHIN THE OPTICAL FIBER AND THUS DOES NOT REQUIRE CAREFULLY DEFINED GRATINGS. FOR QUENCH PROTECTION, BOTH THE FBG AND RB APPROACHES ARE STUDIED. IN THIS CASE, WHILE THE RB APPROACH HAS THE ABILITY TO PROVIDE SIGNIFICANTLY BETTER SPATIAL RESOLUTION THAN FBGS, THE LARGE QUANTITY OF DATA REQUIRED RESULTS IN MUCH SLOWER TIME RESOLUTION. APPROACHES TO OVERCOME THE LIMITATIONS OF EACH APPROACH, OR TO INTEGRATE BOTH APPROACHES INTO ONE QUENCH DETECTION SYSTEM, ARE DISCUSSED.

SUPPORTED IN PART BY DOE SBIR GRANT DE-FG02-08ER85024

2LA-04

DETECTION SYSTEM FOR PROPAGATING NORMAL-ZONES WITH PICK-UP COILS IN THE LHD HELICAL COILS ***S. IMAGAWA****, N. YANAGI, T. MITO;* NATIONAL INSTITUTE FOR FUSION SCIENCE. — PROPAGATION AND RECOVERY OF NORMAL ZONES WERE OBSERVED SEVERAL TIMES IN A PAIR OF HELICAL COILS, WHICH ARE H1 AND H2 COILS, OF THE LARGE HELICAL DEVICE. IN ORDER TO DETECT THE POSITION OF A PROPAGATING NORMAL ZONE, PICK-UP COILS WERE INSTALLED ALONG THE HELICAL COILS BY THE PITCH OF 30 DEGREE OF THE POLOIDAL ANGLE. THE DIAMETER AND TURN NUMBER OF THE PICK-UP COIL ARE 100 MM AND 10,000, RESPECTIVELY. THEY DETECT THE CHANGE OF MAGNETIC FIELD BY CURRENT TRANSFER BETWEEN THE SUPERCONDUCTING STRANDS AND AN ALUMINUM STABILIZER. IN ORDER TO CANCEL THE EFFECT FROM THE COIL CURRENT, THE OUTPUT OF EACH PICK-UP COIL ON THE H1 COIL IS BALANCED BY THAT ON THE H2 COIL AT THE OPPOSITE TOROIDAL ANGLE. THE POSITION AND THE VELOCITY OF PROPAGATING NORMAL-ZONES WERE DETECTED SUCCESSFULLY 15 TIMES SINCE THE PICKUP COILS HAD BEEN INSTALLED. THEY WERE INDUCED 12 TIMES IN H1 COIL AND THREE TIMES IN H2 COIL. MOST OF THE NORMAL ZONES WERE INDUCED AT THE BOTTOM OF THE COILS, AND ALL OF THEM PROPAGATED TO ONE SIDE, WHICH IS THE DOWNSTREAM OF THE TRANSPORT CURRENT, WITH RECOVERY AT THE OPPOSITE SIDE. THE PROPAGATION VELOCITY CAN BE ESTIMATED FROM

THE TIME DELAY OF THE PEAK VOLTAGE OF THE PICKUP COILS. THESE OBTAINED DATA ARE VERY USEFUL TO INVESTIGATE THE CAUSE OF THE NORMAL-ZONE PROPAGATION AND CRYOGENIC STABILITY OF THE HELICAL COILS. FURTHERMORE, THIS METHOD IS APPLICABLE FOR OTHER SUPERCONDUCTING MAGNETS MADE OF ASYMMETRICAL CONDUCTORS.

2LA-06

BRITTLE SUPERCONDUCTING MAGNETS: AN EQUIVALENT STRAIN MODEL *E. BARZI[1], **M. DANUSO**[2];* [1]FERMILAB, [2]FINMECCANICA. — TO EXCEED FIELDS OF 10 T IN ACCELERATOR MAGNETS, BRITTLE SUPERCONDUCTORS LIKE A15 NB3SN AND NB3AL OR CERAMIC HIGH TEMPERATURE SUPERCONDUCTORS HAVE TO BE USED. FOR SUCH BRITTLE SUPERCONDUCTORS IT IS NOT THEIR MAXIMUM TENSILE YIELD STRESS THAT LIMITS THEIR STRUCTURAL RESISTANCE AS MUCH AS STRAIN VALUES THAT PROVOKE DEFORMATIONS IN THEIR DELICATE LATTICE, WHICH IN TURN DRAMATICALLY AFFECT THEIR SUPERCONDUCTING PROPERTIES. WORK ON THE SENSITIVITY OF NB3SN CABLES TO STRAIN HAS BEEN CONDUCTED IN A NUMBER OF STRESS STATES, INCLUDING UNIAXIAL [1-5] AND MULTI-AXIAL [6-8], PRODUCING USUALLY DIFFERENT RESULTS. THIS HAS MADE THE NEED OF A CONSTITUENT DESIGN CRITERION IMPERATIVE FOR MAGNET BUILDERS. IN CONVENTIONAL STRUCTURAL PROBLEMS AN EQUIVALENT STRESS MODEL IS TYPICALLY USED TO VERIFY MECHANICAL SOUNDNESS. IN THE SUPERCONDUCTING COMMUNITY A SIMPLE SCALAR EQUIVALENT STRAIN TO BE USED IN PLACE OF AN EQUIVALENT STRESS WOULD BE AN EXTREMELY USEFUL TOOL. AS IS WELL KNOWN IN FUNDAMENTAL MECHANICS, THERE IS NOT ONE SINGLE WAY TO REDUCE A MULTIAXIAL STRAIN STATE AS REPRESENTED BY A 2ND ORDER TENSOR THE STRAIN TENSOR TO A SCALAR. THE CONCEPTUAL EXPERIMENT PROPOSED HERE WILL HELP DETERMINE THE BEST SCALAR REPRESENTATION TO USE IN THE IDENTIFICATION OF AN EQUIVALENT STRAIN MODEL.

THIS WORK WAS SUPPORTED BY DOE

2LA-07**INTRODUCTION OF NONLINEAR PROPERTIES INTO HIERARCHICAL MODELS OF NB3SN STRANDS** ***B. COLLINS**, J. KRISHNAN, D. ARBELAEZ, S. PRESTEMON, P. FERRACIN, A. GODEKE, D. DIETDERICH, G. SABBI;* LAWERENCE BERKELEY NATIONAL LABORATORY. — THE DEVELOPMENT OF COMPUTATIONAL MODELS REPRESENTING RUTHERFORD CABLE FORMATION AND DEFORMATION IS NECESSARY TO INVESTIGATE THE STRAIN STATE IN THE SUPERCONDUCTING FILAMENTS IN NB3SN MAGNETS. THE WIDE VARIETY OF LENGTH SCALES WITHIN ACCELERATOR MAGNETS SUGGESTS USAGE OF A HIERARCHICAL STRUCTURE WITHIN THE MODEL. AS PART OF AN ONGOING INVESTIGATION AT LBNL, A TWO-DIMENSIONAL SIMPLIFIED NONLINEAR MULTISCALE MODEL IS DEVELOPED AS A WAY TO EXTEND PREVIOUS LINEAR ELASTIC VERSIONS. THE INCLUSION OF PLASTICITY MODELS INTO THE PROBLEM FORMULATION ALLOWS AN IMPROVED REPRESENTATION OF STRAND BEHAVIOR COMPARED TO THE LINEAR ELASTIC MODEL. THIS FORMULATION IS APPLIED TO A SINGLE NB3SN STRAND TO FIND THE EFFECTIVE PROPERTIES OF THE CABLES AND STRANDS AS WELL AS THE STRAIN STATE IN THE CONDUCTOR UNDER LOADING.

2LA-08

A NOVEL OPTICAL GAUGE FOR MEASURING COIL STRAIN DURING THERMAL COOLDOWN AND ENERGIZATION OF A SUPERCONDUCTING COIL ***M. LAKRIMI**, S. BAXTER, A. M. THOMAS, Y. GAO, H. BLAKES;* SIEMENS PLC, HEALTHCARE SECTOR, MR MAGNET TECHNOLOGY. — WE REPORT ON THE FIRST OPERATION OF A LOW COST AND EASY TO USE NOVEL FIBER OPTIC STRAIN GAUGE (FOSG) IN CRYOGENIC AND HIGH MAGNETIC FIELD ENVIRONMENTS.BEFORE ITS DEPLOYMENT ON COILS, THE GAUGE WAS FIRST VALIDATED ON AN ALUMINUM STRIP TO SHOW THAT THE MECHANICAL STRAIN MEASURED IS INDEED INDEPENDENT OF TEMPERATURE FOR A GIVEN DEFLECTION AND THAT THIS IS ALSO NOT AFFECTED BY THE BACKGROUND FIELD.FOUR STRAIN GAUGES WERE THEN MOUNTED ON A SUPERCONDUCTING COIL WHICH WAS IMPREGNATED IN EPOXY RESIN. THE STRAINS WERE MONITORED DURING EVERY STAGE OF THE COIL BUILD AND WE MEASURED, FOR EXAMPLE, THAT UPON POST GEL RESIN POLYMERIZATION SHRINKAGE AND WITH THE COIL AT ROOM TEMPERATURE, THE RESIN CONTRACTION STRAINS IN THE AXIAL DIRECTION IS ABOUT THREE TIMES THAT EXPERIENCED IN THE HOOP DIRECTION. THE FOSG MONITORED THE THERMAL CONTRACTION STRAINS DURING CRYOGENIC COOLDOWN OF THE COIL AND THE ELECTROMAGNETIC STRAINS DURING ENERGIZATION TO SEVERAL CURRENTS, UP TO 700A. THE COIL WAS THEN DELIBERATELY QUENCHED, IN EXCESS OF 175 TIMES, AND THE FOSG WERE ABLE TO DETECT THE QUENCHES AND MEASURE THE THERMAL EXPANSION-INDUCED STRAINS AND SUBSEQUENT RE-COOLING OF THE COIL AFTER A QUENCH. WE COULD ALSO INFER THE TEMPERATURE OF THE COIL DURING QUENCH. WE WILL SHOW THAT THESE THERMAL CONTRACTION AND ENERGIZATION STRAINS AGREED WITH FEA PREDICTION.

2LB-01

(INVITED) **ITER NB_3SN STRAND TESTING UNDER AXIAL STRAIN, SPATIAL PERIODIC BENDING AND CONTACT STRESS** ***A. NIJHUIS**[1], R. P. POMPE VAN MEERDERVOORT[1], F. LIU[2], H. J. G. KROOSHOOP[1], Y. MYOSHI[1], W. A. J. WESSEL[1];* [1]UNIVERSITY OF TWENTE, [2]ASIPP, HEFEI, CHINA. — NUMEROUS MANUFACTURERS AND DIFFERENT STRAND PROCESSING TECHNIQUES ARE INVOLVED WITH THE PRODUCTION OF NB3SN STRAND MATERIAL FOR ITER. THE SUPERCONDUCTING TRANSPORT PROPERTIES OF BRITTLE NB3SN LAYERS STRONGLY DEPEND ON THE STRAIN STATE. HENCE, THE THERMAL COMPRESSION AND THE LARGE TRANSVERSE LOAD IN COMBINATION WITH THE KEY CHOICE FOR THE CABLING PATTERN OF THE ITER CICCS, WILL DETERMINE THEIR PERFORMANCE. KNOWLEDGE OF THE INFLUENCE OF AXIAL STRAIN, PERIODIC BENDING AND CONTACT STRESS ON THE CRITICAL CURRENT (IC) OF THE USED NB3SN STRANDS IS INEVITABLE TO GAIN SUFFICIENT CONFIDENCE IN AN ECONOMIC DESIGN AND A STABLE OPERATION. WE HAVE MEASURED THE IC AND N-VALUE OF THE ACTUAL ITER NB3SN STRANDS FROM VARIOUS MANUFACTURERS IN THE TARSIS

FACILITY, WHEN SUBJECTED TO SPATIAL PERIODIC BENDING AND CONTACT STRESS AT A TEMPERATURE OF 4.2 K AND IN A MAGNET FIELD OF 12 T. THE STRANDS HAVE ALSO BEEN SUBJECTED TO UNI-AXIAL APPLIED STRAIN IN COMPRESSIVE AND TENSILE DIRECTION. THE IC, N-VALUES AND IRREVERSIBILLITY LIMIT HAVE BEEN DETERMINED FOR STRAIN VARYING FROM -0.8 % UP TO +0.5 %, AT TEMPERATURES BETWEEN 4.2 K AND 10 K AND MAGNET FIELDS RANGING FROM 6 T TO 15 T. THE STRAIN SENSITIVITY VARIES APPRECIABLY FOR DIFFERENT STRAND TYPES BUT SINCE THE ELECTROMAGNETIC FORCE IS THE DRIVING PARAMETER FOR STRAND BENDING IN A CICC, THE STIFFNESS OF THE STRANDS IS ALSO RELEVANT. WE PRESENT AN OVERVIEW OF THE RESULTS OBTAINED SO FAR.

THIS WORK IS SUPPORTED BY THE ITER INTERNATIONAL ORGANISATION, CADARACHE (FRANCE) AND F4E BARCELONA (SPAIN).

2LB-03

DESIGN OF THE ITER PF COIL ***B. LIM***[1]*, F. SIMON*[1]*, Y. ILIN*[1]*, C. GUNG*[1]*, J. SMITH*[2]*, Y. HSU*[3]*, C. LUONGO*[1]*, C. JONG*[1]*, N. MITCHELL*[1]*;* [1]ITER ORGANIZATION, [2]GENERAL ATOMICS, [3]GENERAL ATOMICS. — ITER MAGNETS ARE ALL DESIGNED USING SUPERCONDUCTING CONDUCTORS WITH A HIGH CURRENT CARRYING CAPABILITY. THE POLOIDAL FIELD (PF) COILS ARE OPERATED IN PULSED MODE WITH 48KA FOR PFC-1 AND 6, 55KA FOR PFC-2,3, AND 4 AND 52KA FOR PFC-5 IN NORMAL OPERATION. THE PF SYSTEM CONSISTS OF 6 RING COILS, PF1 THROUGH PF6, THAT SERVE TO STABILIZE THE POSITION AND CONTROL THE SHAPE OF THE PLASMA IN THE TOKAMAK. THE PF COILS POSITIONS AND SIZES HAVE BEEN OPTIMIZED FOR THE PLASMA REQUIREMENTS CONSISTENT WITH THE CONSTRAINTS IMPOSED BY THE ACCESS AND PUMPING DUCTS TO THE IN-VESSEL COMPONENTS. THE PF COILS WILL ALL BE WOUND WITH NBTI CABLE-IN-CONDUIT CONDUCTORS (CICC), AND RANGE IN DIAMETER FROM ~8 M TO ~ 24 M. THE WINDING PACK CONSISTS OF STACKED DOUBLE PANCAKES, WITH JOINTS ONLY ON THE OUTER RADIUS FOR ACCESS/REPAIR AND EDDY CURRENT/AC LOSS REASONS, WHILE THE HELIUM INLETS ARE LOCATED AT THE INNER RADIUS.SINCE THE 2001 DESIGN OPTION, THE PF COILS WINDINGS AND THEIR SUBCOMPONENTS HAVE BEEN REDESIGNED TO SATISFY NEW OPERATIONAL REQUIREMENTS. THE FINAL DETAILED DESIGN HAS BEEN ESTABLISHED IN 2009 AND VALIDATED BY THE DESIGN REVIEW HELD THE SAME YEAR.IN THIS PAPER, THE UP-TO-DATE DESIGN OF THE PF COILS AND EACH SUB-COMPONENT SUCH AS WINDING PACK, ELECTRICAL INSULATION, JOINTS AND TERMINATIONS, HELIUM INLET, JUMPERS, AND COILS' SUPPORTS ARE DISCUSSED TOGETHER WITH THEIR FABRICATION METHODS.

2LB-04

DEVELOPMENT OF THE JOINTS FOR ITER CENTRAL SOLENOID ***N. N. MARTOVETSKY****;* LLNL/ORNL. — THE ITER CENTRAL SOLENOID HAS 36 INTERPANCAKE JOINTS AND 12 BUS JOINTS IN THE MAGNET. THE JOINTS ARE REQUIRED TO HAVE RESISTANCE BELOW 4 NOHM AT 45 KA AT 4.5 K. THE INTERPANCAKE JOINTS WILL HAVE TO WITHSTAND A SIGNIFICANT CYCLIC TENSILE STRAIN DURING ITER OPERATION. THE JOINTS ARE LOCATED AT THE OD OF THE MAGNET EMBEDDED IN THE WINDING PACK AND THEREFORE NEED TO BE COMPLIANT WITH THE REST OF THE WINDING PACK TO AVOID EXCESSIVE STRESS.THE US ITER PROJECT OFFICE IS CARRYING OUT A PROGRAM FOR JOINTS DEVELOPMENT IN ORDER TO ESTABLISH FABRICATION PROCESS AND ALSO CHARACTERIZE ELECTRICAL AND MECHANICAL PERFORMANCE OF THE JOINTS IN A SPECIAL JOINT TEST APPARATUS.STATUS OF THE JOINT DEVELOPMENT AND TEST RESULTS ARE PRESENTED AND DISCUSSED IN THE PAPER.

THIS WORK PERFORMED UNDER THE AUSPICES OF THE U.S. DEPARTMENT OF ENERGY BY OAK RIDGE NATIONAL LABORATORY UNDER CONTRACT DE-AC05-00OR22725 AND BY LAWRENCE LIVERMORE NATIONAL LABORATORY UNDER CONTRACT DE-AC52-07NA27344

2LB-05

PERFORMANCE QUALIFICATION OF THE ITER TF MAGNET CONDUCTORS ***M. C. JEWELL***[1]*, T. BOUTBOUL*[2]*, K. KIM*[3]*, A. KRIVYKH*[4]*, N. MARTOVETSKY*[5]*, K. OKUNO*[6]*, Y. WU*[7]*, A. VOSTNER*[1]*, D. BESSETTE*[1]*, A. DEVRED*[1]*, N. MITCHELL*[1]*;* [1]ITER ORGANIZATION, [2]FUSION FOR ENERGY (F4E), [3]NATIONAL FUSION RESEARCH INSTITUTE (NFRI), [4]KURCHATOV INSTITUTE, [5]ORNL US-ITER PROJECT OFFICE, [6]JAPAN ATOMIC ENERGY AGENCY (JAEA), [7]INSTITUTE OF PLASMA PHYSICS, CHINESE ACADEMY OF SCIENCES (ASIPP). — THE STRAND PERFORMANCE OF THE TOROIDAL FIELD (TF) MAGNET CONDUCTORS FOR THE ITER MACHINE ARE QUALIFIED BY A SHORT SAMPLE (2.5 M) CURRENT SHARING (TCS) TEST IN THE SULTAN FACILITY AT CRPP IN VILLIGEN, SWITZERLAND, USING THE FULL OPERATING CURRENT OF 68 KA AND THE DESIGN PEAK FIELD OF 11.8 T. AT PRESENT, SEVEN SUCH SAMPLES, INCLUDING AT LEAST ONE FROM EACH OF THE SIX ITER DOMESTIC AGENCIES PARTICIPATING IN TF CONDUCTOR FABRICATION (CHINA, EUROPEAN UNION, JAPAN, RUSSIA, SOUTH KOREA AND THE UNITED STATES), HAVE BEEN QUALIFIED FOR STRAND PERFORMANCE BY THE ITER ORGANIZATION AFTER ACHIEVING TCS VALUES OF 6.0 - 6.9 K, AFTER 700 - 1000 ELECTRICAL (LORENTZ FORCE) CYCLES. THESE TCS VALUES EXCEED THE ITER SPECIFICATION AND ALLOW THE FABRICATION OF THESE LONG-LEAD ITEMS FOR THE ITER TOKAMAK TO BEGIN IN EACH DOMESTIC AGENCY. IN THIS PAPER, WE SUMMARIZE THE PERFORMANCE OF THE QUALIFIED SAMPLES, ANALYZE THE EFFECT OF STRAND PERFORMANCE ON CONDUCTOR PERFORMANCE, AND DISCUSS THE FINALIZATION OF THE TEST CAMPAIGN FOR PRODUCTION UNIT LENGTHS.

THE AUTHORS WISH TO THANK PIERLUIGI BRUZZONE AND HIS TEAM AT CRPP FOR HELPFUL TECHNICAL DISCUSSIONS AND FOR OVERSIGHT OF THE TEST PROGRAM.

2LB-06

SIMULATION OF THE INTERSTRAND COUPLING LOSSES IN A FULL-SIZE ITER CABLE-IN-CONDUIT CONDUCTOR ***E. P. A. VAN LANEN****, A. NIJHUIS;* UNIVERSITY OF TWENTE. — THE DOUBLE-PANCAKE JOINTS OF THE ITER PF COILS WILL BE SUBJECTED TO HEAT LOAD OF BOTH DC AND AC ORIGIN. THIS HEAT LOAD HAS TO BE KEPT WITHIN A RESTRICTED RANGE, AS TO PREVENT INSTABILITY IN THE PF COILS. WE EVALUATE THE JOINT PERFORMANCE WITH THE NUMERICAL MODEL JACKPOT, WHICH HAS ALREADY BEEN APPLIED TO CALCULATE THE HEAT LOAD IN THE JOINT OF A FULL-SIZE ITER CABLE-IN-CONDUIT CONDUCTOR (CICC) IN DC MODE. FOR THIS, IT TAKES INTO ACCOUNT THE (MAGNETO-) RESISTANCE OF THE COPPER SOLE, THE CURRENT DISTRIBUTION IN ALL THE SUPERCONDUCTING STRANDS, IMPOSED NOT ONLY BY THE STRAND'S RESISTIVE CONNECTIONS WITH THE JOINT COPPER SOLE, BUT ALSO BY THE CONTACT RESISTANCES BETWEEN ALL STRANDS. AS A FIRST ESSENTIAL STEP, THE ADVANCED EXPANSION OF JACKPOT NOW INCLUDES, AMONG OTHERS, THE SELF- AND MUTUAL INDUCTANCES OF STRANDS, AS WELL AS THE COUPLING WITH AN EXTERNALLY APPLIED TIME-CHANGING MAGNETIC FIELD.THE PAPER DESCRIBES THE IMPLEMENTATION OF THE INDUCTANCES, AND THE RESULTS OF THE SIMULATION OF A FULL-SIZE ITER CICC THAT IS SUBJECTED TO A CHANGING EXTERNAL MAGNETIC FIELD. THESE RESULTS ARE BENCHMARKED AGAINST COUPLING LOSS MEASUREMENTS ON SHORT SECTIONS OF ITER CONDUCTORS PERFORMED IN, E.G. THE TWENTE PRESS EXPERIMENT.

2LB-07

PREPARATION OF PF1/6 AND PF2 CONDUCTOR PERFORMANCE QUALIFICATION SAMPLES ***L. RECCIA***[1]*, S. TURTÙ*[1]*, G. POLLI*[1]*, L. AFFINITO*[1]*, A. DELLA CORTE*[1]*, P. DECOOL*[2]*, D. BESSETTE*[3]*, A. DEVRED*[3]*, A. VOSTNER*[3]*, T. BOUTBOUL*[4]*;* [1]ENEA, [2]CEA, [3]ITER, [4]F4E. — THE ITER CONDUCTOR PROCUREMENT ARRANGEMENT REQUIRES THAT ALL THE CONDUCTORS HAVE TO BE QUALIFIED BEFORE THE START OF THE PRODUCTION PHASE. THE OBJECT OF THE WORK HERE PRESENTED IS THE MANUFACTURE OF THE POLOIDAL FIELD COILS CONDUCTOR SAMPLES TO BE TESTED IN SULTAN , SPECIFICALLY THE NBTI PF1/6 AND THE PF2 ONES.THE REALIZATION OF THESE SAMPLES INCLUDED THE JACKETING, THE COMPACTION AND THE STRAIGHTENING OF THE CICC, TOGETHER WITH THE DESIGN AND MANUFACTURING OF THE BOTTOM HAIR-PIN BOX AND THE UPPER TERMINATIONS. THE INSTRUMENTATION AND THE RELATED JACKET MACHINING COMPLETED THE SAMPLE PREPARATION.THE SAMPLES HAVE BEEN ASSEMBLED ACCORDING TO THE SPECIFICATION DEFINED BY ITER AND HAVE BEEN SHIPPED TO CRPP, SWITZERLAND TO BE TESTED IN THE SULTAN FACILITY.THIS PAPER DESCRIBES ALL THE ACTIVITIES PERFORMED DURING THE PREPARATION, THE SAMPLE FEATURES AND ALL THE RELATED ISSUES.

2LP1A-01

MAGNETIC FIELD SHIMMING AND THE FIELD MEASUREMENT ISSUE ON THE 130-POLE SUPERCONDUCTING UNDULATOR ***J. C. JAN****, C. S. HWANG, C. M. WU, F. Y. LIN, C. H. CHANG;* NATIONAL SYNCHROTRON RADIATION RESEARCH CENTER. — A 130-POLE SUPERCONDUCTING UNDULATOR WITH NBTI WIRES WAS WOUND AND TESTED AT NATIONAL SYNCHROTRON RADIATION RESEARCH CENTER (NSRRC). THE MAGNETIC FIELD WAS MEASURED WITH A CRYOGENIC MINI-HALL SENSOR IN A VERTICAL DEWAR. HOWEVER, THE TOTAL LENGTH DIFFERENCE BETWEEN THE NOMINAL DESIGN AND THE EXPERIMENT OF THE HALL PROBE ROD IS APPROXIMATELY 1.2 MM. THE DISCREPANCY ARISES FROM THE THERMAL CONTRACTION DURING THE FIELD MEASUREMENT IN THE TEST DEWAR. THE RELIABILITY OF THE MEASUREMENT SYSTEM IS CONFIRMED, AND IS DISCUSSED IN TERMS OF THE FIELD-MAPPING SPECTRUM. MEASUREMENT OF THE FIELD STRENGTH REVEALED A NON-UNIFORM DISTRIBUTION OF THE FIELD IN THE ARRAYS OF LENGTH 1 M. A SHIMMING METHOD WITH AN IRON POLE PIECE WAS USED TO SHIM THE ON-AXIS FIELD STRENGTH OF THE UNDULATORS. IN THIS ARTICLE WE STUDY THE THERMAL EFFECT OF THE MEASUREMENT SYSTEM, AND DISCUSS A USEFUL SHIMMING METHOD AND ITS RESULTS FOR THE SUPERCONDUCTING UNDULATOR.

2LP1A-03

FEASIBILITY OF SHORT-PERIOD SUPERCONDUCTING UNDULATORS USING 2G YBCO HTS TAPES* ***S. KIM****, C. L. DOOSE, M. S. JASKI, M. T. KASA;* ARGONNE NATIONAL LABORATORY. — THIS PAPER PRESENTS A FEASIBILITY STUDY OF A SHORT-PERIOD SUPERCONDUCTING UNDULATOR (SCU) USING YBCO HIGH-TEMPERATURE SUPERCONDUCTOR (HTS). CURRENTLY, THE CONDUCTOR IS AVAILABLE AS TAPE THAT IS 4 MM WIDE AND 0.1 MM THICK BEFORE INSULATION, WHICH IS SUITABLE FOR THE DESIGN OF A SCU WITH A MAGNETIC PERIOD OF 15 MM. THE PHYSICAL AND MECHANICAL PROPERTIES OF THE HTS TAPE RESTRICT THE CONDUCTOR TRANSITION FROM ONE GROOVE TO THE NEXT FOR THE COIL WINDING. THE CONDUCTOR TRANSITION REQUIRES A CONDUCTOR SOLDERING JOINT BETWEEN THE GROOVES. ALSO, CONTINUOUS WINDING WITHOUT A CONDUCTOR JOINT IS POSSIBLE BY MAKING A SMALL SEMI-CIRCULAR LOOP OF THE CONDUCTOR FOR THE TRANSITION. THE ENGINEERING CURRENT DENSITY OF THE HTS IN THE COIL GROOVE FOR THE DESIGN IS COMPARABLE TO THAT OF NBTI AT 4.2 K. DETAILS OF THE MAGNETIC DESIGN AND DEVELOPMENT WILL BE PRESENTED.

*WORK SUPPORTED BY THE U.S. DEPARTMENT OF ENERGY, OFFICE OF SCIENCE, OFFICE OF BASIC ENERGY SCIENCES, UNDER CONTRACT NO. DE-AC02-06CH11357.

2LP1A-04

DESIGN OF NB3SN-BASED SHORT PERIOD MODEL HELICAL UNDULATOR ***M. MAJOROS****, M. D. SUMPTION, E. W. COLLINGS;* THE OHIO STATE UNIVERSITY. — SUPERCONDUCTING UNDULATORS ARE BEING CONSTRUCTED TO SATISFY AN INCREASING NEED WITHIN THE SYNCHROTRON RADIATION COMMUNITY FOR PHOTON BEAMS WITH AS SHORT A WAVELENGTH AS POSSIBLE. FINITE ELEMENT METHOD (FEM) MODELLING WAS PERFORMED TO EXTEND THE DESIGN OF OUR EXISTING 14 MM PERIOD UNDULATOR DESIGN TO SHORTER AND SHORTER PERIODS WITH A VIEW

TOWARDS THE FINAL DESIGN, CONSTRUCTION AND TESTING OF A 10 MM UNDULATOR. TO LAUNCH THIS TASK WE MODELED THE PROPERTIES OF 10 MM PERIOD UNDULATORS FORMED AROUND BORE TUBES OF THE ABOVE 8 MM OD WITH WINDING-PACK CROSS-SECTIONS OF: (A) 5 MM X 5 MM, (B) 5 MM X 10 MM, AND (C) 3 MM X 10 MM. WITH WINDING-PACK WIDTHS OF 5 MM (WINDINGS (A) AND (B)) THE 10 MM-PERIOD UNDULATOR WOULD HAVE NO ROOM FOR FE POLES AND AS SUCH IS A DESIGN LIMIT. WINDING (C) DOES ALLOW A POLE WIDTH OF 2 MM AND CAN TAKE ADVANTAGE OF THE CORRESPONDING 0.2 T FIELD INCREMENT DUE TO IT. IN ORDER TO REACH THE TARGET BORE FIELD OF 1.1 T IT IS NECESSARY TO EITHER REDUCE THE BORE SIZE AND TIGHTEN THE ASSOCIATED TOLDERANCES, OR TO USE A HIGHER PERFORMING STRAND. IN THE PRESENT WORK WE HAVE CHOSEN TO OPTIMIZE THE UNDULATOR DESIGN BASING IT ON THE PROPERTIES OF AN ADVANCED TUBE-TYPE STRAND KEEPING THE BORE TUBE DIAMETER AT 8 MM IN ORDER TO SEE THE NEEDED PERFORMANCE TO MEET THIS UNDULATOR SPECIFICATION.

2LP1A-05**A DESIGN CONCEPT FOR A PLANAR SUPERCONDUCTING UNDULATOR FOR THE APS** ***Y. IVANYUSHENKOV***[1]*, M. ABLIZ*[1]*, K. BOERSTE*[1]*, T. BUFFINGTON*[1]*, D. CAPATINA*[1]*, C. DOOSE*[1]*, Q. HASSE*[1]*, M. JASKI*[1]*, M. KASA*[1]*, S. KIM*[1]*, R. KUSTOM*[1]*, N. MEZENTSEV*[2]*, E. MOOG*[1]*, V. SYROVATIN*[2]*, E. TRAKHTENBERG*[1]*, I. VASSERMAN*[1]*, J. XU*[1]*;* [1]ARGONNE NATIONAL LABORATORY, [2]BUDKER INSTITUTE OF NUCLEAR PHYSICS. — A SUPERCONDUCTING PLANAR UNDULATOR IS UNDER DEVELOPMENT AT THE ADVANCED PHOTON SOURCE. THE R&D PHASE CULMINATED IN THE SUCCESSFUL TESTS OF SEVERAL SHORT MAGNETIC STRUCTURE PROTOTYPES. WORK IS NOW FOCUSED ON A COMPLETE DESIGN FOR THE FIRST UNDULATOR. THE CONCEPTUAL DESIGNS FOR THE SUPERCONDUCTING MAGNET, THE COOLING SYSTEM, AND THE CRYOSTAT ARE DESCRIBED IN THIS PAPER.

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2LP1B-01

DESIGN OF A SUPERCONDUCTING MAGNET SYSTEM FOR THE AEGIS EXPERIMENT AT CERN ***A. DUDAREV****, M. DOSER, D. PERINI, H. TEN KATE;* CERN. — THE AEGIS (ANTIMATTER EXPERIMENT: GRAVITY, INTERFEROMETRY, SPECTROSCOPY) EXPERIMENT WILL BE CONSTRUCTED IN THE ANTIPROTON DECELERATOR HALL AT CERN. THE MAIN TASK IS TO MEASURE THE EARTH'S GRAVITATIONAL ACCELERATION OF ANTIHYDROGEN ATOMS. THE EXPERIMENT CONSISTS OF TWO HIGH HOMOGENEITY SOLENOIDS PLACED ON THE SAME AXIS. THE 5 T MAGNET SERVES AS A PART OF A CYLINDRICAL PENNING TRAP TO CATCH AND TO ACCUMULATE ANTIPROTONS DELIVERED FROM THE DECELERATOR. THE ANTIHYDROGEN IS THEN PRODUCED IN THE 1 T REGION WHERE SUB-KELVIN ANTIPROTON TEMPERATURES PROVIDED BY THE DILUTION REFRIGERATOR ARE REQUIRED TO FORM A SLOWLY-MOVING BEAM OF ANTIHYDROGEN. THE HELIUM BATH COOLED SUPERCONDUCTING MAGNETS, THE DIFFERENT TRAPS AND THE DILUTION REFRIGERATOR ARE INTEGRATED IN A COMMON VACUUM VESSEL WITH AN INTERNAL VACUUM BARRIER BETWEEN THE INSULATING CRYOGENIC AND THE VERY HIGH VACUUM. IN ADDITION, THE MAGNET SYSTEM HAS TO GUARANTEE A SMOOTH TRANSITION BETWEEN THE 5 T AND THE 1 T MAGNETIC FIELD AREAS REQUIRED FOR A LOSS-FREE TRANSFER OF ANTIPROTONS AND POSITRONS FROM THE TRAPPING REGION TO THE ANTIHYDROGEN PRODUCTION AREA. IN THIS PAPER THE DESIGN OF THE AEGIS MAGNET SYSTEM IS PRESENTED AND DISCUSSED.

2LP1B-02

CONCEPTUAL DESIGN OF A SUPERCONDUCTING SOLENOID SYSTEM FOR THE SUPER OMEGA MUON BEAM LINE AT J-PARC ***Y. MAKIDA***[1]*, T. OGITSU*[1]*, T. ADACHI*[2]*, Y. IKEDO*[1]*, K. SHIMOMURA*[1]*, Y. MIYAKE*[1]*, N. KAWAMURA*[1]*, P. STRASSER*[1]*, A. KODA*[1]*, K. NAKAHARA*[1]*, T. NAKAMOTO*[1]*, K. SASAKI*[1]*;* [1]KEK (HIGH ENERGY ACCELERATOR RESEARCH ORGANIZATION), [2]THE UNIVERSITY OF TOKYO. — A 3 GEV/1 MW/333 MA PROTON BEAM FROM THE J-PARC RAPID CYCLE SYNCHROTRON PASS THROUGH A GRAPHITE TARGET PRODUCING MUONS IN THE MATERIAL AND LIFE SCIENCE FACILITY. THE PRODUCED MUONS OF VARIOUS MOMENTUMS UP TO 60 MEV/C AND OF BOTH ELECTRIC CHARGES ARE CAPTURED AND TRANSPORTED TO AN EXPERIMENTAL AREA BY USING THE AXIAL MAGNETIC FIELD AT THE INNER BORE OF THE SOLENOID MAGNETS. THE BEAM LINE, NAMED SUPER OMEGA, IS COMPOSED OF 1) DOUBLE NORMAL CONDUCTING MAGNETS MIC (MINERAL INSULATION CABLE) FOR CAPTURE, 2) THE CURVED SUPERCONDUCTING SOLENOIDS FOR TRANSPORTATION, AND 3) AXIALLY SYMMETRIC SUPERCONDUCTING COILS FOR FOCUSING. THE SUPERCONDUCTING TRANSPORT MAGNET IS COMPOSED OF ONE 6 M LONG STRAIGHT SECTION AND TWO 45[[UNSUPPORTED CHARACTER - ◦]] SEGMENTED CURVED SECTIONS ONTO THE BOTH ENDS OF THE STRAIGHT SECTION. THE REQUIRED MAGNETIC FIELD IN THE TRANSPORTING CHANNEL WITH DIAMETER OF 300 MM IS ABOUT 2 T. ONCE IN THE EXPERIMENTAL AREA, THE MUON BEAM IS FOCUSED ONTO THE EXPERIMENTAL TARGET BY AN AXIAL FOCUSING MAGNET. DESIGNS OF THE SUPERCONDUCTING MAGNETS SYSTEM ARE REPORTED.

2LP1B-03

SUPERCONDUCTING SOLENOID MAGNETS FOR THE COMET EXPERIMENT ***M. YOSHIDA***[1]*, T. NAKAMOTO*[1]*, T. OGITSU*[1]*, K. TANAKA*[1]*, A. YAMAMOTO*[1]*, M. AOKI*[2]*, Y. KUNO*[2]*, A. SATO*[2]*;* [1]HIGH ENERGY ACCELERATOR RESEARCH ORGANIZATION, KEK, [2]OSAKA UNIVERSITY. — AN INTENSE MUON BEAM IS MANDATORY FOR THE NEXT-GENERATION EXPERIMENTS TO SEARCH FOR LEPTON FLAVOR VIOLATING PROCESSES IN THE MUON SECTOR. THE COMET EXPERIMENT, J-PARC E21, AIMS TO SEARCH FOR MUON TO ELECTRON CONVERSION WITH AN UNPRECEDENTED SENSITIVITY.ALL THE EQUIPMENTS FOR THE EXPERIMENT, SUCH LIKE A PION PRODUCTION TARGET, MUON STOPPING TARGETS AND DETECTORS ARE EMBEDDED IN THE SUPERCONDUCTING SOLENOID, WHICH TOTAL LENGTH IS LONGER THAN 30 M. A LARGE SUPERCONDUCTING COIL WITH

THE DIAMETER OF 1.3M ENCLOSES THE PION-PRODUCTION TARGET TO CAPTURE PIONS IN THE FIELD OF 5 T. THE TRAPPED PIONS DECAY TO MUONS IN THE SUBSEQUENT 3 T TOROIDAL MAGNETS WITH THE LENGTH OF 10 M. THE PION CAPTURE SOLENOID IS DESIGNED TO BE AS SMALL AS POSSIBLE, ALTHOUGH A THICK SHIELDING IS NECESSARY INSIDE THE PION CAPTURE SOLENOID TO AVOID SEVERE RADIATION FROM THE TARGET. AN ALUMINUM-STABILIZED NBTI SUPERCONDUCTING WIRE IS EMPLOYED TO REDUCE COLD MASS AND ENERGY DEPOSIT IN IT. THE DAMAGE OF THE CONDUCTOR OF THE COILS SHOULD BE ESTIMATED CAREFULLY, SINCE THE EXPECTED NEUTRON FLUENCE REACHES 10^22 NEUTRONS/M^2. THIS PAPER DESCRIBES THE DESIGN OF THE SOLENOID MAGNETS AND R&D PROGRAMS.

2LP1B-04

QUENCH PROTECTION OF CURVED SOLENOIDS FOR HIGH INTENSITY MUON BEAMLINE ***T. ADACHI***[1]*, Y. IKEDO*[2]*, Y. MAKIDA*[2]*, M. YOSHIDA*[2]*, K. SASAKI*[2]*, T. NAKAMOTO*[2]*, T. OGITSU*[2]*, A. YAMAMOTO*[2]*, Y. MIYAKE*[2]*, A. SATO*[3]*, Y. KUNO*[3]*;* [1]THE UNIVERSITY OF TOKYO, [2]KEK, [3]OSAKA UNIVERSITY. — QUENCH PROTECTION SYSTEMS FOR SUPERCONDUCTING SEGMENTED, CURVED SOLENOIDS HAVE BEEN EXPERIMENTALLY STUDIED. THE CURVED SOLENOIDS ARE DESIGNED FOR HIGH-INTENSITY MUON BEAM LINES AND CONSIST OF SHORT SOLENOIDS ALIGNED ALONG THE CURVED BEAM DIRECTION. QUENCH PROPAGATION BETWEEN THE SHORT SOLENOIDS MAY NOT BE NATURALLY MADE BECAUSE OF SEPARATION OF THE SOLENOIDS, AND QUENCH-BACK ACTION FOR EACH SHORT SOLENOID CAN BOOST QUENCH PROPAGATION. TWO QUENCH-BACK SCHEMES OF ONE DRIVEN BY MAGNET CURRENT AND ANOTHER BY USING INDUCTIVE CURRENT WERE TESTED WITH MODEL COILS. THE MODEL COIL WORK WAS ORIGINALLY PERFORMED WITH NBTI SUPERCONDUCTOR AND IS BEING EXTENDED WITH MGB2 SUPERCONDUCTOR.

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2LP1B-05

MODEL SUPERCONDUCTING HELICAL COOLING CHANNEL SOLENOIDS ***M. J. LAMM***[1]*, N. ANDREEV*[1]*, V. S. KASHIKHIN*[1]*, V. V. KASHIKHIN*[1]*, A. V. MAKAROV*[1]*, M. A. TARTAGLIA*[1]*, K. YONEHARA*[1]*, M. YU*[1]*, A. V. ZLOBIN*[1]*, R. P. JOHNSON*[2]*, S. A. KAHN*[2]*;* [1]FERMILAB, [2]MUONS, INC.. — MAGNETS ARE BEING DEVELOPED AT FERMILAB FOR FUTURE 6-DIMENSIONAL MUON BEAM COOLING CHANNELS NEEDED FOR MUON COLLIDERS AS WELL AS THE MANX DEMONSTRATION EXPERIMENT. THESE MAGNETS HAVE A LONGITUDINAL SOLENOID FIELD WITH SUPERIMPOSED TRANSVERSE HELICAL DIPOLE AND HELICAL QUADRUPOLE FIELDS. TWO 0.6 M DIAMETER 4-COIL HELICAL SOLENOID MODEL MAGNETS HAVE BEEN BUILT AND TESTED TO VERIFY THE DESIGN CONCEPT, FABRICATION TECHNOLOGY, AND THE MAGNET SYSTEM PERFORMANCE. DETAILS OF MAGNETIC AND MECHANICAL DESIGNS, INCLUDING THE 3D ANALYSIS BY TOSCA AND ANSYS WILL BE PRESENTED AND COMPARED TO MEASUREMENTS. THE MODEL QUENCH PERFORMANCE IN THE TEST SETUP IN THE FERMILAB VERTICAL MAGNET TEST FACILITY CRYOSTAT WILL BE DISCUSSED.

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2LP1B-06

PROGRESS ON FABRICATION OF A MUCOOL COUPLING MAGNET ***L. WANG***[1]*, H. PAN*[2]*, H. WU*[2]*, X. GUO*[2]*, F. XU*[2]*, S. ZHENG*[2]*, D. LI*[3]*, M. GREEN*[3]*, S. VIROSTEK*[3]*, M. ZISMAN*[3]*;* [1]SHANGHAI INSTITUTE OF APPLIED PHYSICS,CAS, [2]INSTITUTE OF CRYOGENICS AND SUPERCONDUCTIVITY TECHNOLOGY, HIT, [3]LAWRENCE BERKELEY NATIONAL LABORATORY, BERKELEY CA 94720, USA. — THE MUCOOL PROGRAM UNDERTAKEN BY THE US NEUTRINO FACTORY AND MUON COLLIDER COLLABORATION IS TO STUDY THE COMPONENTS BEHAVIOR FOR MUON IONIZATION COOLING CHANNEL. A SINGLE SUPERCONDUCTING COUPLING SOLENOID IS NECESSARY TO PURSUE THE RESEARCH AND DEVELOPMENT ON THE PERFORMANCE OF HIGH GRADIENT, LARGE SIZE RF CAVITIES IMMERSED IN MAGNETIC FIELD. THE MUCOOL COUPLING MAGNET IS TO BE BUILT USING COMMERCIAL NIOBIUM TITANIUM CONDUCTORS AND COOLED BY TWO COOLERS WITH TOTAL AVAILABLE COOLING CAPACITY OF 2.6 W AT 4.2 K. THE MAGNET WILL BE POWERED BY USING A SINGLE 300A POWER SUPPLY THROUGH A PAIR OF LEADS DESIGNED TO CARRY A MAXIMUM CURRENT OF 210A. THE HIGH TEMPERATURE SUPERCONDUCTING LEADS ARE TO BE APPLIED BETWEEN THE FIRST STAGE OF THE COOLER AND THE MAGNET IN ORDER TO REDUCE THE HEAT LEAK AROUND 4.2 K. THE MAGNET IS TO BE PASSIVELY PROTECTED BY COLD DIODES AND RESISTORS ACROSS SECTIONS OF COIL AND BY QUENCH BACK FROM THE 6061 AL MANDREL IN ORDER TO LOWER THE QUENCH VOLTAGES AND THE HOT SPOT TEMPERATURE. A SELF-CENTERING DOUBLE-BAND SUPPORT SYSTEM IS APPLIED FOR THE MAGNET. THE COUPLING MAGNET IS CURRENTLY UNDER CONSTRUCTION. THIS PAPER IS TO PRESENT ITS UPDATED DESIGN DURING FABRICATION, RECENT FABRICATION PROGRESS AND COIL WINDING SKILLS.

THIS WORK IS SUPPORTED BY FUNDS OF THE CRYOGENICS AND SUPERCONDUCTING TECHNOLOGY INNOVATION PROJECT UNDER THE “985-2” PLAN OF THE HIT. THIS WORK IS ALSO SUPPORTED BY THE OFFICE OF SCIENCE, US-DOE UNDER DOE CONTRACT DE-AC02-05CH11231.

2LP1B-07

THE RESISTANCE AND STRENGTH OF SOFT SOLDER SPLICES BETWEEN CONDUCTORS FOR MICE SUPERCONDUCTING COILS *H. PAN*[1]*, H. WU*[1]*,* ***M. A. GREEN***[2]*, D. DIETDERRICH*[2]*, H. HIGLEY*[2]*, F. XU*[1]*, D. TAM*[2]*, L. WANG*[3]*, S. ZHENG*[1]*;* [1]INSTITUTE OF CRYOGENICS AND SUPERCONDUCTIVE TECHNOLOGY, HIT, HARBIN, CHINA, [2]LAWRENCE BERKELEY NATIONAL LABORATORY, [3]SHANGHAI INSTITUTE OF APPLIED PHYSICS, SHANGHAI, CHINA.. — THE SUPERCONDUCTING MAGNETS FOR THE MUON IONIZATION COOLING EXPERIMENT (MICE),

USE A COPPER BASED NB-TI CONDUCTOR WITH UN-INSULATED DIMENSIONS OF ABOUT 0.95 BY 1.60 MM. THE MICE COUPLING COILS MAY HAVE AS MANY AS FIFTEEN SPLICES WITHIN THE COIL, DUE TO RELATIVELY SHORT CONDUCTOR PIECE LENGTHS. WE PREFER TO USE LAP SPLICES THAT USE SOFT-SOLDER BETWEEN THE CONDUCTORS, BECAUSE OF THEIR LOW RESISTANCE. THE STRENGTH OF LONG SPLICE (>0.25-METER) IS ALMOST INDEPENDENT OF ITS LENGTH. THE STRENGTH OF SHORT SPLICE (<0.15-METER) WILL VARY WITH LENGTH AND THE TYPE OF SOLDER USED IN THE SPLICE. THE SPLICES WITH DIFFERENT LENGTHS WERE FABRICATED USING TIN-SILVER SOLDER AND TIN-LEAD EUTECTIC SOLDER. MEASUREMENTS OF SPLICE RESISTANCE WERE MADE AT 4.2 K AT MAGNETIC INDUCTIONS FROM ZERO TO 5 T. MEASUREMENTS OF SPLICE STRENGTH WERE MADE AT BOTH 300 K AND 77 K. THIS REPORT DISCUSSES THE RESISTANCE AND STRENGTH OF THE CONDUCTOR SPLICES AS A FUNCTION OF LENGTH, MAGNETIC FIELD, AND THE TYPE OF SOLDER USED TO FABRICATE THE SPLICE.

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2LP1C-01

THE CAVITIES FOR SUPERCONDUCTING CW LINAC OF PROJECT X ***I. GONIN**, T. KHABILOULINE, A. SAINI, N. SOLYAK, V. YAKOVLEV;* FERMILAB. — **THE CAVITIES FOR SUPERCONDUCTING CW LINAC OF PROJECT X**.I. GONIN, T. KHABILOULINE, A. SAINI, N. SOLYAK, V. YAKOVLEVTHE PROJECT X LINAC CONTAINS LOW-ENERGY PART OPERATING AT 325 MHZ (2.5 MEV- 160 MEV), AND HIGH-ENERGY PART OPERATING AT 650 MHZ (160 MEV - 2 GEV). FURTHER ACCELERATION UP TO 3 GEV WILL TAKE PLACE IN 1.3 GHZ ILC-TYPE CAVITIES. IN THE LOW-ENERGY PART OF THE LINAC THERE FAMILIES OF 325 MHZ SC SINGLE SPOKE CAVITIES WILL BE USED, HAVING BETA = 0.11, 0.22 AND 0.4. IN THE HIGH ENERGY PART TWO FAMILIES OF THE ELLIPTIC 5-CELL 650 MHZ SC CAVITIES WILL BE USED WITH BETA =0.61 AND 0.9. RESULTS OF DETAILED OPTIMIZATION OF ALL THE CAVITIES ARE PRESENTED.

2LP1C-02**CAVITY PERFORMANCE AND SURFACE CHARACTERIZATION USING REPLICA TECHNIQUE** ***G. WU**, M. GE, D. BURKE, L. COOLEY;* FERMILAB. — MAGNETIC FIELD ENHANCEMENT HAS BEEN STUDIED IN THE PAST THROUGH REPLICA AND CAVITY CUTTING. CONSIDERABLE PROGRESS OF NIOBIUM CAVITY MANUFACTURING AND PROCESSING HAS BEEN MADE. THIS WORK IS TO REVIEW THE STATE OF THE ART OF NIOBIUM CAVITY PERFORMANCE AND CAVITY SURFACE GEOMETRICAL QUALITY OBTAINED BY REPLICA TECHNIQUE.

2LP1C-03

THE RF PERFORMANCE OF CAVITIES MADE FROM DEFECTIVE NIOBIUM MATERIAL DETERMINED BY EDDY CURRENT SCANNING ***G. WU**[1], L. COOLEY[1], A. BRINKMANN[2], W. SINGER[3], X. SINGER[3];* [1]FERMILAB, [2]DESY, [3]DESY. — EDDY CURRENT SCANNING (ECS) HAS BEEN USED TO SCREEN NIOBIUM SHEETS TO AVOID DEFECTIVE MATERIAL BEING USED IN COSTLY CAVITY FABRICATION. THE CRITERION OF THIS QUALITY CONTROL TOOL IS NOT WELL UNDERSTOOD. PAST SURFACE STUDIES SHOWED SOME FEATURES WERE SHALLOW ENOUGH TO BE REMOVED BY CHEMICAL ETCHING. THE REMAINING FEATURES WERE IDENTIFIED TO BE SMALL NUMBER OF DEEPER INCLUSIONS, BUT MOSTLY UNIDENTIFIABLE FEATURES (BY CHEMICAL ANALYSIS). INVESTIGATING A REAL CAVITY MADE OF DEFECTIVE NIOBIUM MATERIAL COULD HELP TO DEFINE THE CONTROL STANDARD CLEARLY.

2LP1C-04

ULTRA-GRADIENT TEST CAVITY FOR TESTING SRF WAFER SAMPLES ***P. MCINTYRE**[1], N. POGUE[1], C. REECE[2], A. SATTAROV[1];* [1]TEXAS A&M UNIVERSITY, [2]JEFFERSON NATIONAL LABORATORY. — DEVELOPMENT OF A 1.3 GHZ ULTRA-GRADIENT TEST CAVITY IS REPORTED. THE TE01 CAVITY IS DESIGNED TO TEST WAFER SAMPLES OF ADVANCED MATERIALS FOR SUPERCONDUCTING RF CAVITIES. THE CAVITY IS DIELECTRIC-LOADED BY A LOCATING A HEMISPHERE OF ULTRA-PURE SAPPHIRE JUST ABOVE THE TEST WAFER. THE DIELECTRIC PULLS SURFACE FIELDS OFF THE NB WALLS OF THE CAVITY SO THAT THE MAXIMUM NB SURFACE FIELD IS ONLY 25% OF THE SURFACE FIELD ON THE SAMPLE. CURRENTS CIRCULATE ON THE CAVITY WALLS AND ON THE WAFER SURFACE SO FIELD EMISSION SHOULD BE SUPPRESSED. IN THIS WAY IT SHOULD BE POSSIBLE TO DRIVE A SAMPLE WAFER WELL BEYOND THE BCS LIMIT FOR NB WHILE MAINTAINING HIGH Q ON THE CAVITY.DESIGN AND INITIAL CONSTRUCTION OF THE CAVITY WILL BE REPORTED. RESULTS WILL BE REPORTED FROM A FIRST EXPERIMENT TO MEASURE THE LOSS TANGENT OF THE ULTRAPURE SAPPHIRE.

THIS RESEARCH IS SUPPORTED IN PART BY DOE GRANT DE-FG02-06ER41405.

2LP1C-05

CALCULATIONS WITH FLUENT FOR THE CRYOGENIC RADIATION LOSS OF A SUPERCONDUCTING RF MODULE ***M. CHANG**, C. WANG, M. LIN;* NATIONAL SYNCHROTRON RADIATION RESEARCH CENTER. — THE LOSS OF CRYOGEN DUE TO A SUPERCONDUCTING RADIO-FREQUENCY (SRF) MODULE CAN BE TEN OR A HUNDRED TIMES THAT OF A SUPERCONDUCTING MAGNET, MAINLY BECAUSE OF THE DYNAMIC RF LOSS PREDICTABLE WITH THE BCS THEORY AND OF THE STATIC LOSS FROM THE LARGE OPENINGS ON BOTH SIDES OF THE SRF CAVITY TO ALLOW THE PASSAGE OF THE BEAM OF ACCELERATED ELECTRONS. THE RADIATION LOSS OF AN SRF MODULE IS CONVENTIONALLY ESTIMATED WITH AN EMPIRICAL APPROACH THAT MIGHT DEVIATE SIGNIFICANTLY FROM REALISTIC CONDITIONS. IN THIS PROJECT WE APPLIED COMMERCIALLY AVAILABLE CODE FLUENT FOR 3D CFD TO SIMULATE THE RADIATION LOSS OF THE SRF MODULE OF CORNELL DESIGN, WHICH IS TAKEN AS AN EXAMPLE. THE SO-CALLED *DISCRETE ORDINATE MODEL* (DOM) IS SELECTED FOR

OUR SIMULATION TO TREAT SIMULTANEOUSLY THE RADIATIVE HEAT TRANSFER DUE TO DIFFUSE AND SPECULAR REFLECTION FROM A POLISHED SURFACE MADE OF A TECHNICAL MATERIAL. THE MEASURED AND CALCULATED STATIC CRYOGENIC LOSSES OF THE SRF MODULE OF CORNELL DESIGN ROUTINELY OPERATED AT NSRRC ARE COMPARED IN DETAIL. OUR APPROACH IS APPLICABLE FOR A MORE PRECISE ESTIMATION OR OPTIMIZATION OF THE CRYOGENIC LOSS IN THE DESIGN OF A NEW SRF MODULE.

2LP1C-07

RESIDUAL RESISTANCE DATA FROM CAVITY PRODUCTION PROJECTS AT JEFFERSON LAB ***G. CIOVATI***[1]*, R. GENG*[1]*, J. MAMMOSSER*[2]*, J. SAUNDERS*[2]*;* [1]JEFFERSON LAB, [2]OAK RIDGE NATIONAL LABORATORY. — A FUNDAMENTAL LIMITATION TOWARDS ACHIEVING HIGH QUALITY FACTORS IN SUPERCONDUCTING RADIO-FREQUENCY CAVITIES IS THE SO-CALLED RESIDUAL RESISTANCE. UNDERSTANDING AND CONTROLLING THE RESIDUAL RESISTANCE HAS IMPORTANT IMPLICATIONS TOWARDS IMPROVING THE EFFICIENCY AND REDUCE THE OPERATING COST OF CONTINUOUS WAVE SUPERCONDUCTING LINEAR ACCELERATORS. IN THIS CONTRIBUTION WE WILL REPORT ON THE RESIDUAL RESISTANCE VALUES OBTAINED FROM MEASUREMENTS OF THE QUALITY FACTOR OF A LARGE SET OF MULTI-CELL CAVITIES, WITH RESONANT FREQUENCY BETWEEN 805 MHZ AND 1.5 GHZ, ALL OF THEM PROCESSED AND TESTED AT JEFFERSON LAB. SURFACE TREATMENTS INCLUDED BOTH BUFFERED CHEMICAL POLISHING AND ELECTROPOLISHING.

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2LP1C-08

DESIGN AND TESTING OF MAGNETIC SHIELDING FOR SRF CAVITIES PROXIMAL TO FOCUSING SOLENOIDS IN REA3 CRYOMODULES AT NSCL ***J. DELAUTER****, S. CHOUHAN, J. BIERWAGEN, S. BRICKER, C. COMPTON, J. DEKAMP, K. ELLIOTT, W. HARTUNG, M. HODEK, M. JOHNSON, O. KESTER, T. KOLE, L. POPIELARSKI, J. POPIELARSKI, N. VERHANOVITZ, J. WLODARCZAK, X. WU, A. ZELLER;* NATIONAL SUPERCONDUCTING CYCLOTRON LAB - MICHIGAN STATE UNIVERSITY. — THE NATIONAL SUPERCONDUCTING CYCLOTRON LABORATORY (NSCL) IS CONSTRUCTING A 3 MEV PER NUCLEON REACCELERATOR (REA3) IN ORDER TO REACCELERATE STOPPED ION BEAMS. REA3 ACCELERATION IS PROVIDED BY SUPERCONDUCTING RADIO FREQUENCY (SRF) QUARTER WAVE RESONATORS MADE OF NIOBIUM; FOCUSING IS PROVIDED BY 9 T SUPERCONDUCTING SOLENOIDS WITH AN EFFECTIVE LENGTH OF 20 CM. THE SOLENOID INCLUDES DIPOLES FOR X AND Y TRANSVERSE STEERING, EACH PROVIDING AN INTEGRATED FIELD OF 0.024 T*M. MAGNETIC FIELDS AT THE SURFACE OF THE RESONATORS CAN PRODUCE A DEGRADATION IN THE RESONATOR PERFORMANCE. MAGNETIC SHIELDING WAS DESIGNED AND SIMULATED TO MEET THE STRICT FIELD REQUIREMENTS. THE SHIELDING SYSTEM CONSISTS OF ACTIVE BUCKING COILS AND A STEEL YOKE FLUX RETURN AROUND THE SOLENOID, ALONG WITH A CRYOGENIC MU-METAL CAN AROUND THE RESONATOR (IN ADDITION TO THE MEISSNER SHIELDING INTRINSIC TO THE RESONATOR ITSELF). THE SHIELDING SYSTEM WAS TESTED IN A DEWAR CONFIGURATION AT NSCL. THE CAVITY PERFORMANCE WAS NOT DEGRADED WITH THE SOLENOID OPERATING AT 6.5 T. AFTER OPERATION OF THE SOLENOID, THE RESONATOR WAS WARMED UP ABOVE TRANSITION, COOLED BACK DOWN, AND RETESTED TO CHECK FOR TRAPPING OF REMNANT FIELDS. SOME MINOR PERFORMANCE DEGRADATION WAS FOUND IN THIS TEST. DEMAGNETIZATION OF THE SOLENOID MIGHT ALLOW FOR THE DEGRADATION TO BE REVERSED.

2LP2A-02

DESIGN AND MANUFACTURE OF THE SUPERCONDUCTING JOINT FOR THE 40 T HYBRID MAGNET ***Y. TAN****;* HIGH MAGNETIC FIELD LABORATORY, CHINESE ACADEMY OF SCIENCES. — **DESIGN AND MANUFACTURE OF THE SUPERCONDUCTING JOINT FOR THE 40 T HYBRID MAGNET**TWO KINDS OF THE SUPERCONDUCTING CICC JOINTS HAVE BEEN DESIGNED FOR THE SUPERCONDUCTING MAGNET OF THE 40 T HYBRID MAGNET, ONE IS FOR THE OUTER JOINT BETWEEN THE TERMINALS OF THE SUPERCONDUCTING COILS, AND ANOTHER IS FOR THE INNER JOINT BETWEEN THE INTRA-LAYERS OF THE COILS. BOTH OF THE INNER JOINT AND THE OUTER JOINT ARE FABRICATED BEFORE HEAT TREATMENT, THE INNER JOINT HAS NO ANY PROCESS AFTER HEAT TREATMENT, AND THE OUTER JOINT ONLY NEEDS CONNECTIONS BETWEEN THE TERMINALS OF THE SUPERCONDUCTING COILS THROUGH THE COPPER SOLES BY PBSN SOLDER. TWO FULL-SIZE JOINTS ARE MANUFACTURING AND WILL BE TESTED IN HIGH MAGNETIC FILED LABORATORY, CHINESE ACADEMY OF SCIENCES. THIS PAPER WILL DESCRIBE AN OVERVIEW OF THE JOINTS' CONSTRUCTION AND FABRICATION, AND THE TEST RESULTS WILL BE ALSO PRESENTED.KEYWORDS: HYBRID MAGNET, NB3SN CICC, SUPERCONDUCTING JOINT

2LP2A-03

COMPARISON OF A CONTACT MECHANICS MODEL WITH EXPERIMENTAL RESULTS TO OPTIMIZE THE PREDICTION OF TRANSVERSE LOAD EFFECTS OF LARGE SUPERCONDUCTING CABLE-IN-CONDUIT-CONDUCTOR ***L. CHIESA***[1]*, M. TAKAYASU*[2]*;* [1]TUFTS UNIVERSITY, [2]MIT, PLASMA SCIENCE AND FUSION CENTER. — A MODEL BASED ON CONTACT MECHANICS CONCEPTS HAS BEEN DEVELOPED TO ANALYZE AND QUANTITATIVELY EVALUATE MECHANICAL TRANSVERSE LOAD EFFECTS ON SUPERCONDUCTING STRANDS IN A CABLE-IN-CONDUIT-CONDUCTOR (CICC). THE MODEL ESTIMATES THE NUMBER OF CONTACT POINTS AND THE EFFECTIVE CONTACT PRESSURES BETWEEN THE STRANDS IN A CABLE. EXPERIMENTAL MEASUREMENTS CONFIRMED THE MODEL, WHICH WAS THEN USED TO EVALUATE MECHANICAL TRANSVERSE LOAD EFFECTS ON THE CRITICAL CURRENT DEGRADATION OF SUB-SIZED CABLE SAMPLES OF NB3SN WIRES. IT COULD PREDICT THE TRANSVERSE LOAD DEGRADATIONS OF THE CRITICAL CURRENTS OF A LARGE CICC

CABLE USING EXPERIMENTAL CRITICAL-CURRENT DEGRADATION DATA OF A 3-STRAND CABLE AS A FUNCTION OF THE EFFECTIVE CONTACT PRESSURE. THIS PAPER WILL REVIEW THE MODEL TO ESTIMATE THE DEGRADATION CAUSED BY THE TRANSVERSE LOAD EFFECT AND DISCUSS THE RESULTS WITH REPORTED EXPERIMENTAL RESULTS OF SEVERAL CABLE CONFIGURATIONS. THE ANALYSIS PROVIDES SUGGESTIONS FOR FUTURE DESIGN EVALUATION OF MECHANICAL BEHAVIORS OF LARGE NB3SN CICC CABLE MAGNETS DURING OPERATIONS.

2LP2A-04

NEUTRON DIFFRACTION STUDY OF THERMAL RESIDUAL STRAIN IN NB_3SN CONDUCTORS ***T. HEMMI***[1], *S. HARJO*[1], *K. MATSUI*[1], *Y. NUNOYA*[1], *N. KOIZUMI*[1], *Y. TAKAHASHI*[1], *H. NAKAJIMA*[1], *T. ITO*[1], *K. AIZAWA*[1], *H. SUZUKI*[1], *S. MACHIYA*[2], *Y. TSUCHIYA*[3], *K. OSAMURA*[4]; [1]JAPAN ATOMIC ENERGY AGENCY, [2]DAIDO UNIVERSITY, [3]NATIONAL INSTITUTE FOR MATERIALS SCIENCE, [4]RESEARCH INSTITUTE FOR APPLIED SCIENCES. — RESIDUAL STRAIN IN CONDUCTORS IS CAUSED BY THE DIFFERENCE IN THE COEFFICIENT OF EXPANSION BETWEEN NB_3SN STRANDS AND THE STAINLESS STEEL JACKET OVER A TEMPERATURE RANGE OF 5 - 923 K. THE SUPERCONDUCTING PROPERTIES OF NB_3SN STRANDS VARY SIGNIFICANTLY, DEPENDING ON THE INCIDENCE OF RESIDUAL STRAIN. IT IS IMPORTANT TO CLARIFY THE INCIDENCE OF RESIDUAL STRAIN AS PART OF THE EVALUATION OF SUPERCONDUCTING PERFORMANCE. HOWEVER, THE RESIDUAL STRAIN OF STRANDS IN THE CONDUCTOR HAS NOT BEEN MEASURED SO FAR BECAUSE OF THEIR COMPLICATED CONFIGURATION AND THEIR LOCATION IN A JACKET. THE ENGINEERING MATERIALS DIFFRACTOMETER “TAKUMI” IN J-PARC, IN OPERATION SINCE 2008, CAN MEASURE RESIDUAL STRAIN WITH A RELATIVE ACCURACY OF AROUND 0.02% USING NEUTRON DIFFRACTION. IN THIS STUDY, NEUTRON DIFFRACTION USING THE TAKUMI WAS APPLIED TO THE MEASUREMENT OF RESIDUAL STRAIN IN STRANDS FOR THE ITER TF CONDUCTOR. VARIATIONS IN THE LATTICE SPACING OF EACH LAYER, SUCH AS NB_3SN, NB BARRIER, COPPER AND STAINLESS STEEL, ALSO WERE MEASURED BY THE TAKUMI AT THE SAME TIME. RESULTS INDICATE THAT THE RESIDUAL STRAIN OF STRANDS IN THE CONDUCTOR CAN BE DETERMINED, THEREBY CLARIFYING THE MECHANISM OF RESIDUAL STRAIN AND ITS RELATIONSHIP TO SUPERCONDUCTING PERFORMANCE.

2LP2A-05

ROLE OF THE CROSS-SECTION GEOMETRY IN RECTANGULAR NB3SN CICC PERFORMANCES ***S. TURTÙ***[1], *L. RECCIA*[1], *V. CORATO*[1], *A. DELLA CORTE*[1], *A. DI ZENOBIO*[1], *C. FIAMOZZI ZIGNANI*[1], *L. MUZZI*[1], *D. BOSO*[2]; [1]ENEA, [2]PADOVA UNIVERSITY. — IT IS NOW A MATTER OF FACT THAT PARAMETERS SUCH AS CABLE TWIST PITCH (TP) AND VOID FRACTION (VF) HAVE A STRONG IMPACT ON CABLE-IN-CONDUIT CONDUCTOR PERFORMANCES. A PROPER CHOICE OF THEIR VALUES IN THE DIRECTION OF RAISING THE FORMER (TP) AND LOWERING THE LATTER (VF) HAS BEEN PROVED TO CONSIDERABLY ENHANCE THE TRANSPORT PROPERTIES, THOUGH INCREASING THE AC LOSSES, AND TO APPRECIABLY REDUCE THE CONDUCTOR DEGRADATION WITH ELECTROMAGNETIC AND THERMAL LOADING CYCLES. IT HAS BEEN ALSO DEMONSTRATED THAT A FURTHER ROUTE FOR CICCS PERFORMANCE IMPROVEMENT IS REPRESENTED BY A SUITABLE OPTIMIZATION OF THE CONDUCTOR SHAPE WITH RESPECT TO THE ELECTROMAGNETIC FORCE DISTRIBUTION. IN THIS SENSE, CIC CONDUCTORS WITH HIGH ASPECT RATIO RECTANGULAR GEOMETRY, IF PROPERLY ORIENTED, HAVE SHOWN A BETTER RESPONSE TO HIGH ELECTROMAGNETIC PRESSURE, AS PROVED BY EXPERIMENTAL EVIDENCES.IN THIS PAPER, THE TEST RESULTS OF SOME RECTANGULAR NB3SN CIC CONDUCTORS ARE INTERPRETED BY MEANS OF FEM MECHANICAL ANALYSIS. THIS IS INTENDED TO CLARIFY THE ROLE OF THE CONDUCTOR CROSS-SECTION GEOMETRY ON THE ELECTROMAGNETIC LOAD SHARING AMONG THE STRANDS AND/OR ON THE CABLE STIFFNESS, AND THUS ON THE STRAIN DISTRIBUTION OVER THE CABLE WIRES.

2LP2A-06

A POSSIBLE SOLUTION FOR THE INTER-PANCAKE JOINTS OF THE JT-60SA TF COILS ***A. DI ZENOBIO***, *L. AFFINITO, U. BESI VETRELLA, G. BROLATTI, S. CHIARELLI, V. CORATO, A. CUCCHIARO, G. DE MARZI, A. DELLA CORTE, C. FIAMOZZI ZIGNANI, R. FREDA, G. GIORGI, F. MAIERNA, G. MESSINA, L. MUZZI, M. NAPOLITANO, E. PEDRUZZI, A. PIZZUTO, G. POLLI, L. RECCIA, S. TURTÙ;* ENEA. — IN THE FRAMEWORK OF THE BROADER APPROACH ACTIVITIES, THE DESIGN OF THE SUPERCONDUCTING TF COILS FOR THE JT-60SA TOKAMAK REACTOR IS CURRENTLY AT THE CONSTRUCTIVE DETAILS LEVEL. A SIGNIFICANT COMPONENT OF THE MAGNETS IS THE ELECTRICAL AND HYDRAULIC JOINT BETWEEN THE ADJACENT DOUBLE PANCAKES. SUCH A JUNCTION, BETWEEN TWO CABLE-IN-CONDUIT CONDUCTORS, SHALL OBVIOUSLY FULFILL PRECISE ELECTRICAL, MECHANICAL, AND THERMO-HYDRAULIC SPECIFICATIONS. BESIDE THE “TWIN-BOX” JOINT CONCEPT, CURRENTLY FORESEEN FOR SOME ITER COILS, TWO DIFFERENT DESIGNS ARE BEING TAKEN INTO CONSIDERATION: ONE ALREADY ADOPTED FOR THE W7-X REACTOR COILS, DESIGNED AND IMPLEMENTED BY THE ASG COMPANY, AND ANOTHER ONE ALREADY ADOPTED FOR THE EDIPO COIL, DEVELOPED AND PATENTED BY ENEA. IN ORDER TO ADAPT AND QUALIFY THE LATTER SOLUTION TO THE SPECIFIC JT-60SA CHARACTERISTICS, ENEA, IN AGREEMENT WITH THE EU JT-60SA HOME TEAM, DECIDED TO PRODUCE ONE PROTOTYPE AND TO TEST IT IN THE “12T CICC” FACILITY. A DISCUSSION ABOUT THE JOINT DESIGN, FEATURES AND POSSIBLE ARRANGEMENT IN THE COIL, PLUS THE TEST RESULTS, ARE HERE PRESENTED.

2LP2A-07

VIRTUAL TESTING OF NB3SN STRANDS FOR CIC CONDUCTORS ***D. P. BOSO***; UNIVERSITY OF PADOVA. — AN ACCURATE ESTIMATION OF THE STRAIN STATE OF A STRAND INSIDE A COIL IS A CRUCIAL POINT IN THE PREDICTION OF NB3SN CONDUCTOR PERFORMANCE, SINCE NB3SN STRANDS SHOW A STRAIN-DEPENDENCE OF THEIR CRITICAL PARAMETERS. TO PERFORM A NUMERICAL ANALYSIS OF A SUPERCONDUCTING COIL, IT WOULD BE IMPOSSIBLE TO OPERATE A SPATIAL

DISCRETIZATION FINE ENOUGH TO TAKE INTO CONSIDERATION EACH SINGLE MATERIAL. BY USING HOMOGENIZATION METHODS, THE STRAND - OR THE TRIPLET OR HIGHER ORDER BUNDLES - CAN BE SCHEMATIZED BY MEANS OF AN EQUIVALENT HOMOGENEOUS MATERIAL.THIS PAPER SHOWS THE RESULTS OF A LONG LASTING RESEARCH EFFORT DEVOTED TO NUMERICAL SIMULATION OF SUPERCONDUCTING STRANDS. THE HOMOGENIZATION METHOD KNOWN AS "VIRTUAL TESTING" IS PRESENTED IN DETAIL, FOR THE LINEAR AND NON LINEAR CASE. THE EQUIVALENT HOMOGENIZED PROPERTIES OF SEVERAL ITER RELEVANT WIRES ARE REPORTED, FOR THE MECHANICAL AND THE THERMAL FIELD. TO VALIDATE THE METHOD, HOMOGENIZATION RESULTS ARE FINALLY COMPARED WITH AVAILABLE EXPERIMENTAL TESTS.

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2LP2B-01

TEST RESULTS OF TWO ITER POLOIDAL FIELD CONDUCTOR SAMPLES IN SULTAN ***P. BRUZZONE***[1], *B. STEPANOV*[1], *R. WESCHE*[1], *S. TURTÙ*[2], *V. CORATO*[2], *A. DEVRED*[3], *D. BESSETTE*[3], *A. VOSTNER*[3], *T. BOUTBOUL*[4], *S. LELEKHOV*[5], *Y. WU*[6]; [1]EPFL-CRPP, [2]ENEA, [3]ITER, [4]F4E, [5]KURCHATOV INSTITUTE, [6]ASIPP. — THE SUPERCONDUCTORS FOR THE POLOIDAL FIELD COILS OF ITER ARE LARGE CABLE-IN-CONDUIT CONDUCTORS (CICC) OF NBTI STRANDS ENCASED IN A ROUND-IN-SQUARE STEEL JACKET. TWO PROTOTYPE CONDUCTORS FOR PF1 AND PF2 COILS RESPECTIVELY HAVE BEEN TESTED IN SULTAN AT THE NOMINAL OPERATING CONDITIONS.THE TEST AIMS TO CHARACTERIZE THE DC AND AC BEHAVIOUR OF THE CONDUCTORS. THE DC TEST IS FOCUSSED ON THE CURRENT SHARING TEMPERATURE AT THE NOMINAL CURRENT AND BACKGROUND OPERATING FIELD. THE TAKE-OFF ELECTRIC FIELD AT THE NOMINAL MASS FLOW RATE IS INVESTIGATED VERSUS THE CABLE CURRENT DENSITY OVER A BROAD RANGE OF FIELD AND TEMPERATURE. THE THRESHOLD FOR THE OCCURRENCE OF SELF-FIELD INSTABILITIES IS COMPARED WITH THE FORECAST BASED ON FORMER TESTS OF LARGE NBTI CICC'S.THE AC LOSS TEST INCLUDES ALSO A NUMBER OF LOAD CYCLES AND THE IMPACT OF CYCLIC LOADS ON THE COUPLING CURRENTS CONSTANT OF THE CABLE. BESIDE THE SINUSOIDAL FIELD SWEEP, SOME SEQUENCE OF FIELD CHANGE TYPICAL OF PLASMA CONTROL ACTION IS REPRODUCED AND THE AC LOSS IS MEASURED.FROM THE TEST RESULTS IN SULTAN, THE MARGINS IN NORMAL OPERATION AND THE LIMITS OF THE OPERATION RANGE OF THE ITER PF CONDUCTOR ARE ASSESSED.

2LP2B-02

FROM DESIGN TO DEVELOPMENT PHASE OF THE ITER CORRECTION COILS ***A. FOUSSAT***[1], *N. DOLGETTA*[1], *C. JONG*[1], *P. LIBEYRE*[1], *N. MITCHELL*[1], *W. WU*[2], *L. LIU*[2], *S. DU*[2], *X. LIU*[2], *X. YU*[2], *S. HAN*[2], *J. WEI*[2], *Y. SONG*[2]; [1]ITER ORGANIZATION, [2]ACADEMY OF SCIENCE INSTITUTE OF PLASMA PHYSICS. — THE CORRECTION COILS SYSTEM (CC) WITHIN THE INTERNATIONAL THERMONUCLEAR EXPERIMENTAL REACTOR, ITER, IS INTENDED TO REDUCE THE RANGE OF MAGNETIC ERROR FIELDS CREATED BY ASSEMBLY OR GEOMETRICAL IMPERFECTIONS OF THE OTHER COILS USED TO CONFINE, HEAT, AND SHAPE THE PLASMA. THE PROPOSED MAGNET SYSTEM CONSISTS OF THREE SETS OF 6 COILS EACH, LOCATED AT THE TOP (TCC), SIDE (SCC) AND BOTTOM (BCC) OF THE TOKAMAK DEVICE AND USES A NBTI CABLE-IN-CONDUIT SUPERCONDUCTING CONDUCTOR (CICC) OPERATING AT 4.2 K. THE ITER ORGANIZATION (IO) AND THE INSTITUTE OF PLASMA PHYSICS AT THE CHINESE ACADEMY OF SCIENCES (ASIPP) ARE JOINTLY PREPARING THE UPCOMING QUALIFICATION PROGRAM FOR THE CORRECTION COILS. THE PROPOSED DESIGN CONSISTS OF A ONE IN HAND CONDUCTOR WINDING WITHOUT INTERNAL JOINT INSERTED IN A STRUCTURAL CASING WHICH REACTS THE ELECTROMAGNETIC LOADS. THE DEVELOPMENT OF MAJOR ITEMS SUCH AS TERMINAL JOINTS, CASING MANUFACTURE, AND VACUUM IMPREGNATION SYSTEM, IS AN ESSENTIAL PHASE BEFORE THE SERIES PRODUCTION AND BOTH WILL TAKE PLACE AT ASIPP. THIS PAPER DISCUSSES THE KEY TECHNOLOGIES ON CC COILS AND FUTURE PLANS FOR SHORT SAMPLE PROTOTYPES FABRICATION.

2LP2B-03

TRANSIENT THERMAL AND FLOW-DYNAMIC ANALYSIS OF ITER MAGNET SYSTEM ON BASIS OF VINCENTA NUMERICAL CODE *V. BELYAKOV*[1], *D. BESSETTE*[2], ***I. GORNIKEL***[3], *V. KALININ*[1], *M. KAPARKOVA*[1], *N. MITCHELL*[2], *D. SHATIL*[1], *N. SHATIL*[1], *S. SYCHEVSKYI*[1], *V. VASILIEV*[1]; [1]EFREMOV'S INSTITUTE, ST.PETERSBURG, RUSSIA, [2]ITER ORGANIZATION, CADARACHE, FRANCE, [3]ALPHYSICA, INC.. — LARGE PULSED HEAT LOADS ARE DEPOSITED IN CICC CONDUCTORS AND STRUCTURES OF THE ITER MAGNET SYSTEM DUE TO VARIATIONS OF ELECTROMAGNETIC FIELDS AND NEUTRON PRODUCTION DURING EACH PLASMA PULSE. LOCAL CICC TEMPERATURES ARE GREATLY DEPENDANT ON TIME EVOLUTION OF PULSED HEAT LOADS, THEIR NON-UNIFORM DISTRIBUTION ALONG CICC AND THERMAL CONDUCTIVITY BETWEEN THE STRUCTURES AND WINDING. COMPLEX THERMAL HYDRAULIC (TH) ANALYSIS WAS A HIGH DEMAND FOR OPTIMIZATION OF THE ITER MAGNETS AND CRYOGENICS. DEVELOPMENT OF VINCENTA TH NUMERICAL MODELS OF THE ITER MAGNETS WAS STARTED IN 1995. THE CODE WAS THOROUGHLY VALIDATED ON THE BASIS OF CSMC EXPERIMENTS WITH POWERFUL TRAPEZOIDAL HEAT PULSES. THE MODELS WERE THEN UPGRADED TO GUARANTEE ACCURACY OF TRANSIENT TEMPERATURE MAPS FOR CS, TF AND PF COILS AND CLARIFY TRANSIENT OPERATING CONDITIONS OF THE ITER CRYOGENIC SYSTEM, INCLUDING ITS DESIGN TEMPERATURE. THE PAPER SUMMARIZES THE EXPERIENCE OF USING VINCENTA MODELS AND ILLUSTRATE TH ANALYSIS OF THE ITER MAGNETS FOR NOMINAL PLASMA SCENARIOS, PLASMA DISRUPTION CONDITIONS, RAPID EVACUATION OF HELIUM AT FAST ENERGY DISCHARGE OF TF COILS AND MITIGATION OF PULSED HEAT LOADS ON THE CRYOPLANT.

2LP2B-05

NUMERICAL SIMULATION OF CURRENT DISTRIBUTION IN CABLE-IN-CONDUIT CONDUCTOR FOR ITER TF COIL ***H. KAJITANI***[1], *H. UEDA*[1], *A. ISHIYAMA*[1], *H. MURAKAMI*[2], *N. KOIZUMI*[2], *K. OKUNO*[2]; [1]WASEDA UNIVERSITY, [2]JAEA. — THE CRITICAL CURRENT MEASUREMENT OF CABLE-IN-CONDUIT CONDUCTOR (CICC) FOR ITER TF COIL, WHICH CONSIST OF A PAIR OF SHORT AND STRAIGHT CICC ELECTRICALLY CONNECTED THROUGH THE JOINT, WERE PERFORMED USING SULTAN TEST FACILITY TO CONFIRM THAT THEY SATISFY THE SPECIFICATIONS. HOWEVER, IN ONE SAMPLE, THE CRITICAL CURRENT WAS LOWER THAN THE VALUE EXPECTED BASED ON THE CRITICAL CURRENT PERFORMANCE OF A SINGLE STRAND. ONE OF THE EXPLANATIONS OF THIS PHENOMENON IS A NON-UNIFORM CURRENT DISTRIBUTION DUE TO A NON-UNIFORM JOINT RESISTANCE. THIS MAKES A PRECISE EVALUATION OF PERFORMANCE OF CONDUCTOR DIFFICULT. THEREFORE, TO DEMONSTRATE THIS PHENOMENON AND INVESTIGATE AN INFLUENCE OF JOINT, WE DEVELOPED A NEW ANALYSIS MODEL: THE LUMPED CIRCUIT MODEL AND DISTRIBUTED CIRCUIT MODEL WERE USED FOR THE CONDUCTOR AND JOINT, RESPECTIVELY. IN THIS PAPER WE REPORTED THE VALIDATION OF OUR ANALYSIS MODEL BY COMPARING A SIMULATION RESULT WITH EXPERIMENT ONE AND THE RELATIVITY OF THE NON-UNIFORM CURRENT DISTRIBUTION AND THE CRITICAL CURRENT PERFORMANCE OF CONDUCTOR.

2LP2B-06

EVALUATION OF EFFECTIVE STRAIN AND *N*-VALUE OF ITER TF CONDUCTOR SAMPLES ***M. BRESCHI***[1], *D. BESSETTE*[2], *A. DEVRED*[2], *P. RIBANI*[1]; [1]UNIVERSITY OF BOLOGNA, [2]ITER I/O, CADARACHE, FRANCE. — THE ACCEPTANCE TESTS OF THE CABLE IN CONDUIT CONDUCTORS FOR THE TOROIDAL FIELD COILS OF THE ITER MAGNET SYSTEM ARE PRESENTLY BEING PERFORMED AT THE SULTAN FACILITY IN VILLIGEN, SWITZERLAND. THE MAIN PHYSICAL QUANTITY MEASURED IN THESE TESTS IS THE CURRENT SHARING TEMPERATURE, T_{CS}. IN T_{CS} MEASUREMENTS, THE *E-T* CHARACTERISTIC CURVE OF THE CONDUCTOR IS TRACED. THE ELECTRICAL CHARACTERISTIC OF EACH CABLE CAN BE COMPARED WITH THE CORRESPONDING ELECTRICAL CHARACTERISTIC OF ITS CONSTITUTING STRANDS. THIS WORK PRESENTS A MODEL TO EVALUATE AN EFFECTIVE VALUE OF THE STRAIN OF THE SUPERCONDUCTING NB_3SN STRANDS INSIDE THESE CABLES, UNDER THE SIMPLIFYING ASSUMPTIONS OF A UNIFORM STRAIN, CURRENT DENSITY AND TEMPERATURE DISTRIBUTION IN THE CABLE CROSS SECTION. THE COMPLETE 3D FIELD MAP OF THE MAGNETIC FIELD IN THE HIGH FIELD ZONE OF THE SULTAN FACILITY IS CONSIDERED FOR THE COMPUTATION OF THE LOCAL ELECTRIC FIELD DURING A T_{CS} TEST. A BEST FITTING PROCEDURE IS THEN APPLIED TO DETERMINE THE EFFECTIVE STRAIN AND *N*-VALUE OF EACH CONDUCTOR BY MINIMIZING THE RELATIVE ERROR BETWEEN COMPUTED AND EXPERIMENTAL RESULTS. THE EFFECT OF THE MAGNETIC FIELD 3D DISTRIBUTION ON THE STRAIN COMPUTED IS PRESENTED. THE VARIATIONS OF *N*-VALUE AND EFFECTIVE STRAIN WITH MECHANICAL CYCLING DURING A TYPICAL T_{CS} TEST CAMPAIGN ARE ALSO PRESENTED FOR VARIOUS CONDUCTOR SAMPLES TESTED RECENTLY.

2LP2B-08

WINDING SHOP OF THE PF1 COIL DOUBLE PANCAKES ***A. A. MEDNIKOV***[1], *I. Y. RODIN*[1], *A. V. PUGACHEV*[2], *S. A. EGOROV*[1]; [1]THE D.V. EFREMOV SCIENTIFIC RESEARCH INSTITUTE OF ELECTROPHYSICAL APPARATUS, [2]FORSS CONSULTING LTD. — THE POLOIDAL FIELD (PF) COILS ARE ONE FROM FOUR MAIN SUB-SYSTEMS OF THE ITER MAGNET. THE PF1 COIL - A CYLINDRICAL SOLENOID WITH EXTERNAL DIAMETER ~9M, HEIGHT ~1M AND WEIGHT ~200 TON - IS SUPPOSED TO BE WOUND IN RUSSIAN FEDERATION. THE SOLENOID IS COMPOSED OF STACKS OF EIGHT DOUBLE PANCAKES (DP). EACH DP IS WOUND WITH TWO-IN-HAND CONDUCTORS AND CONSISTS OF UPPER AND LOWER PANCAKES.THE PAPER PRESENTS THE AUTOMATICALLY CONTROLLED COMPLEX FOR TURN INSULATING AND WINDING OF PF1 COIL DOUBLE PANCAKES. KEY FEATURES OF THE COMPLEX ARE:• MOVABLENESS - THE COMPLEX CAN BE COMPLETELY DISMOUNTED AND MOUNTED A NEW WITHIN 1 MONTHS;• USING OF 18 ROLLERS SUPPORT, THAT IS MUCH CHEAPER AND EASIER IN SERVICE, THAN THE ROTARY BENDER;• TWO IN HAND WINDING BY THE SET OF AUTOMATICALLY CONTROLLED THREE ROLL BENDERS AND INSULATING MACHINES;• SYNCHRONIZATION OF ALL COMPLEX DEVICES BY THE PILOT BLOCK WITH USING OF THE NATIONAL INSTRUMENTS UNITS AND LAB VIEW SOFTWARE.THE COMPLEX IS PUT INTO OPERATION. THE RESULTS OF FIRST WINDING AND INSULATING TRIALS ARE PRESENTED.

2LP2B-09

EFFECT OF MASS FLOW RATE UNBALANCE ON THE INTERPRETATION OF T_{CS} MEASUREMENTS OF ITER TF SHORT SAMPLES ***L. SAVOLDI RICHARD***[1], *F. BELLINA*[2], *M. BRESCHI*[3], *P. RIBANI*[3], *F. SUBBA*[1], *R. ZANINO*[1]; [1]POLITECNICO DI TORINO, [2]UNIVERSITA' DI UDINE, [3]UNIVERSITA' DI BOLOGNA. — IN THE FRAME OF THE ITER PROJECT, SEVERAL SHORT TOROIDAL FIELD (TF) CONDUCTOR SAMPLES ARE BEING TESTED FOR DC CHARACTERIZATION IN THE SULTAN FACILITY AT PSI VILLIGEN, CH. THE STANDARD PROCEDURE OF THE CURRENT SHARING TEMPERATURE (T_{CS}) MEASUREMENTS OF THE SAMPLES IS BASED ON THE ASSUMPTION THAT TEMPERATURE AND MASS FLOW RATE ARE SUFFICIENTLY HOMOGENOUS ACROSS THE CONDUCTOR CROSS SECTION. THE JOINT OF THESE SAMPLES IS SOLDER-FILLED, SO THAT THE HELIUM COOLANT CAN ONLY FLOW INSIDE THE CENTRAL CHANNEL, WHICH IS HOWEVER PLUGGED IN THE HIGH FIELD REGION, ~ 40-45 MM DOWNSTREAM. THE HELIUM HAS THEN TO PASS FROM THE CENTRAL CHANNEL INTO THE ANNULAR CABLE REGION OVER SUCH A SHORT LENGTH THAT THE HOMOGENEITY OF THE FLOW DISTRIBUTION AMONG PETALS IS NOT GUARANTEED A PRIORI, IN VIEW OF THE INTERFERENCE BETWEEN THE DIFFERENT TWIST PITCHES OF PETALS, PETAL WRAPPINGS AND CENTRAL HELIX. IN THE PAPER WE FIRST PRESENT A PURELY GEOMETRICAL MODEL TO ESTIMATE THE MASS FLOW RATE DISTRIBUTION AMONG THE PETALS. THE LATTER IS THEN USED IN INPUT BY THE THELMA CODE, TO ASSESS THE INFLUENCE OF THESE THERMAL-HYDRAULIC INHOMOGENEITIES ON THE

INTERPRETATION OF ELECTRICAL AND CALORIMETRIC T_{CS} MEASUREMENTS.

2LP2B-10

TEST RESULT OF A FULL-SIZE NB3SN CONDUCTOR DEVELOPED FOR THE ITER TF COILS ***Y. NUNOYA***[1], *Y. NABARA*[1], *M. YOSHIKAWA*[1], *K. MATSUI*[1], *T. HEMMI*[1], *Y. TAKAHASHI*[1], *T. ISONO*[1], *N. KOIZUMI*[1], *H. NAKAJIMA*[1], *B. STEPANOV*[2], *P. BRUZZONE*[2]; [1]JAPAN ATOMIC ENERGY AGENCY, [2]ECOLE POLYTECHNIQUE FEDERALE DE LAUSANNE, CRPP FUSION TECHNOLOGY. — JAPAN ATOMIC ENERGY AGENCY (JAEA) HAS DEVELOPED ITER TF NB3SN CONDUCTORS THAT FULFILL ITER REQUIREMENTS AND THEN COMMENCED FABRICATING CONDUCTORS TO BE USED FOR ITER TF COILS. AS A QUALIFICATION OF CONDUCTOR FABRICATION, TWO FULL-SIZE CONDUCTOR SAMPLES NAMED AS JATF4 WERE PREPARED AND TESTED BY THE SULTAN FACILITY AT CRPP IN SWITZERLAND. THE LENGTH OF THE SAMPLES WAS ABOUT 3 M, AND TEMPERATURE SENSORS AND VOLTAGE TAPS WERE ATTACHED ON CONDUCTORS TO MEASURE THE CURRENT SHARING TEMPERATURE (TCS). THE MEASUREMENT WAS PERFORMED AT THE BEGINNING OF THE TEST CAMPAIGN, DURING CYCLIC TEST, AND AT THE END OF THE CAMPAIGN THAT CORRESPONDED TO AFTER ONCE WARM UP AND COOL DOWN. THE TCS VALUES ELECTRICALLY ASSESSED BY THE AGREED PROCEDURE AT OUTER MAGNETIC FIELDS OF 10.78 T WERE 6.5 K AND 6.2 K AT THE BEGINNING AND 6.1 K AND 6.0 K AT THE END OF THE CAMPAIGN FOR EACH CONDUCTOR, RESPECTIVELY. THESE VALUES CONCLUDED THAT THE CONDUCTORS HAVE ENOUGH TCS MARGIN TO SATISFY THE CRITERION OF 5.7 K AS ITER TF CONDUCTOR, AND CONDUCTOR FABRICATION IS QUALIFIED. DETAIL OF THE TEST RESULTS WILL BE PRESENTED AND DISCUSSED.

2LP2B-11

DEVELOPMENT OF THE ITER SUPERCONDUCTING MAGNET MANUFACTURING DATABASE ***K. SEO***, *F. SAVARY, J. KNASTER, R. GALLIX, C. CAPUANO, V. PATEL, M. GARDNER, N. MITCHELL;* ITER ORGANIZATION. — ITER SUPERCONDUCTING MAGNET MANUFACTURING DATABASE, MMD IS DESIGNED AND UNDER DEVELOPMENT. MMD IS NOT ONLY THE DATA ARCHIVE, BUT ALSO THE COMMON COMMUNICATION PLATFORM, ON WHICH CONTRIBUTORS TO THE MAGNET MANUFACTURING CAN COLLABORATE AND TAKE COORDINATED ACTIONS. A FEATURE OF THE ITER CONSTRUCTION IS IN-KIND PROCUREMENT. REGARDING THE MAGNET SYSTEM, 6 DOMESTIC AGENCIES IN EU, JAPAN, RUSSIA, U.S.A, KOREA, CHINA, AND BELONGING CONTRACTORS ARE INVOLVED. WHERE, THE MAGNET SYSTEM CONSISTS OF MANY COMPONENTS SUCH AS COILS, STRUCTURES, AND FEEDERS. QUALITY MONITORING AND CONTROL BY ITER ORGANIZATION, IO ARE THE CRITICAL, BECAUSE THE IO TAKES RESPONSIBILITY OF THE MACHINE EVEN EACH LARGE COMPONENT CAN NOT BE TESTED UNDER THE NOMINAL CONDITION BEFORE ITS ACCEPTANCE. HOWEVER, THE QUALITY MONITORING AND CONTROL FOR MANY CONTRIBUTORS WITH DIFFERENT CULTURES, QUALITY ASSURANCE SYSTEMS, LANGUAGES, ETC. ARE BIG CHALLENGES. MMD IS A WEB-BASE APPLICATION MAKING ALL CONTRIBUTORS ACCESS THE IO SERVER COMPUTER WITH OWN PRIVILEGES. THE USERS CAN UPLOAD AND BROWSE UPDATED MANUFACTURING STATUS, DRAWINGS, PROCEDURES, INSPECTION REPORTS ETC., AND COMMUNICATE INTERNATIONALLY BY WATCHING IDENTICAL SCREEN. FINALLY, STORED DATA IS AVAILABLE IN FUTURE SITE ASSEMBLING AND OPERATION PHASES. IN THIS PAPER, DESIGNS AND FUNCTIONALITIES OF MMD ARE PRESENTED.

2LP2C-02

STABILITY MARGIN OF NBTI CIC CONDUCTOR FOR JT-60SA EQUILIBRIUM FIELD COIL ***H. MURAKAMI***[1], *T. ICHIGE*[1], *K. KIZU*[1], *K. TSUCHIYA*[1], *K. YOSHIDA*[1], *T. OBANA*[2], *S. HAMAGUCHI*[2], *K. TAKAHATA*[2], *N. YANAGI*[2], *T. MITO*[2], *S. IMAGAWA*[2]; [1]JAPAN ATOMIC ENERGY AGENCY, [2]NATIONAL INSTITUTE FOR FUSION SCIENCE. — JT-60 SUPER ADVANCED (JT-60SA) MAGNETS SYSTEM CONSISTS OF 18 TOROIDAL FIELD (TF) COILS, 4 STACKS OF CENTRAL SOLENOID (CS) AND 6 PLASMA EQUILIBRIUM FIELD (EF) COILS. THE EF COIL CONDUCTORS ARE DESIGNED WITH NBTI CABLE IN CONDUIT (CIC) CONDUCTOR BECAUSE THE MAGNETIC FIELD OF EF COILS IS UP TO 4.8 T OR 6.2 T.THE FIRST EF CONDUCTOR WAS MANUFACTURED AND PROCESSED INTO THE PERFORMANCE VERIFICATION TEST SAMPLE. THE PERFORMANCE VERIFICATION TEST WAS CONDUCTED BY JAPAN ATOMIC ENERGY AGENCY (JAEA) AND NATIONAL INSTITUTE FOR FUSION SCIENCE (NIFS) AT THE NIFS FACILITY.THE CRITICAL CURRENT MEASUREMENT OF THIS SAMPLE WAS PERFORMED AND THE TEST RESULTS INDICATES THAT THE EF CONDUCTOR SATISFY THE SPECIFICATIONS. THE QUENCH TEST WAS ALSO CONDUCTED UNDER THE SEVERAL MAGNETIC FIELDS AND TEMPERATURES TO EVALUATE THE STABILITY MARGIN OF EF CONDUCTOR UNDER THE COIL OPERATION.IN THIS PAPER, WE DESCRIBED THE RESULTS OF PERFORMANCE VERIFICATION TEST: THE CRITICAL CURRENT AND THE MINIMUM QUENCH ENERGY OF THIS CONDUCTOR. WE ALSO ESTIMATE THE STABILITY MARGIN OF EF CONDUCTOR UNDER THE COIL OPERATION BASED ON THE QUENCH TEST AND THE THERMAL ANALYSIS.

2LP2C-03

INVESTIGATION OF AN OPTIMUM STRUCTURE FOR MECHANICAL BUTT JOINT OF A STACKED HTS CABLE WITH A METAL JACKET ***S. ITO***, *T. SAKASHITA, H. HASHIZUME;* TOHOKU UNIVERSITY. — A REMOUNTABLE HIGH-TEMPERATURE SUPERCONDUCTING (HTS) MAGNET WAS PROPOSED AS AN INNOVATIVE DESIGN OF A SUPERCONDUCTING MAGNET FOR A FUSION REACTOR. A SUPERCONDUCTING MAGNET IS CONSTRUCTED BY ASSEMBLING SOME SECTIONS OF THE MAGNET, WHICH CAN BE MOUNTED AND DEMOUNTED ITERATIVELY USING MECHANICAL JOINT. FOR THIS DESIGN, WE HAVE INVESTIGATED A MECHANICAL BUTT JOINT FOR A STACKED BSCCO 2223 CABLE WITH COPPER JACKET, WHERE THE CROSS-SECTION OF THE CABLE IS JOINTED MECHANICALLY. FROM OUR PREVIOUS STUDIES, CONTACT PRESSURE DISTRIBUTION AT JOINT SURFACE IS ONE OF THE DOMINANT FACTOR TO DETERMINE JOINT RESISTANCE.IN THIS STUDY, AT FIRST, STRUCTURAL ANALYSIS IS PERFORMED TO

INVESTIGATE JOINT STRUCTURE ACHIEVING RELATIVELY UNIFORM CONTACT PRESSURE DISTRIBUTION AT JOINT SURFACE. THEN, JOINT RESISTANCE IN MECHANICAL BUTT JOINT OF A STACKED BSCCO 2223 CABLE WITH COPPER JACKET IS EVALUATED EXPERIMENTALLY USING AN EXPERIMENTAL SET-UP ESTABLISHED BASED ON THE STRUCTURAL ANALYSIS, TO CONFIRM EFFECT OF DECREASING JOINT RESISTANCE BY THE JOINT STRUCTURE. FINALLY, WE DISCUSS APPLICABILITY THE MECHANICAL BUTT JOINT TO LARGE HTS CABLE WITH OBTAINED RESULTS.

2LP2C-04

EXPERIMENTAL EVALUATION OF THE INDUCTANCE AND ITS IMPACT ON THE QUENCH DETECTION OF KSTAR COILS ***H. YONEKAWA****, Y. CHU, Y. O. KIM, K. R. PARK, H. K. NA, M. KWON;* NATIONAL FUSION RESEARCH INSTITUTE. — THE INDUCTANCE OF SUPERCONDUCTING COILS IS ONE OF ESSENTIAL CHARACTERISTICS TO OPERATE THE COILS AND PROTECT THEM AGAINST QUENCH. THE SUPERCONDUCTING COILS OF THE KOREA SUPERCONDUCTING TOKAMAK ADVANCED RESEARCH (KSTAR) CONSIST OF SIXTEEN TOROIDAL FIELD (TF) COILS AND SEVEN PAIRS OF POLOIDAL FIELD (PF) COILS. THE JACKETS OF THE NB3SN CABLE-IN-CONDUIT CONDUCTORS (CICCS) OF ALL THE TF COILS AND PF1-PF5 COILS ARE MADE OF INCOLOY 908, WHICH EXHIBITS WEAK FERROMAGNETISM; ACCORDINGLY, THE INDUCTANCES OF THE KSTAR COILS MAY DYNAMICALLY AND PARTIALLY VARY DEPENDING ON A MAGNETIC FIELD TO WHICH THEY ARE EXPOSED. A BALANCE BRIDGE METHOD TO CANCEL OUT AN INDUCED VOLTAGE ON COILS IS IMPLEMENTED IN APPROXIMATELY HALF THE QUENCH DETECTORS OF THE KSTAR COILS; THEREFORE, THE INFLUENCE OF THE INDUCTANCE VARIATION ON THE QUENCH DETECTION IS ONE OF THE NECESSARY MATTERS FOR THE KSTAR COILS. ALONG THE KSTAR 2ND CAMPAIGN IN 2009, THE INDUCTANCE OF THE KSTAR COILS WAS EVALUATED ON THEIR MEASURED VOLTAGE AND CURRENT; IN ADDITION, THE OPERATION OF THE QUENCH DETECTORS WAS CONTINUOUSLY MONITORED AND ARCHIVED INTO A DATABASE. IN THIS PAPER, THE EXPERIMENTAL EVALUATION OF THE INDUCTANCE AND THE IMPACT OF THE INDUCTANCE VARIATION ON THE QUENCH DETECTION OF THE KSTAR COILS IS DISCUSSED.

2LP2C-05

REVIEW AND EXPERIMENTAL VERIFICATION ON THE DESIGN OF THE STABILITY AND PROTECTION OF THE KSTAR TF MAGNET ***Y. CHU****, Y. KIM, H. YONEKAWA, S. PARK, H. LEE, K. PARK, H. NA;* NATIONAL FUSION RESEARCH INSTITUTE. — DURING THE OPERATION OF THE KOREA SUPERCONDUCTING TOKAMAK ADVANCED RESEARCH (KSTAR), THERE EXIST VARIOUS DISTURBANCES WHICH CAUSE THE MAGNET CONDUCTORS TO BECOME UNSTABLE. THE KSTAR TOROIDAL MAGNET (TF) MAGNET SYSTEM WAS DESIGNED TO SECURE THE SUFFICIENT STABILITY AGAINST VARIOUS DISTURBANCES. THE STABILITY ANALYSIS INDICATED THAT THE ENERGY MARGIN OF THE TF CABLE-IN-CONDUIT (CIC) CONDUCTOR WAS SUFFICIENTLY HIGH SO THAT THE EXPECTED DISTURBANCES COULD NOT CAUSE THE CONDUCTOR TO QUENCH. DURING THE 2ND KSTAR CAMPAIGN, THE CRYOGENIC STABILITY OF THE TF MAGNET SYSTEM WAS ANALYZED BY ENERGIZING IT UP TO 36 KA, WHICH IS A BIT HIGHER THAN THE DESIGNED CURRENT OF 35.2 KA. THE TEMPERATURE INCREASE MEASURED AT HELIUM OUTLETS WAS LESS THAN 0.1 K AND THE MECHANICAL DEFORMATION WAS ABOUT 20 % OF THE YIELD STRENGTH OF THE TF STRUCTURE AT THE CRYOGENIC TEMPERATURE. THE QUENCH ANALYSIS WAS CARRIED OUT TO VALIDATE THE DESIGN OF THE PRESENT TF CIC CONDUCTOR FROM THE MAGNET PROTECTION'S POINT OF VIEW. IN THIS PAPER, THE DESIGN FOR THE CRYOGENIC STABILITY AND QUENCH PROTECTION FOR THE TF MAGNET SYSTEM WAS REVIEWED AND VERIFIED FROM THE RESULTS ARCHIVED DURING THE 2ND KSTAR CAMPAIGN IN 2009.

2LP2C-06

HYDRAULIC BEHAVIOR OF RECTANGULAR CABLE-IN-CONDUIT CONDUCTOR FOR KSTAR SUPERCONDUCTING MAGNET SYSTEM ***S. PARK****, Y. CHU, H. YONEKAWA, Y. KIM, K. KIM, I. WOO, W. HAN, J. HONG, K. PARK, H. NA, M. KWON;* NATIONAL FUSION RESEARCH INSTITUTE. — KSTAR (KOREA SUPERCONDUCTING TOKAMAK ADVANCED RESEARCH) HAS BEEN OPERATED SINCE 2008 AND 2ND CAMPAIGN WAS SUCCESSFULLY COMPLETED IN DECEMBER 2009. THE CONDUCTOR FOR KSTAR MAGNET SYSTEM IS A RECTANGULAR CABLE-IN-CONDUIT CONDUCTOR (CICC) WITHOUT CENTRAL HOLE FOR HELIUM COOLANT. IN TF COIL, WE ACHIEVED THE MAXIMUM CURRENT OF 36 KA WHICH EXCEEDED OUR DESIGN REQUIREMENT. IT MEANS KSTAR SUPERCONDUCTING MAGNET SYSTEM IS WELL MANUFACTURED AND IS POSSIBLE TO OPERATE STABLY IN REAL EXPERIMENTS.BEFORE PLASMA OPERATION, WE CARRIED OUT SEVERAL BASIC TESTS OF SUPERCONDUCTING COILS NOT ONLY CRYOGENIC TEMPERATURE BUT ALSO ROOM TEMPERATURE. DURING WHOLE TESTS AND OPERATIONS, THE HYDRAULIC CHARACTERISTICS AND BEHAVIOR LIKE PRESSURE DROP THROUGH HELIUM CROSS SECTION AREA BETWEEN COOLING CHANNELS, THE FRICTION FACTOR WHICH IS A REPRESENTATIVE PARAMETER TO CONFIRM THE STATUS IN CICC AND COOLANT MOVEMENT WERE MEASURED AND CALCULATED. WE CAN ALSO FIND OUT THE CHANGE OR CONSISTENCY OF THESE PROPERTIES BY TRACKING ACCORDING TO THE TIME AND CONDITION. IF WE KNOW THE HYDRAULIC BEHAVIOR OF CICC, WE CAN EASILY APPROACH THE ESTIMATION OF HEAT TRANSFER BETWEEN COIL AND STRUCTURE, AC LOSS, STRUCTURAL STABILITY AND SO ON.IN THIS PAPER, WE COMPARE THE HYDRAULIC BEHAVIORS BETWEEN 1ST AND 2ND CAMPAIGN OF KSTAR AT FIRST AND THEN ATTEMPT TO ANALYSIS THE EFFECT OF CONTINUOUS AND REPEATABLE CURRENT CHARGING DURING OPERATION.

THIS WORK WAS SUPPORTED BY THE KOREAN MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY UNDER THE KSTAR PROJECT.

2LP2C-07

ANALYSIS OF REVERSAL FLOW PHENOMENON OF SUPERCRITICAL HELIUM DUE TO AC LOSS IN THE KSTAR PF

COIL AT LOW CURRENT ***H. LEE****, Y. PARK, Y. CHU, D. OH, N. SONG, H. PARK, H. YANG;* NATIONAL FUSION RESERCH CENTER. — THE KSTAR (KOREA SUPERCONDUCTING TOKAMAK ADVANCED RESEARCH) SUPERCONDUCTING COIL OF CICC (CABLE-IN-CONDUIT-CONDUCTOR) TYPE IS COOLED BY SUPERCRITICAL HELIUM AND IT EXPANDS TO THE BOTH SIDE OF HELIUM INLET AND OUTLET DUE TO GENERATED AC LOSSES WHEN THE CURRENT CHARGE.THE EXPANDED HELIUM IN THE INLET PART HAS INFLUENCE ON THE HELIUM DISTRIBUTION SYSTEM(HDS) ABOUT 10 M FAR FROM COIL FEED THRU. THIS PHENOMENON IS CAUSED BY BLOCK AS WELL AS REVERSAL OF THE HELIUM FLOW AND CAN BE SEEN DOMINANTLY AT PF1 COIL CHARGING EXPERIMENT IN SPITE OF LOW CURRENT DURING THE KSTAR SECOND CAMPAIGN. IN CASE OF NON ZERO CROSSING EXPERIMENT (+4 KA), TEMPERATURE, PRESSURE, AND MASS FLOW WAS SLIGHTLY CHANGED AT THE HDS, ON THE ORDER HAND, IN CASE OF ZERO CROSSING (± 4 KA), THESE VALUE WERE REMARKABLY CHANGED AND SPECIALLY THE MASS FLOW BLOCKED FOR A WHILE AND REPEATED COMPRESSION AND EXPANSION. FOR THE THERMAL-HYDRAULICS SIMULATION, THE COOLING CHANNEL GEOMETRY AND AC LOSSES WAS MODELED INCLUDING THE JACKET EDDY CURRENT LOSS BECAUSE THE EDDY CURRENT LOSS OF FABRICATED JACKET WITH INCOLOY 908 DOMINANTLY SHOWS AT LOW CURRENT. IN THIS PAPER, WE ESTIMATED THE BEHAVIOR OF HELIUM FLOW WITH CURRENT WAVE FORM OF PF COIL AND VERIFY THE AC LOSSES.

2LP2C-08

AC LOSS AND TEMPERATURE MARGIN OF CABLE-IN-CONDUIT CONDUCTORS FOR JT-60SA POLOIDAL FIELD COIL ***K. NAKAMURA****[1], T. MASUDA[1], K. NISHIMURA[1], T. TAKAO[1], H. MURAKAMI[2], K. YOSHIDA[2];* [1]SOPHIA UNIVERSITY, [2]JAPAN ATOMIC ENERGY AGENCY. — COUPLING CURRENT LOSS IN CABLE-IN-CONDUIT CONDUCTOR (CICC) IS ONE OF THE IMPORTANT PARAMETERS FOR STABILITY OF THE SUPERCONDUCTING COIL. ONE OF TECHNIQUES TO INCREASE STABILITY OF MULTI-STRANDED CABLES IS CABLE LAYOUT TO CONSIST OF THE SUPERCONDUCTING AND COPPER STRANDS IN THE CICC. NON COPPER RATIO CAUSES LOWER TEMPERATURE MARGIN OF THE CONDUCTOR.IN THIS STUDY, THREE KINDS OF THE CICC CONDUCTOR FOR JT-60SA POLOIDAL FILED COIL ARE EVALUATED: (1) A CABLE CONSISTS OF ONLY NBTI SUPERCONDUCTING STRANDS, (2) A CABLE CONSISTS OF NBTI SUPERCONDUCTING STRANDS AND PURE COPPER STRAND, (3) A CABLE CONSISTS OF NB_3SN SUPERCONDUCTING STRANDS AND PURE COPPER STRAND. WE MEASURED THE AC LOSS UNDER A TIME-VARYING EXTERNAL MAGNETIC FIELD. THE AC LOSS EXPERIMENT ON CICC SAMPLES WAS CARRIED OUT WITH A CALORIMETRIC METHOD.AS A RESULT, THE AC LOSS OF THE CONDUCTOR TO CONSIST OF THE SUPERCONDUCTING STRANDS AND COPPER STRANDS WAS SMALLER THAN THE CONDUCTOR TO CONSIST OF THE SUPERCONDUCTING STRANDS. IN THIS PAPER, WE DESCRIBE THE RELATION THE MEASURED AC LOSS AND THE TEMPERATURE MARGIN OF THE CONDUCTOR DURING PULSE OPERATION.

2LX-01

(INVITED) **ADVANCES IN WHOLE-BODY MRI MAGNETS** *T. COSMUS, M. DHAR, J. VAN DER KOIJK,* ***M. PARIZH****;* PHILIPS MEDICAL SYSTEMS. — MAGNET RESONANCE IMAGING (MRI) IS THE LARGEST COMMERCIAL APPLICATION OF SUPERCONDUCTIVITY. MRI IS A POWERFUL DIAGNOSTIC TOOL THAT THE MEDICAL COMMUNITY CONSIDERS AS A PROCEDURE OF CHOICE FOR VISUALIZATION OF A SOFT TISSUE INSIDE OF BONE STRUCTURE. SINCE INTRODUCTION IN THE EARLY 1980'S, MORE THAN TWENTY FIVE THOUSAND OF MRI SYSTEMS HAVE BEEN INSTALLED WORLDWIDE. THE RECENT DECADE HAVE MARKED A SUBSTANTIAL PROGRESS IN MRI MAGNETS AND SYSTEMS. THE 3.0-TESLA HORIZONTAL FIELD AND 1.0 TESLA VERTICAL FIELD OPEN WHOLE-BODY MRI SYSTEMS HAVE BECOME COMMERCIALLY AVAILABLE.THE SUPERCONDUCTING MAGNET IS THE LARGEST AND MOST EXPENSIVE COMPONENT OF THE MRI SYSTEM. THE MAGNET CONFIGURATION IS DETERMINED BY NUMEROUS COMPETING REQUIREMENTS INCLUDING OPTIMIZED FUNCTIONAL PERFORMANCE, PATIENT COMFORT, EASE OF SITTING IN HOSPITAL ENVIRONMENT, MINIMUM ACQUISITION AND LIFECYCLE COST INCLUDING SERVICE. ALL THESE FACTORS DRIVE THE MAGNET REQUIREMENTS SUCH AS INCREASED CENTER FIELD, MAXIMIZED UNIFORMITY VOLUME, MINIMIZED FIELD DECAY AND STRAY FIELD, THE MAGNET COMPACTNESS, LONG HELIUM REFILL PERIOD, AND OTHER FACTORS. ADVANCES IN THE CRYOGENIC TECHNOLOGY AND MAGNET DESIGN PRACTICE PROVIDE MEANS FOR DRAMATIC IMPROVEMENT IN THE MAGNET PERFORMANCE WHILE MEETING THE MARKET REQUIREMENT FOR CONTINUOUS SYSTEM COST REDUCTION.

2LX-02

BI-2223 INNERMOST COIL FOR 1.03 GHZ NMR MAGNET ***S. MATSUMOTO****, T. KIYOSHI[1], S. CHOI[1], [1], K. ZAITSU[2], T. HASE[2], T. MIYAZAKI[2], M. HAMADA[3], M. HOSONO[4], H. MAEDA[5];* [1]NATIONAL INSTITUTE FOR MATERIALS SCIENCE, [2]KOBE STEEL, LTD., [3]JAPAN SUPERCONDUCTOR TECHNOLOGY, INC., [4]JEOL LTD., [5]RIKEN. — USING HIGH-T_C SUPERCONDUCTORS (HTS) IS CONSIDERED TO BE THE ONLY SOLUTION TO DRAMATICALLY INCREASE THE HIGHEST FIELDS OF NMR MAGNETS BECAUSE OF THEIR HIGH CRITICAL FIELDS. WE HAVE SUCCESSFULLY DEMONSTRATED THAT A 500 MHZ HTS/LTS NMR SYSTEM WITH A BI-2223 INNERMOST COIL COULD BE USED FOR SOLUTION NMR IN A DRIVEN-MODE OPERATION. AS THE NEXT STEP, THE UPGRADE OF THE 920 MHZ NMR SYSTEM INSTALLED AT THE TSUKUBA MAGNET LABORATORY IS UNDERWAY. THE INNERMOST NB_3SN COIL WILL BE REPLACED BY A BI-2223 COIL. THE COIL WAS FABRICATED AS A LAYER-WOUND COIL USING FIVE BI-2223 CONDUCTORS REINFORCED WITH BRONZE TAPE. ITS WINDING INNER DIAMETER, OUTER DIAMETER, AND HEIGHT WERE 78.4 MM, 126.6 MM, AND 840 MM, RESPECTIVELY. THE TOTAL TURN NUMBER WAS 10,094. IT WILL BE CONNECTED IN SERIES WITH THE OUTER NB_3SN AND NBTI COILS AND GENERATE A FIELD OF 24.2 T (1.03 GHZ OF ^1H RESONANCE FREQUENCY) AT AN OPERATING CURRENT OF 244 A. THE OPERATION TEST IN A BACKUP FIELD OF 11 T IS SCHEDULED FOR THE SPRING OF 2010. AFTER THE TEST, THE

COIL WILL BE INSTALLED IN THE 1.03 GHZ NMR MAGNET. ITS COOLING AND OPERATION ARE SCHEDULED TO TAKE PLACE WITHIN FISCAL YEAR 2010.

THIS WORK HAS BEEN SUPPORTED BY SENTAN, JST.

2LX-03

STATUS OF THE NHMFL CICC MAGNET PROGRAM ***M. D. BIRD**, T. ADKINS, H. BAI, S. BOLE, K. CANTRELL, J. CHEN, I. R. DIXON, A. V. GAVRILIN, K. HAN, J. LU, T. A. PAINTER, K. D. SMITH, R. P. WALSH, H. W. WEIJERS, Y. ZHAI;* NHMFL - FSU. — THE NATIONAL HIGH MAGNETIC FIELD LABORATORY IS DEVELOPING MAGNETS USING CABLE-IN-CONDUIT CONDUCTOR (CICC) FOR HIGH-FIELD APPLICATIONS IN BOTH RESISTIVE-SUPERCONDUCTING HYBRID MAGNETS AND IN ALL-SUPERCONDUCTING MAGNETS. INTENDED APPLICATIONS ARE BOTH INTERNAL AND FOR INSTALLATION AT OTHER FACILITIES SUCH AS THE HELMHOLTZ CENTER BERLIN AND THE SPALLATION NEUTRON SOURCE. THE NHMFL MAGNET WILL HAVE A VERTICAL FIELD AND PROVIDE 36 T IN A 40-MM BORE WITH 1-PPM HOMOGENEITY OVER A 10-MM DIAMETER SPHERICAL VOLUME. THE HZB AND SNS VERSIONS WILL PROVIDE A HORIZONTAL FIELD IN A DOUBLE-CONICAL CONFIGURATION SUITABLE FOR NEUTRON-SCATTERING EXPERIMENTS. THE MAGNETS WILL USE COPIES OF THE SAME 20 KA NB_3SN CICC FOR THE SUPERCONDUCTING OUTSERT.. AN OVERVIEW OF THE INNOVATIONS AND PRESENT STATUS IS PRESENTED.

JOHN R. MILLER, ALESSANDRO BONITO OLIVA, PIERLUIGI BRUZZONE, NICOLAI MARTOVETSKY, JOE MINERVINI, JOEL SCHULTZ

2LX-04

SERIES-CONNECTED HYBRID OUTSERT COIL AND COLD MASS ENGINEERING DESIGN AND FABRICATION ***T. A. PAINTER**, S. BOLE, T. W. ADKINS, I. R. DIXON;* NHMFL. — THE NATIONAL HIGH MAGNETIC FIELD LABORATORY (NHMFL) HAS DESIGNED AND IS CONSTRUCTING A 20 KA, 36 T, HIGH-HOMOGENEITY (< 1 PPM) SERIES-CONNECTED HYBRID (SCH) MAGNET SYSTEM TO BE INSTALLED IN THE NHMFL USER FACILITY IN TALLAHASSEE, FL. THE SCH WILL CONNECT ELECTRICALLY IN SERIES A FLORIDA BITTER RESISTIVE COIL PRODUCING 24.5 T AND A NB_3SN CABLE-IN-CONDUIT (CIC) SUPERCONDUCTING OUTSERT COIL PRODUCING 11.5 T. THE CIC OUTSERT COIL IS AN 18-LAYER, 0.6 M INNER DIAMETER, 1.2 M OUTER DIAMETER AND 0.8 M HIGH SOLENOIDAL COIL USING THREE GRADES OF CONDUCTOR. EACH CIC CONDUCTOR GRADE HAS A DIFFERENT COMBINATION OF NB3SN/COPPER COMPOSITE AND PURE COPPER WIRE CABLE ENCASED IN A MODIFIED CHEMISTRY 316LN STAINLESS STEEL CONDUIT. THE OUTSERT WINDING PACK CURRENT DENSITIES RANGE FROM 42.6 A/MM^2 TO 62.5 A/MM^2. THIS PAPER PRESENTS SALIENT ENGINEERING DESIGN AND FABRICATION ISSUES OF THE SUPERCONDUCTING OUTSERT COIL.

2LX-05

A 22T COMPACT SUPERCONDUCTING MAGNET SYSTEM AT 4.2K WITH INTEGRATED BI-2212 SOLENOID INSERT COILS ***S. P. G. CHAPPELL**[1], Z. MELHEM[1], C. FRIEND[1], A. TWIN[1], Y. B. HUANG[1], H. P. MIAO[1], E. A. YOUNG[2], Y. YANG[2];* [1]OXFORD INSTRUMENTS, [2]UNIVERSITY OF SOUTHAMPTON. — WE HAVE PREVIOUSLY DEMONSTRATED FIELDS OF 22.5T AT 4.2K USING A 100MM HIGH, 14 LAYER WIND-AND-REACT BI2212 HTS INSERT SOLENOID OPERATING IN A WIDE-BORE LTS MAGNET BACKGROUND FIELD OF 20T. AS A SIGNIFICANT STEP TOWARDS REALIZATION OF COMMERCIAL HIGH FIELD MAGNETS WE NOW REPORT ON DEVELOPMENT OF A COMPACT SUPERCONDUCTING MAGNET SYSTEM WITH IMPROVED BI2212 INSERT COILS AND FOCUS ON HIGH FIELD QUENCH STABILITY AND SYSTEM INTEGRATION.FOR OPTIMAL HEAT TREATMENT, MECHANICAL SUPPORT AND PROTECTION FLEXIBILITY, TWO 6-LAYER CONCENTRIC 300MM LONG BI2212 HTS SOLENOIDS WERE COMBINED AND INTEGRATED INTO A 20T LTS SYSTEM. SYSTEMATIC TESTS WERE PERFORMED AT DIFFERENT LTS FIELDS (15, 18, 20T) AND HTS CURRENTS UP TO 50-90% IC. REPEATED CONTROLLED QUENCHES OF THE HTS COILS WERE INDUCED BY LOCALISED HEAT PULSES AND THE INTERPLAY OF HTS AND LTS SYSTEMS WAS STUDIED.THE HTS COILS WERE DEMONSTRATED TO BE SAFELY PROTECTED BY A SHUNT SYSTEM DESPITE SLOW PROPAGATION OF THE NORMAL ZONE. UPON THESE FORCED QUENCHES OF THE HTS COILS, THE LTS COILS WITHSTOOD RAPID FIELD CHANGE (UP TO 2T/S) WITHOUT DEVELOPING A SINGLE QUENCH EVENT. A PROTECTION-CONTROL PROCEDURE WAS TESTED SUCCESSFULLY TO PREVENT THE QUENCH OF THE LTS SYSTEM AT A HIGHER FIELD CHANGE RATE (>10T/S). IT WAS ALSO FOUND THAT THE QUENCH OF HTS COIL INDUCED BY THE QUENCH OF THE LTS SYSTEM COULD BE SAFELY MANAGED WITH THE SHUNT PROTECTION.

THIS PROJECT WAS SUPPORTED IN PART BY UK TECHNOLOGY STRATEGY BOARD.

2LX-06

LAYER-WOUND YBCO COILS FOR HIGH FIELD MAGNET APPLICATIONS ***U. P. TROCIEWITZ**[1], M. DALBAN-CANASSY[1], D. MYERS[1], P. NOYES[2], Y. VIOUCHKOV[2], H. W. WEIJERS[2], D. C. LARBALESTIER[1];* [1]APPLIED SUPERCONDUCTIVITY CENTER - NHMFL, [2]MAGNET SCIENCE & TECHNOLOGY - NHMFL. — THERE IS A RAPIDLY EVOLVING PULL FOR HIGH FIELD MAGNETS APPROACHING 30 T AND BEYOND IN RESEARCH AS WELL AS INDUSTRY. WITH LOW TEMPERATURE SUPERCONDUCTING MATERIALS REACHING THEIR PHYSICAL LIMIT IN HIGH FIELD MAGNET APPLICATIONS BEYOND FIELDS OF 23 T, THERE IS STRONG INTEREST IN EMPLOYING HTS CONDUCTORS TO FILL THAT NEED. HIGH FIELD MAGNET PROJECTS ARE CURRENTLY PURSUED AT SEVERAL PLACES INCLUDING THE NHMFL. CONSIDERING THE FACT THAT THIS IS A VERY YOUNG AND DEVELOPING TECHNOLOGY, SUBSTANTIAL R&D EFFORTS ARE NEEDED TO ESTABLISH AND ADVANCE IT. IN AN APPROACH TO EXPLORE AND UNDERSTAND THE TECHNOLOGICAL LIMITS OF CURRENT GENERATION YBCO COATED CONDUCTOR FOR HIGH FIELD MAGNET APPLICATIONS SEVERAL SMALL TEST SPIRALS AND COILS HAVE BEEN BUILT AT THE NHMFL AND CHARACTERIZED

IN FIELDS UP TO 31 T. MORE RECENTLY A SERIES OF LARGE DIAMETER LAYER WOUND COILS HAVE BEEN BUILT USING COATED CONDUCTOR BY SUPERPOWER THAT TESTED VERY SUCCESSFULLY AT HIGHEST STRESSES. HERE WE REPORT ON THE PROGRESS OF SMALL LAYER WOUND INSERT COILS TO REACH INTO THE 35 + T RANGE. FIELD GENERATION, POTENTIAL COIL DEGRADATION AND PERFORMANCE OF THE COIL TERMINALS WILL BE PRESENTED AND DISCUSSED.

2LY-01

(INVITED) **DEVELOPMENT AND DEPLOYMENT OF SATURATED-CORE FAULT CURRENT LIMITERS IN DISTRIBUTION AND TRANSMISSION SUBSTATIONS** *F. MORICONI, F. DE LA ROSA, F. DARMANN, A. NELSON,* ***L. MASUR****;* ZENERGY POWER. — SINCE 2006, ZENERGY POWER HAS BEEN DEVELOPING A SATURATED-CORE FAULT CURRENT LIMITER (FCL) FOR ELECTRIC POWER GRID APPLICATIONS. THE FCL EMPLOYS A MAGNETICALLY SATURATING REACTOR CONCEPT WHICH ACTS AS A VARIABLE INDUCTOR IN AN ELECTRIC CIRCUIT.IN THIS PAPER WE WILL REPORT ON THREE FCL PROJECTS CURRENTLY UNDERWAY. IN MARCH 2009 ZENERGY POWER, WITH FUNDING FROM THE CALIFORNIA ENERGY COMMISSION AND THE U.S. DEPARTMENT OF ENERGY (DOE), INSTALLED AN FCL IN THE AVANTI DISTRIBUTION CIRCUIT OF SOUTHERN CALIFORNIA EDISON'S SHANDIN SUBSTATION IN SAN BERNARDINO, CA. RATED AT 15 KV AND 1,250 AMPERES STEADY-STATE, THE "AVANTI" DEVICE IS THE FIRST SUPERCONDUCTOR FCL INSTALLED IN A US UTILITY. IN JANUARY 2010, THE "AVANTI" DEVICE SUCCESSFULLY LIMITED ITS FIRST SERIES OF REAL-WORLD FAULTS WHEN THE CIRCUIT EXPERIENCED MULTIPLE SINGLE-PHASE AND THREE-PHASE FAULTS. IN THIS PAPER WE WILL REVIEW THE PERFORMANCE TESTING OF THIS DEVICE, ITS OPERATING HISTORY, AND THE DETAILS OF THIS RECENT FAULT EVENT.WE WILL ALSO REVIEW THE DEVELOPMENT ACTIVITIES AND PROJECT DETAILS FOR THE INSTALLATION OF A 12 KV, 1,250 AMPERES "COMPACT" FCL IN THE CE ELECTRIC UK MALLEABLE SUBSTATION IN THE SECOND HALF OF 2010 AND THE INSTALLATION OF A 138 KV, 1,300 AMPERES FCL AT THE TIDD SUBSTATION OF AMERICAN ELECTRIC POWER IN LATE 2011.

ZENERGY POWER GRATEFULLY ACKNOWLEDGES FUNDING FROM THE CALIFORNIA ENERGY COMMISSION AND THE US DEPT. OF ENERGY

2LY-02

PERFORMANCE OF THE 35KV/90MVA SFCL IN LIVE-GRID FAULT CURRENT LIMITING TESTS ***Y. XIN***[1]*, H. HONG*[1]*, J. Z. WANG*[1]*, W. Z. GONG*[1]*, J. Y. ZHANG*[1]*, A. L. REN*[1]*, M. R. ZI*[2]*, Z. Q. QIONG*[2]*, D. J. SI*[2]*, F. YE*[2]*;* [1]INNOPOWER SUPERCONDUCTOR CABLE CO., LTD., [2]YUNNAN POWER GRID, CO.. — A 35KV/90MVA SATURATED IRON-CORE TYPE SUPERCONDUCTING FCL WAS DEVELOPED AND INSTALLED AT THE END OF 2007 IN A TRANSMISSION NETWORK AT PUJI SUBSTATION OF CHINA SOUTHERN POWER GRID. TO FULLY VERIFY ITS CURRENT LIMITING CAPACITY, CURRENT LIMITING TESTS WERE CONDUCTED IN LIVE-GRID UNDER ARTIFICIALLY IMPOSED SHORT-CIRCUIT CONDITIONS ON JULY 20, 2009. FIVE TESTS, INCLUDING A FAIL-SAFE TEST, WERE CARRIED OUT EITHER UNDER DIFFERENT GRID CONDITIONS OR WITH DIFFERENT OBJECTIVES. THE TESTING RESULTS VERIFY THAT THE FCL HAS A RELIABLE CURRENT LIMITING CAPABILITY AND ITS PERFORMANCE IS IN GOOD AGREEMENT WITH THE DESIGN EXPECTATIONS. THE RESULTS ALSO SHOW THAT THE DEVICE SATISFIES THE REQUIREMENTS OF GRID ROUTINE PROTECTIVE PROCEDURES. IN THIS PAPER, WE REPORT SOME DETAILS OF THESE TESTS AND THE RESULTANT DATA.

THIS WORK WAS SUPPORTED IN PART BY THE CHINESE MINISTRY OF SCIENCE AND TECHNOLOGY (GRANT NUMBER 2006AA03Z234) AND TIANJIN MUNICIPAL SCIENCE AND TECHNOLOGY COMMISSION (GRANT NUMBER 05FZZDGX00700).

2LY-03

QUENCH PERFORMANCE OF ASSEMBLIES AND MODULES BASED ON HTS COATED CONDUCTORS: FUNCTIONAL TESTS OF CURRENT LIMITATION AND RECOVERY AT FULL POWER ***A. USOSKIN***[1]*, F. MUMFORD*[2]*, A. HANDAZE*[1]*, B. LUKASIK*[2]*, A. RUTT*[1]*, K. SCHLENGA*[1]*, B. PRAUSE*[1]*, H. U. KLEIN*[3]*, D. KRISCHEL*[3]*;* [1]BRUKER HTS GMBH, [2]AREVA T&D TECHNOLOGY CENTRE IN STAFFORD, [3]BRUKER ASC GMBH. — STUDIES OF THE QUENCH PERFORMANCE OF THE SUPERCONDUCTING ELEMENTS BASED ON SPECIALLY DEVELOPED YBCO COATED CONDUCTORS (CC) FOR CURRENT LIMITER APPLICATIONS ARE REPORTED. A FUNCTIONALITY OF NEWLY DEVELOPED TAPE ASSEMBLIES BASED ON CCS WITH ENHANCED PERFORMANCE AT QUENCH CONDITIONS WAS RECENTLY INVESTIGATED IN THE COURSE OF FULL POWER TESTS.AN INDUCTIVE SHIELDED FAULT CURRENT LIMITER (ISFCL) BASED ON THESE TAPE ASSEMBLIES WAS DESIGNED AND TESTED (AT AREVA T&D, STAFFORD) AS A SINGLE MODULE OF A 13 MVA (2000 A, 6.4 KV) SINGLE-PHASE ISFCL. THE TESTS HAVE SHOWN THE FOLLOWING: (I) THE ISFCL MODULE LIMITED A PROSPECTIVE 68.5 KAPEAK FAULT TO 9 KAPEAK WITH EXTREMELY SMALL DELAY, (II) FAULT CURRENT AFTER FIVE CYCLES (BEFORE CIRCUIT BREAKER OPENING) WAS REDUCED BY A FACTOR OF 10, (III) THE ISFCL EXHIBITS FAST SELF-RECOVERY UNDER CURRENT LOAD AFTER A CIRCUIT FAULT; DURATION OF THIS "UNDER-PATIAL-LOAD" SELF-RECOVERY IS <200 MSEC, AND (IV) THE MODULE ALREADY WITHSTOOD A SUFFICIENT NUMBER OF LIMITATION SEQUENCES. EXPERIMENTAL DETAILS OF ISFCL TESTS AND PROSPECTS FOR INDUSTRIAL IMPLEMENTATION OF SUCH CURRENT LIMITING DEVICES ARE DISCUSSED.

THIS WORK IS SUPPORTED IN PART BY GERMAN MINISTRY OF ECONOMY AND TECHNOLOGY (BMWI), PROJECT NO. 0327456A.

2LY-04

SLIMFORMER - SELF-LIMITING TRANSFORMER PILOT PLANT DESIGN, CONSTRUCTION AND TESTS ***I. VAJDA***[1]*, A. HYDE*[2]*, A. GYORE*[1]*, G. NADOR*[3]*, T. TROLLIER*[4]*, B. SAILER*[5]*, R. BOHM*[6]*;* [1]BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS, [2]AREVA T&D TECHNOLOGY CENTRE, [3]CG ELECTRIC SYSTEMS HUNGARY ZRT., [4]AIR LIQUIDE ADVANCED TECHNOLOGIES,

[5]BRUKER HTS GMBH, [6]NEXANS SUPERCONDUCTORS GMBH. — THE CURRENT LIMITING OR SELF-LIMITING TRANSFORMER (SLIMFORMER, CLT) IS A MULTIFUNCTIONAL DEVICE, WHICH COMBINES THE FUNCTIONS OF A POWER TRANSFORMER WITH THE FUNCTIONS OF A CURRENT LIMITER. THE INVESTIGATED SLIMFORMER CONSISTS OF A ROOM TEMPERATURE PRIMARY WINDING AND A SECONDARY HIGH TEMPERATURE SUPERCONDUCTOR (HTS) WINDING (BSCCO 2223) DIVIDED INTO TWO PARTS LOCATED ON DIFFERENT LIMBS AND AN HTS RING (BSCCO 2212). THE PRIMARY WINDING IS CONNECTED TO THE NETWORK, THE SECONDARY WINDING IS INTENDED TO SUPPLY AN HTS CABLE. AS A RESULT THE SLIMFFORMER IS AN INDUCTIVE TERMINAL BETWEEN THE ROOM TEMPERATURE NETWORK AND A PROJECTED HTS CABLE. FOR INVESTIGATION OF THE SLIMFORMER A 100 KVA RATING EXPERIMENTAL DEVICE (PILOT PLANT) WAS DESIGNED, BUILT AND TESTED. THE DESIGN AND OPTIMIZATION ASPECTS AS WELL AS THE CONSTRUCTION OF THE PILOT PLANT WILL BE PRESENTED. THE PRESENT WORK IS BASED ON THE PREVIOUS 20 KVA SLIMFORMER PRE-PROTOTYPE DEVICE WHICH WAS TESTED AT BUTE LAB. THE SLIMFORMER WAS INVESTIGATED EXPERIMENTALLY FOR BOTH SUDDEN SHORT CIRCUIT AND STATIONARY (TRANSFORMER) OPERATIONAL MODES. THE ACTIVATION CURRENTS WERE DETERMINED FOR BOTH OPERATIONAL MODES WITH THE RATED SECONDARY WINDING TURN RATIO. SLIMFORMER WORK IS BEING PERFORMED AS PART OF AN EC FUNDED PROJECT.

THE AUTHORS ARE THANKFUL FOR DR. V. MEEROVICH AND V. SOKOLOVSKY (BEN GURION UNIVERSITY, ISRAEL) FOR THEIR VALUABLE CONTRIBUTIONS AS WELL AS FOR THE EC FOR FUNDING THE PROJECT NO.518310 (SES6).

2LY-05

CONSIDERATIONS ABOUT THE DESIGN OF AN INDUCTIVE-RESISTIVE ELEMENT FOR A MATRIX TYPE SFCL ***A. ALVAREZ****, P. SUÁREZ, J. M. CEBALLOS, B. PÉREZ;* UNIV. OF EXTREMADURA. — ONE OF THE MOST IMPORTANT PROBLEMS IN RESISTIVE SFCLS IS THE DAMAGE OF THE SUPERCONDUCTOR ELEMENT DUE TO THE INHOMOGENEITY OF THE THERMAL TRANSITION (QUENCH). SUCH A SITUATION STARTS AT A PARTICULAR POINT THAT BECOMES A HOT POINT THAT DESTROYS THE SUPERCONDUCTOR. IN THIS SENSE, INDUCTIVE SFCLS SHOW BETTER CHARACTERISTICS BECAUSE THE TRANSITION IS PRODUCED WHEN THE MAGNETIC FIELD IS HIGHER THAN THE CRITICAL MAGNETIC FIELD OF THE SUPERCONDUCTING SCREEN THAT IS LOCATED AROUND THE CORE OF THE REACTOR. THE ELEMENT STUDIED HERE IS PART OF A PROJECT DEVOTED TO THE STUDY, DESIGN, AND CONSTRUCTION OF A HYBRID SFCL THAT INTEGRATES, ADAPTS, AND IMPROVES THE FEATURES OF THE KNOWN MODELS, TRYING TO REDUCE BOTH CONSTRUCTION AND MAINTENANCE COSTS. WE HAVE STUDIED THE POSSIBILITY OF PRODUCING THE TRANSITION OF A RESISTIVE SFCL NOT BY MEANS OF THE TRANSPORT CURRENT, BUT BY PLACING THE RESISTIVE ELEMENT IN AN EXTERNAL MAGNETIC FIELD. THIS MUST BE HIGHER THAN THE CRITICAL MAGNETIC FIELD VALUE WHEN THE CURRENT REACHES ITS LIMIT VALUE, LOWER THAN THE CRITICAL CURRENT. THUS, THE TRANSITION OCCURS IN THE WHOLE ELEMENT AT THE SAME TIME. WE PROPOSE A MATRIX TYPE SFCL WHOSE ELEMENTS HAVE A RESISTIVE PART AND AN INDUCTIVE PART. THE MAGNETIC FIELD CREATED BY THE LATTER IS USED TO MAKE THE FORMER TRANSIT. RESULTS OF PARTIAL TESTS, AND CONCLUSIONS ABOUT THE DESIGN OF A MATRIX TYPE, INDUCTIVE-RESISTIVE SFCL ARE PRESENTED.

AUTHORS WISH TO ACKNOWLEDGE FINANCIAL SUPPORT FROM THE “MINISTERIO DE CIENCIA E INNOVACIÓN” OF THE GOVERNMENT OF SPAIN, BY MEANS OF THE PROJECT: ENE2007-67426

2LY-06

TESTS AND PERFORMANCE ANALYSIS OF CORELESS INDUCTIVE HTS FAULT CURRENT LIMITERS ***J. KOZAK****[1], M. MAJKA[1], T. JANOWSKI[2], S. KOZAK[1], G. WOJTASIEWICZ[1], B. KONDRATOWICZ-KUCEWICZ[1];* [1]ELECTROTECHNICAL INSTITUTE, [2]LUBLIN UNIVERSITY OF TECHNOLOGY. — SUPERCONDUCTING FAULT CURRENT LIMITERS (SFCL) ARE DESIGNED TO PROTECT THE ELECTRICAL GRID FROM FAULTS THAT RESULT FROM LIGHTNING STRIKES, DOWNED POWER LINES AND OTHER SYSTEM INTERRUPTIONS. THE RAPID INCREASE OF IMPEDANCE OF THE SFCL REDUCES THE SHORT CURRENT IN THE CIRCUIT. SEVERAL CORELESS CONSTRUCTIONS OF INDUCTIVE SFCLS HAVE BEEN TESTED. THE SPACE BETWEEN THE WINDINGS IS THE THICK OF THE POLYIMIDE FILM KAPTON INSULATION TO INCREASE THE COUPLING AND REDUCES THE LEAKAGE REACTANCE. BOTH PRIMARY AND SECONDARY WINDINGS HAVE BEEN IMMERSED IN LIQUID NITROGEN. THE PRESENTED SOLUTIONS REDUCE THE SIZE AND THE WEIGHT OF THE DEVICE. A FEW LIMITERS BASED ON HTS 1G AND HTS 2G TAPES HAS BEEN DESCRIBED, TESTED AND COMPARED.

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2LY-07

CURRENT LIMITING EXPERIMENT OF TRANSFORMER TYPE SUPERCONDUCTING FAULT CURRENT LIMITER WITH REWOUND STRUCTURE USING BSCCO WIRE IN SMALL MODEL POWER SYSTEM ***S. ODA****[1], S. NODA[1], H. NISHIOKA[2], M. MORI[2], J. BABA[2], Y. SHIRAI[1];* [1]KYOTO UNIVERSITY, [2]TOKYO UNIVERSITY. — SUPERCONDUCTING FAULT CURRENT LIMITERS (SCFCLS) ARE EXPECTED TO IMPROVE THE RELIABILITY AND STABILITY OF POWER SYSTEMS. SCFCLS CAN BE CLASSIFIED INTO A RESISTIVE CURRENT LIMITING (R-TYPE) AND AN INDUCTIVE CURRENT LIMITING (L-TYPE) DEPENDING ON THE LIMITING IMPEDANCE. WE HAVE PROPOSED NEW DESIGN OF A TRANSFORMER TYPE SCFCL WHOSE PRIMARY AND SECONDARY SUPERCONDUCTING COIL HAS REWOUND STRUCTURE. THE PRIMARY COIL IS CONNECTED TO A POWER LINE. THE SECONDARY COIL IS SHORT-CIRCUITED AND HAS LESS TURNS THAN THE PRIMARY COIL. THE FUNDAMENTAL CHARACTERISTICS OF THE PROPOSED SCFCL WERE INVESTIGATED USING A SMALL MODEL DESIGNED AND MADE WITH BSCCO WIRE.THIS PAPER DESCRIBES ON THE POWER SYSTEM CHARACTERISTICS OF THE PROPOSED SCFCL WITH

REWOUND STRUCTURE. THE BASIC EXPERIMENTS WERE CARRIED OUT BY USE OF THE MODEL SCFCL IN A LABORATORY SCALE POWER SYSTEM (ONE-MACHINE AND INFINITE BUS SYSTEM). IT WAS CONFIRMED THAT THE PROPOSED SCFCL SUCCESSFULLY LIMITED THE FAULT CURRENT AND SUPPRESSED THE VOLTAGE DROP OF THE GENERATOR AND RECOVERED QUICKLY EVEN IN REPETITIVE LIMITING OPERATION. FOR SMALL FAULT CURRENT, ONLY THE SECONDARY COIL CURRENT EXCEEDED ITS CRITICAL CURRENT AND THE SCFCL WORKED AS L-TYPE ONE. FOR LARGER FAULT CURRENT, THE PRIMARY COIL CURRENT ALSO EXCEEDED ITS CRITICAL CURRENT AND THE RESISTIVE COMPONENT APPEARED. THE SCFCL REDUCED THE FAULT CURRENT MORE BY THE ADDITIONAL RESISTANCE (L+R-TYPE).

2LZ-01

OPERATION AND TEST RESULTS FROM THE SULTAN TEST FACILITY ***P. BRUZZONE****, B. STEPANOV, R. WESCHE, M. BAGNASCO, R. HERZOG, C. CALZOLAIO, M. VOGEL;* EPFL-CRPP. — THE LAST YEAR OF ITER CONDUCTOR TEST IN SULTAN HAS SEEN THE COMPLETION OF THE TOROIDAL FIELD (TF) CONDUCTOR QUALIFICATION PHASE AND THE START OF THE CONDUCTOR QUALIFICATION FOR THE CENTRAL SOLENOID (CS) AND POLOIDAL FIELD (PF) CONDUCTORS. TWO NON-ITER CONDUCTOR SAMPLES ARE ALSO TESTED IN THE SAME PERIOD.BESIDE A SUMMARY OF THE RESULTS FOR ALL THE SAMPLES TESTED IN THE LAST 12 MONTHS, AN UPDATED STATISTICS IS PRESENTED FOR THE V-I AND V-T CHARACTERISTICS OF THE CABLE-IN-CONDUIT CONDUCTORS (CICC), INCLUDING NB3SN AND NBTI SAMPLES ASSEMBLED WITH EITHER A “BOTTOM JOINT” OR A “U-BEND”.THE CYCLIC LOAD RATE HAS BEEN ENHANCED WITH THE FIRST CS CONDUCTOR SAMPLE. THE CURRENT METER BY HALL SENSORS HAS BEEN BENCH MARKED VERSUS A CRYOGENIC SHUNT RESISTOR DESIGNED, MANUFACTURED AND CALIBRATED AT CRPP. THE THERMAL GRADIENT OVER A CONDUCTOR CROSS SECTION DURING COOL-DOWN AND WARM-UP HAS BEEN MEASURED WITH DEDICATED INSTRUMENTATION.IN THE LAST 12 MONTHS, LONG OPERATION BREAKS OF THE SULTAN FACILITY OCCURRED BECAUSE OF THE DISCONTINUOUS SUPPLY OF CONDUCTORS TO BE TESTED. THE BREAKS HAVE BEEN USED TO PROGRESS WITH THE INSTALLATION OF THE EDIPO TEST FACILITY IN THE SULTAN HALL.

2LZ-02

FAST: CONCEPTUAL DESIGN FOR A COMPLETELY SUPERCONDUCTING MAGNET SYSTEM ***A. DI ZENOBIO****, A. DELLA CORTE, L. MUZZI, G. POLLI, L. RECCIA, S. TURTÙ, F. CRISANTI, A. CUCCHIARO, A. PIZZUTO, R. VILLARI;* ENEA. — FAST (FUSION ADVANCED STUDIES TORUS), THE ITALIAN PROPOSAL OF A SATELLITE FACILITY TO ITER, IS A COMPACT TOKAMAK (R0= 1.82M, A = 0.64M, TRIANGULARITY Δ = 0.4) ABLE TO INVESTIGATE NON LINEAR DYNAMICS EFFECTS OF ALPHA-PARTICLE BEHAVIOR IN BURNING PLASMAS AND TO TEST TECHNICAL SOLUTIONS FOR THE FIRST WALL/DIVERTOR DIRECTLY RELEVANT FOR ITER AND DEMO (E.G.: FULL-TUNGSTEN WALL AND DIVERTOR AND ADVANCED LIQUID METAL DIVERTOR). THE MACHINE IS DESIGNED TO OPERATE WITH DEUTERIUM PLASMAS IN A DIMENSIONLESS PARAMETER RANGE CLOSE TO THAT OF ITER AND TO ACCESS ADVANCED TOKAMAK REGIMES WITH LONG PULSE DURATION WITH RESPECT TO THE CURRENT DIFFUSION TIME. IT FORESEES A MAXIMUM MAGNETIC FIELD ON PLASMA AXIS OF 8.5T AND A MAXIMUM PLASMA CURRENT OF 8 MA. IN THE PRESENT DESIGN PHASE, THE FEASIBILITY OF A SUPERCONDUCTING SOLUTION FOR THE MAGNET SYSTEM IS BEING INVESTIGATED BY ENEA. IT CONSISTS OF 18 TOROIDAL FIELD, 6 POLOIDAL FIELD AND 6 CENTRAL SOLENOID MODULE COILS, ALL OF WHICH WOUND BY NB3SN AND NBTI CABLE-IN-CONDUIT CONDUCTORS (CICCS). ALL THE MAIN ASPECTS DRIVING THE MAGNETS’ DESIGN, FROM MECHANICAL TO NEUTRONIC AND THERMAL ANALYSES, ARE HERE PRESENTED AND DISCUSSED.

2LZ-03

(INVITED) **DESIGN OF JT-60SA MAGNETS AND ASSOCIATED EXPERIMENTAL VALIDATIONS** ***L. ZANI***[1]*, P. BARABASCHI*[1]*, M. PEYROT*[1]*, L. MEUNIER*[1]*, V. TOMARCHIO*[1]*, D. DUGLUE*[1]*, P. DECOOL*[2]*, A. TORRE*[2]*, J. MARECHAL*[2]*, A. DI ZENOBIO*[3]*, L. MUZZI*[3]*, A. CUCCHIARO*[3]*, S. TURTU*[3]*, S. ISHIDA*[4]*, K. YOSHIDA*[4]*, K. TSUCHIYA*[4]*, K. KIZU*[4]*, H. MURAKAMI*[4]*;* [1]FUSION FOR ENERGY, [2]ASSOCIATION EURATOM-CEA, [3]ASSOCIATION EURATOM-ENEA, [4]JAEA. — IN THE FRAMEWORK OF THE JT-60SA PROJECT, AIMING AT UPGRADING THE PRESENT JT-60U TOKAMAK TOWARD A FULLY SUPERCONDUCTING SET-UP, LEADING TO ADOPT FOR THE THREE MAIN MAGNET SYSTEMS A BRAND NEW DESIGN. EU IS EXPECTED TO PROVIDE TO JA THE TOTALITY OF THE TOROIDAL FIELD (TF) MAGNET SYSTEM, WHILE JA WILL PROVIDE BOTH EQUILIBRIUM FIELD (EF) AND CENTRAL SOLENOID (CS) SYSTEMS. ALL MAGNET DESIGNS WERE DESIGN-OPTIMISED TROUGH THE PAST YEARS AND ENTERED INTO EXTENSIVE EXPERIMENTALLY-BASED PHASES OF CONCEPT VALIDATION, WHICH CAME TO MATURATION IN THE YEARS 2009 AND 2010. FOR THIS, ALL MAGNET SYSTEM WERE INVESTIGATED BY MEAN OF DEDICATED SAMPLES, E.G. CONDUCTOR AND JOINT SAMPLES DESIGNED, MANUFACTURED AND TESTED AT FULL SCALE IN AD-HOC FACILITIES EITHER IN EU OR IN JA. THE PRESENT PAPER AFTER A BRIEF OVERALL DESCRIPTION OF MAGNET SYSTEMS, PRESENTS IN A GENERAL APPROACH THE DIFFERENT EXPERIMENTAL CAMPAIGNS DEDICATED TO QUALIFICATION DESIGN AND MANUFACTURE PROCESSES OF EITHER COILS, CONDUCTORS AND ELECTRICAL JOINTS. THE MAIN RESULTS WITH THE ASSOCIATED ANALYSES ARE SHOWN AND THE MAIN CONCLUSIONS PRESENTED, ESPECIALLY REGARDING THEIR CONTRIBUTION TO CONSOLIDATE THE TRIGGERING OF MAGNET MASS PRODUCTION. THE STATUS OF RESPECTIVE MANUFACTURING STAGES IN EU AND IN JA ARE ALSO EVOKED.

2LZ-04

AC LOSS, INTERSTRAND RESISTANCE AND MECHANICAL PROPERTIES OF AN OPTION-II ITER CICC UP TO 30,000 CYCLES IN THE PRESS ***Y. MIYOSHI***[1]*, Y. ILIN*[2]*, W. ABBAS*[1]*, A. NIJHUIS*[1]*;* [1]UNIVERSITY OF TWENTE, [2]ITER INTERNATIONAL ORGANISATION. — THE PERFORMANCE OF A NB3SN CICC OFTEN DEGRADES WITH CYCLIC LOADING FROM LORENTZ

FORCE, LARGELY DUE TO THE DEFORMATION SUFFERED BY THE INDIVIDUAL STRANDS. SINCE THE APPLICATION OF LONGER TWIST PITCHES LEAD TO A REDUCED DEGRADATION, ITER HAS OPTED FOR A CABLING SCHEME WITH LONGER TWIST PITCHES, REFERRED TO AS OPTION-II. WITH TWIST PITCHES, HOWEVER, ELECTROMAGNETIC AND MECHANICAL PROPERTIES OF THE CONDUCTOR WILL CHANGE AS WELL AND THEY NEED TO BE INVESTIGATED UNDER EXPECTED LOADING CONDITIONS.THE TWENTE PRESS IS A FACILITY TO TEST A CONDUCTOR UNDER CYCLIC TRANSVERSE LOAD THAT SIMULATES THE EFFECT OF LOADING CONDITIONS OF THE MAGNET. THE AC LOSS AND THE COUPLING LOSS CONSTANT, THE RESISTANCES BETWEEN STRANDS FROM DIFFERENT CABLING STAGES, AND THE COMPRESSION AND THE ELASTIC MODULUS OF THE CABLE ARE MEASURED FROM THE VIRGIN STATE UP TO 30,000 LOAD CYCLES.SEVERAL PROTOTYPE ITER NBTI AND NB3SN CICCS, HAVE ALREADY BEEN EXTENSIVELY TESTED AND ALL TYPES OF ACTUAL ITER CONDUCTORS ARE SCHEDULED TO BE TESTED IN THE COMING YEARS. IN THIS PAPER, WE REPORT THE LATEST RESULTS FROM THE EUTF3-EAS SAMPLE, WHICH IS THE FIRST OPTION-II CICC TESTED IN THE PRESS. A COMPARATIVE ANALYSIS IS CARRIED OUT AGAINST PREVIOUSLY MEASURED NB3SN CONDUCTORS WITH DIFFERENT CABLING TWIST PITCHES AND VOID FRACTIONS.

THIS WORK, SUPPORTED BY THE EUROPEAN COMMUNITIES UNDER THE CONTRACT OF ASSOCIATION BETWEEN EURATOM/FOM, WAS CARRIED OUT WITHIN THE FRAMEWORK OF THE EUROPEAN FUSION DEVELOPMENT AGREEMENT.

2LZ-05

14 MEV NEUTRON IRRADIATION EFFECTS ON NB_3SN STRAND

A. NISHIMURA[1]*, T. TAKEUCHI*[2]*, G. NISHIJIMA*[3]*;* [1]NATIONAL INSTITUTE FOR FUSION SCIENCE, [2]NATIONAL INSTITUTE FOR MATERIALS SCIENCE, [3]TOHOKU UNIVERSITY. — A FUSION REACTOR WILL GENERATE A LOT OF NEUTRONS AND SOME WILL REACH SUPERCONDUCTING MAGNETS. CHANGES IN SUPERCONDUCTING PROPERTIES OF NB_3SN STRAND ARE INVESTIGATED USING 14 MEV NEUTRON SOURCE IN JAEA. CRITICAL CURRENT AND CRITICAL FIELD MEASUREMENTS WERE PERFORMED AT THE NEUTRON FLUENCE OF 3.52E+20, 1.78E+21 AND 3.10E+21 N/M^2 USING 28 T HYBRID MAGNET. CRITICAL TEMPERATURE WAS MEASURED WITH GM REFRIGERATION SYSTEM.IRRADIATION OF THE SMALLER AMOUNT OF NEUTRON FLUENCE (3.52E+20 N/M^2) CAUSED THE CRITICAL CURRENT INCREASE BELOW 17 T, OF WHICH FIELD IS CALLED AS A BORDER POINT. IN THE CASES OF THE NEUTRON FUENCE OF 1.78E+21 AND 3.10E+21 N/M^2, THE BORDER POINT MOVED TO 20 T AND 22 T. IT MEANS THAT THE LARGER FLUENCE WOULD INCREASE THE FLUX PINNING FORCE AND NOT INCREASE THE CRITICAL CURRENT AT THE HIGHER FIELD OVER THE BORDER POINT. THE CRITICAL MAGNETIC FIELD UNDER 100 MA SHOWED NO CHANGE IN THE CRITICAL FIELD AFTER IRRADIATION UP TO 1.78E+21 N/M^2. HOWEVER, THE CRITICAL TEMPERATURE CHANGED A LITTLE AFTER 3.10E+21 N/M^2 IRRADIATION. FROM THESE RESULTS, IT IS CONSIDERED THAT THE INTERSTITIALS AND VACANCIES INDUCED BY KNOCK-ON EFFECT WOULD STRENGTHEN THE PINNING FORCE OF THE MAGNETIC FLUX AND THE STRENGTHENING WOULD INCREASE WITH AN INCREASE OF THE IRRADIATION. HOWEVER, THE LONG RANGE ORDERING HAS BEGUN TO BE DISTURBED AT THAT FLUENCE.

AUTHORS WOULD LIKE TO THANK DR. K. OCHIAI AND MR. K. TAKAKURA AT FNS, JAEA, AND PROFESSORS K. WATANABE, I. SATO AND T. SHIKAMA AT TOHOKU UNIV., S. NISHIJIMA AT OSAKA UNIV., T. KISS AT KYUSHU UNIV. FOR THEIR CONTINUOUS SUPPORTS.

2LZ-06

VALIDATION OF THE 4C THERMAL-HYDRAULIC CODE AGAINST 25 KA SAFETY DISCHARGE IN THE ITER TOROIDAL FIELD MODEL COIL (TFMC)

R. ZANINO[1]*, R. HELLER*[2]*, L. SAVOLDI RICHARD*[1]*;* [1]POLITECNICO DI TORINO, [2]KARLSRUHE INSTITUTE OF TECHNOLOGY. — THE 4C CODE WAS RECENTLY DEVELOPED FOR THE COUPLED SIMULATION OF THERMAL-HYDRAULIC TRANSIENTS IN THE SUPERCONDUCTING COILS AND RELATED CRYOGENIC CIRCUIT OF THE INTERNATIONAL THERMONUCLEAR EXPERIMENTAL REACTOR (ITER). THE CODE COMBINES A DETAILED 1D DESCRIPTION OF THE COMPRESSIBLE FLOW OF THE SUPERCRITICAL HE COOLANT ALONG EACH CONDUCTOR IN THE WINDING, WITH 3D MODEL OF HEAT CONDUCTION IN THE SOLID STRUCTURES AND 0D-1D MODEL OF THE CRYOGENIC CIRCUIT (INCLUDING PUMPS, VALVES, CRYOLINES, HEAT EXCHANGER). IN THIS PAPER WE PRESENT A FIRST STEP OF THE 4C VALIDATION, AGAINST THE DATABASE OF THE ITER TOROIDAL FIELD MODEL COIL (TFMC), TESTED IN 2001-2002 IN THE TOSKA FACILITY AT THE KARLSRUHE INSTITUTE OF TECHNOLOGY, GERMANY. THE SO-CALLED STANDARD SAFETY DISCHARGE OF THE TFMC FROM 25 KA IS SIMULATED WITH 4C, ACCOUNTING FOR THE TIME DEPENDENT HEAT DEPOSITION IN THE CONDUCTORS, RADIAL PLATES AND COIL CASE. THE RESULTING THERMAL-HYDRAULIC EVOLUTION OF THE SYSTEM IS THEN COMPARED WITH THE EXPERIMENTAL RESULTS.

2LZ-07

(INVITED) **STATUS REPORT OF THE EDIPO PROJECT**

A. PORTONE[1]*, M. BAGNASCO*[2]*, B. BAKER*[1]*, P. BRUZZONE*[2]*, F. CAU*[3]*, E. FERNANDEZ-CANO*[1]*, E. SALPIETRO*[4]*, B. STEPANOV*[2]*, P. TESTONI*[1]*, E. THEISEN*[5]*, R. WESCHE*[2]*;* [1]FUSION FOR ENERGY, [2]EPFL-CRPP, [3]FUSION FOR ENERGY/EPFL-CRPP, [4]EFDA, [5]BABCOCK-NOELL. — AIM OF THIS PAPER IS TO REPORT ON THE PROGRESS MADE OVER THE LAST TWELVE MONTHS IN THE FRAMEWORK OF THE EDIPO PROJECT THAT IT IS NOW HEADING TOWARD COMPLETION.AT BABCOCK-NOELL (BNG) THE DUMMY EDIPO IS COMPLETED. THE TWO SADDLE MAGNETS ARE WOUND, HEAT-TREATED AND IMPREGNATED AND THEIR FINAL ASSEMBLY WITH THE IRON YOKE AND OUTER CYLINDER IS ON-GOING. EACH POLE IS INDEPENDENTLY TESTED GEOMETRICALLY, ELECTRICALLY AND HYDRAULICALLY BOTH IN THE FINAL, IMPREGNATED STATE AND DURING WINDING. THE FINAL IMPREGNATION STEP AND THE FINAL TESTS WILL BE PERFORMED BEFORE DISPATCHING TO CRPP, WHICH IS FORSEEN BY END 2010.AT CRPP, THE MAIN COMPONENTS (E.G. 18 KA POWER SUPPLY AND PROTECTION SYSTEM, VACUUM VESSEL, THERMAL SHIELD, HTS CURRENT

LEADS) HAVE BEEN DELIVERED AND, AS FAR AS POSSIBLE, COMMISSIONED. CONFLICTS BETWEEN THE WORK ON EDIPO COMPONENTS AND THE OPERATION OF THE SULTAN FACILITY IN THE SAME HALL ARE A CONCERN FOR THE FINAL COMMISSIONING PHASE. THE ROADMAP TO IN SITU ASSEMBLY AND FULL COMMISSIONING IS ALSO PRESENTED.

2MA-01

(INVITED) **RECENT R&D PROGRESS ON DI-BSCCO WIRES WITH HIGH CRITICAL CURRENT PROPERTIES** ***T. NAKASHIMA****, S. KOBAYASHI, T. KAGIYAMA, K. YAMAZAKI, M. KIKUCHI, S. YAMADE, E. SHIZUYA;* SUMITOMO ELECTRIC INDUSTRIES, LTD.. — DI-BSCCO IS THE HIGH PERFORMANCE SILVER-SHEATHED BI2223 WIRES PRODUCED WITH THE CONTROLLED-OVERPRESSURE (CT-OP) SINTERING TECHNIQUE. THE PRESENT COMMERCIAL DI-BSCCO CAN PROVIDE THE UNIFORM HIGH CRITICAL CURRENT UP TO 180 A OVER 1000 M, AND RECENTLY WE HAVE SUCCEEDED TO ACHIEVE 200 A WITH THE SAME KIND OF 1000 M-LONG WIRES, RESULTING FROM THE IMPROVEMENT AND CONTROL OF THE MICROSTRUCTURE IN THE FABRICATED BI2223 FILAMENTS. IN SHORT LENGTH OF SEVERAL 10 M, THE WIRE UNDER DEVELOPMENT HAS EXHIBITED OVER 230 A AS THE HIGHEST CRITICAL CURRENT IN 77K, SELF-FIELD (CORRESPONDING TO 540 A PER 1 CM-WIDTH). ALL THE DERIVATIVE PRODUCTS HAVE ALSO UNIFORM CRITICAL CURRENT PROPERTY OVER THE ENTIRE LENGTH EVEN AFTER LAMINATION WITH THE REINFORCEMENTS. THE PERFORMANCES OF DI-BSCCO CAN MEET THE GROWING NEEDS FOR VARIOUS HIGH TEMPERATURE SUPERCONDUCTING APPLICATIONS INVOLVING HIGH IN-FIELD PROPERTIES, SUCH AS MAGNETS AND MOTORS. THE RECENT PROGRESS IN CRITICAL CURRENT INCLUDING IN-FIELD PROPERTIES AND OTHER VARIOUS PERFORMANCES OF DI-BSCCO WILL BE SHOWN IN THE PRESENTATION.

2MA-02

LOCAL CURRENT TRANSPORT PROPERTIES IN 200A-CLASS BI-2223 MULTI-FILAMENTARY TAPES FABRICATED BY THE CONTROLLED OVER PRESSURE PROCESS ***T. KISS***[1]*, K. HIGASHIKAWA*[1]*, Y. HONDA*[1]*, M. INOUE*[1]*, M. KIKUCHI*[2]*, S. KOBAYASHI*[2]*, K. HAYASHI*[2]*, K. SATO*[2]*;* [1]KYUSHU UNIVERSITY, [2]SUMITOMO ELECTRIC INDUSTRIES, LTD.. — CRITICAL CURRENT (I_C) OF BI-2223 MULTI-FILAMENTARY TAPES HAVE BEEN IMPROVED SIGNIFICANTLY BY THE CONTROLLED OVER PRESSURE PROCESS. I_C OF THESE TAPES HAVE NOW REACHED OVER 200 A AT 77K, SELF-FIELD [1]. HOWEVER, LIMITING FACTOR ON THE I_C HAS NOT YET FULLY UNDERSTOOD, AND FURTHER IMPROVEMENT OF THE I_C IS REQUIRED FOR PRACTICAL APPLICATIONS. IN THIS STUDY, WE HAVE INVESTIGATED INTERNAL CURRENT FLOW IN 200A-CLASS BI-2223 TAPES BY USE OF SCANNING HALL PROBE MICROSCOPY. IT HAS BEEN FOUND THAT THE CRITICAL CURRENT DENSITY (J_C) AT CENTRAL AREA OF THE TAPES REACH AS HIGH AS 80-100 KA/CM^2 AT 77K. FROM DETAILED COMPARISON BETWEEN LOCAL CURRENT DENSITY AND FILAMENTARY STRUCTURE, WE HAVE FOUND THAT LOCAL J_C IS INVERSELY PROPORTIONAL TO THE FILAMENT THICKNESS. THIS RESULT STRONGLY SUGGESTS THAT CURRENT CARRYING AREA IS THINNER THAN THE APPARENT FILAMENT THICKNESS. NAMELY, REAL J_C IN THE EFFECTIVE AREA IS HIGHER THAN THE AVERAGE VALUE. SINCE THE LOCAL J_C AT THE THINNEST FILAMENT HAS NOT YET SATURATED, MUCH HIGHER I_C IS ATTAINABLE IF WE CAN EXTEND THE EFFECTIVE CROSS SECTIONAL AREA BY MAKING THINNER FILAMENT. OUR ESTIMATION BASED ON THE PRESENT ANALYSIS INDICATES THAT 300 A OF I_C WILL BE ATTAINABLE BY OPTIMIZING FILAMENT THICKNESS KEEPING THE SAME MICRO-STRUCTURAL QUALITY. INFLUENCE OF EXTERNAL FIELD WILL ALSO BE DISCUSSED.[1] N. AYAI ET AL., IEEE TRANS. APPL. SUPERCOND. 17 (2007) 3075.

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2MA-03

PROGRESS IN REDUCING AC LOSSES OF BI2223 TAPES WITH INTERFILAMENTARY RESISTIVE BARRIERS ***R. INADA***[1]*, Y. OKUMURA*[1]*, T. MAKIHARA*[1]*, Y. NAKAMURA*[1]*, A. OOTA*[1]*, C. LI*[2]*, P. ZHANG*[2]*;* [1]TOYOHASHI UNIVERSITY OF TECHNOLOGY, [2]NORTHWEST INSTITUTE FOR NONFERROUS METAL RESEARCH. — THIS PAPER PRESENTS OUR RECENT ACTIVITIES FOR THE DEVELOPMENT OF LOW-LOSS BI2223 TAPES WITH INTERFILAMENTARY RESISTIVE BARRIERS. IN ORDER TO SUPPRESS THE SIDE EFFECT ON BI2223 PHASE FORMATION IN THE FILAMENTS DURING SINTERING PROCESS, $SRZRO_3$ WAS SELECTED AS BARRIER MATERIALS. MOREOVER, SMALL AMOUNT OF BI2212 WAS MIXED WITH THE OXIDE TO IMPROVE THEIR DUCTILITY FOR COLD WORKING. ALTHOUGH SOME BREAKAGES OF BARRIER LAYERS STILL EXISTED, THE EFFECTIVE TRANSVERSE RESISTIVITY WAS APPROXIMATELY 10 TIMES HIGHER THAN A TAPE WITH PURE AG MATRIX. BY CONTROLLING BARRIER THICKNESS, REDUCING A TAPE WIDTH BELOW 3 MM AND TWISTING THE FILAMENTS WITH ITS LENGTH AROUND 5 MM, COUPLING FREQUENCY F_C EXCEEDED 250 HZ EVEN IN AN AC EXTERNAL FIELD IN PERPENDICULAR TO THE WIDER FACE OF A TAPE. CRITICAL CURRENT DENSITIES J_C OF TIGHTLY TWISTED BARRIER TAPES WERE RANGED IN 12-14 KA/CM^2 AT 77 K AND SELF-FIELD, WHICH WAS 25% LOWER THAN NON-TWISTED ONE (= 17-19 KA/CM^2). IN OUR KNOWLEDGE, THIS IS THE FIRST ACHIEVEMENT FOR BOTH J_C > 12 KA/CM^2 AND F_C > 250 HZ SIMULTANEOUSLY IN BI2223 TAPES WITH BARRIERS. OUR BARRIER TAPES SHOWED 60-70% LOWER PERPENDICULAR FIELD LOSSES THAN A CONVENTIONAL 4 MM-WIDTH TAPE WITH FULLY COUPLED FILAMENTS AT 50 MT AND 50 HZ. ALTHOUGH TRANSPORT J_C OF OUR BARRIER TAPES IS STILL LOWER THAN COMMERCIAL ONE, THESE ACHIEVEMENT IS PROMISING FOR REMARKABLE LOSS REDUCTION IN A PERPENDICULAR FIELD WITH POWER-GRID FREQUENCY.

THIS WORK WAS PARTIALLY SUPPORTED BY GRANT-IN-AIDS FOR SCIENTIFIC RESEARCH (NO.20686020) FROM MEXT OF JAPAN, TEPCO RESEARCH FOUNDATION AND RESEARCH FOUNDATION FOR THE ELECTROTECHNOLOGY OF CHUBU (NO.R-20302).

2MA-04

DEVELOPMENT OF A TEXTURED-POWDER BI-2212 CONDUCTOR *K. DAMBORSKY, F. LU,* ***P. MCINTYRE****, N. POGUE, D. RAHMANI;* TEXAS A&M UNIVERSITY. — WE REPORT THE DEVELOPMENT OF A TECHNIQUE FOR TEXTURING THE GRAIN ORIENTATION IN BI-2212 NANOPOWDER AND A WIRE FABRICATION TECHNIQUE THAT RETAINS THE TEXTURING.DETAILS OF THE POWDER PROCESS AND THE WIRE FABRICATION WILL BE PRESENTED. STUDIES OF TEXTURING AND MICROSTRUCTURE IN CONDUCTOR SAMPLES WILL BE REPORTED.

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2MA-05

CONNECTIVITY ISSUES IN MELT CAST PROCESSED BI2212 BULK MATERIALS ***M. O. RIKEL****[1], S. ELSCHNER[2], A. HASENHUETL[1], M. KLEIN[1], J. BOCK[1];* [1]NEXANS SUPERCONDUCTORS, [2]UNIVERSITY OF APPLIED SCIENCE (MANNHEIM). — MELT CAST PROCESSED (MCP) BULK BI2212 HAS UNIQUE COMBINATION OF CRITICAL CURRENTS, NORMAL STATE THERMAL CONDUCTIVITY AND RESISTIVITY, WHICH MAKES IT SUITABLE FOR APPLICATIONS IN CURRENT LEADS AND ELEMENTS FOR FAULT CURRENT LIMITATION DEVICES. DESPITE OF THE ABSENCE OF LONG-RANGE TEXTURE AND VERY STRONG SELF-FIELD EFFECTS, ENGINEERING CRITICAL CURRENT DENSITIES J_E(77 K, SF) ~ 20 A/MM^2 CONSTITUTE 10% OF THE BEST J_E IN WELL TEXTURED AG SHEATHED BI2223 TAPES. THE MECHANISM THAT ENABLES RELIABLE LONG-RANGE PERCOLATIVE CONNECTIVITY IN MCP BI2212 BULK MATERIALS IS NOT CLEAR.ADDRESSING THE ISSUE OF C-AXIS CURRENT CONTRIBUTION TO PERCOLATION, WE STUDIED AN EFFECT OF BI2201 INTERGROWTH LAYERS ON J_E(77 K, SF) IN MCP BI2212 RODS. A RATHER SMALL DJE/DF = -13 ± 4 A/MM^2 WAS OBSERVED ($0.04 \le F \le 0.10$ IS THE FRACTION OF BI2201 INTERGROWTHS MEASURED BY XRD). MOREOVER, REACHING ALMOST INTERGROWTH-FREE ($0.01 \le F \le 0.03$) STATE WHEN INVOLVING PARTIAL MELTING RESULTED IN 12 ± 2% DROP IN J_E, WHICH IS SHOWN TO BE RELATED TO THE LOSS OF ORIENTATIONAL CORRELATIONS IN ARRANGEMENT OF BI2212 GRAINS - REDUCED PREFERRED ORIENTATION OF AB-PLANES ALONG THE ROD RADIUS.POSSIBLE CONTRIBUTIONS TO PERCOLATIVE CONDUCTIVITY IN MCP BULK BI2212 ARE DISCUSSED AND COMPARED TO THOSE IN BI2212 MULTIFILAMENTARY ROUND WIRES.

TECHNICAL ASSISTANCE OF Z. ABDOULLAEVA, A. GUIGNARD, AND V. PAIRE IS ACKNOWLEDGED.

2MA-06

PROCESSING ISSUES FOR $BI_2SR_2CACU_2O_X$/AGMG ROUND WIRE: LENGTH, INSULATION AND PRE-ANNEALING EFFECTS ***X. LIU****[1], F. HUNTE[1], J. SCHWARTZ[1], W. NACHTRAB[2], T. WONG[2];* [1]NCSU, [2]SUPERCON, INC. — AS ONE OF THE MOST PROMISING CANDIDATES TO ENABLE SUPERCONDUCTING MAGNETS IN THE 25-30T RANGE, $BI_2SR_2CACU_2O_X$/AGMG (BI2212) ROUND WIRE HAS HIGH J_E IN HIGH MAGNETIC FIELD WITH NO MAGNETIC ANISOTROPY. FOR SOLENOID MAGNETS, BI2212/AGMG WIRES ARE ADVANTAGEOUS OVER TAPE CONDUCTORS DUE TO THE HIGHER PACKING FRACTION AND EASE OF LAYER-TO-LAYER TRANSITION. ONE ISSUE THAT HAS HINDERED BI2212 MAGNET DEVELOPMENT IS THE HOMOGENEITY IN J_C IN LONG WIRES. IN THIS STUDY, THE EFFECTS OF CONDUCTOR LENGTH, INSULATION MATERIALS, AND A PRE-ANNEALING HEAT-TREATMENT ON THE TRANSPORT AND MAGNETIZATION PERFORMANCE OF BI2212/AGMG COILS IS INVESTIGATED. WITHOUT PRE-ANNEALING, THE CRITICAL CURRENT IS NON-UNIFORM, DECREASING IN THE MIDDLE SECTION OF COILS. AS A RESULT, THE END-TO-END CRITICAL CURRENT DECREASES WITH INCREASING WIRE LENGTH. WITH A PRE-ANNEALING HEAT-TREATMENT, THE CRITICAL CURRENT OF THE MIDDLE SECTIONS ARE IMPROVED GREATLY AND WIRE PERFORMANCE BECOMES HOMOGENEOUS. THE MICROSTRUCTURE, PHASE ASSEMBLAGE AND INTERACTIONS BETWEEN THE WIRE AND INSULATION FIBERS ARE STUDIED USING SEM AND EDS. THE MECHANISM RESPONSIBLE FOR THE VARIATION OF PERFORMANCE HOMOGENEITY OVER WHOLE COILS AFTER HEAT TREATMENT WITHOUT AND WITH PRE-ANNEALING ARE ANALYZED.**INDEX TERMS:** BISMUTH COMPOUND, SUPERCONDUCTING FILAMENTS AND WIRES, SUPERCONDUCTING MAGNETS

2MA-07

NUMERICAL INVESTIGATION OF THE QUENCH BEHAVIOR OF BI2SR2CACU2OX WIRE ***D. ARBELAEZ****[1], S. O. PRESTEMON[1], D. R. DIETDERICH[1], A. GODEKE[1], L. YE[2], F. HUNTE[2], J. SCHWARTZ[2];* [1]LAWRENCE BERKELEY NATIONAL LABORATORY, [2]NORTH CAROLINA STATE UNIVERSITY. — THE QUENCH BEHAVIOR OF BI2SR2CACU2OX (BI2212) WIRE IS INVESTIGATED THROUGH NUMERICAL SIMULATIONS. THIS WORK IS PART OF THE U.S. VERY HIGH FIELD SUPERCONDUCTING MAGNET COLLABORATION (VHFSMC). NUMERICAL SIMULATIONS ARE CARRIED OUT USING A ONE-DIMENSIONAL COMPUTATIONAL MODEL OF THERMAL TRANSPORT IN BI2212 COMPOSITE WIRES. A QUENCH IS SIMULATED BY INTRODUCING HEAT IN A SECTION OF THE WIRE, AND THE VOLTAGE AND TEMPERATURE ARE MONITORED AS FUNCTION OF TIME AND POSITION. THE QUENCH ENERGY, NORMAL ZONE PROPAGATION VELOCITY, AND SPATIAL DISTRIBUTION OF TEMPERATURE ARE CALCULATED FOR VARYING TRANSPORT CURRENT AND APPLIED MAGNETIC FIELD. THE COMPUTATIONAL RESULTS ARE COMPARED WITH EXPERIMENTAL RESULTS ON QUENCH PROPAGATION IN WIRES.

2MB-01

(INVITED) **MAGNETIC FIELD-ORIENTATION INDEPENDENCE OF LARGE BASAL PLANE CRITICAL CURRENTS IN RBCO FILMS WITH CORRELATED PINNING NANOSTRUCTURE** ***D. K. CHRISTEN****[1], Y. L. ZUEV[2], S. WEE[1], A. GOYAL[1], C. CANTONI[1], C. TARANTINI[3];* [1]OAK RIDGE NATIONAL LABORATORY, [2]UNIVERSITY OF TENNESSEE, [3]FLORIDA STATE UNIVERSITY NHMFL. — OPTIMIZATION OF COATED CONDUCTORS REQUIRES LARGE CRITICAL CURRENTS THAT EXHIBIT LITTLE DEPENDENCE ON MAGNETIC FIELD ORIENTATION. IT HAS BEEN WIDELY CONFIRMED THAT SELF-ASSEMBLED COLUMNAR

STACKS OF SECOND PHASE PRECIPITATES ALIGNED NEAR TO THE *C*–AXIS PROVIDE STRONG FLUX PINNING IN RBCO EPITAXIAL FILMS. SUCH GROWTH-CONTROLLED NANOSTRUCTURES CAN BE PRODUCED BY AT LEAST TWO DIFFERENT DEPOSITION TECHNIQUES AND FOR SEVERAL SPECIES OF OXIDE PRECIPITATES. FOR MANY OF THESE SYSTEMS, THERE IS NEAR INDEPENDENCE OF IN-PLANE TRANSPORT CRITICAL CURRENT DENSITIES, J_C, ON FIELD ORIENTATION AT SPECIFIC TEMPERATURE-DEPENDENT FIELDS, $B^*(T)$. THE PHENOMENON CAN BE DESCRIBED BY A COMPETITION BETWEEN INTRINSIC ELECTRONIC ANISOTROPY AND ORIENTATION-DEPENDENT PINNING. A MODEL DESCRIPTION PARAMETERIZES THE EFFECT, PRINCIPALLY THROUGH THE ANGLE DEPENDENCIES OF THE IRREVERSIBILITY FIELD $H_{IRR}(\Theta)$ AND THE POWER-LAW DECAY EXPONENT $A(\Theta)$, WHERE $J_C \sim H^A$ IN THE INTERMEDIATE FIELD REGIME. FOR MATERIALS THAT EXHIBIT A TILT BIAS IN THE COLUMNAR DEFECT ORIENTATIONS, ADDITIONAL UNUSUAL EFFECTS CAN RESULT, WHICH ARE ALSO QUALITATIVELY CONSISTENT WITH THE MODEL DESCRIPTION.

RESEARCH SPONSORED BY THE U.S. DOE, OFFICE OF ELECTRICITY DELIVERY AND ENERGY RELIABILITY, ADVANCED CABLES AND CONDUCTORS

2MB-02

PINNING PROPERTIES $BAZRO_3$-$YBA_2CU_3O_{7-X}$ THIN FILMS DEPOSITED BY PLD AND MOD ***A. AUGIERI***[1], *V. GALLUZZI*[1], *A. ANGRISANI ARMENIO*[1], *A. MANCINI*[1], *A. RUFOLONI*[1], *A. VANNOZZI*[1], *S. GAUDIO*[1], *G. CELENTANO*[1], *E. SILVA*[2], *N. POMPEO*[2], *T. PETRISOR*[3], *L. CIONTEA*[3]; [1]ENEA, [2]UNIVERSITÀ ROMA TRE, [3]CLUJ NAPOCA UNIVERSITY. — A DETAILED STUDY OF TRANSPORT PROPERTIES MEASURED ON BZO ADDED YBCO FILMS GROWN ON SINGLE CRYSTAL SUBSTRATE BY PHYSICAL (PLD) AND CHEMICAL (MOD) METHODS HAS BEEN PERFORMED. BOTH SAMPLES SETS DID NOT SHOW ANY CRITICAL TEMPERATURE (T_C) DECREASE ON INCREASING BZO CONTENT UP TO 7 MOL.% IN PLD FILMS AND 20 MOL.% IN MOD FILMS. D.C. TRANSPORT PROPERTIES MEASUREMENTS WERE PERFORMED ON ALL THE SAMPLES REVEALING IMPROVED IN-FIELD PERFORMANCES FOR BZO-YBCO FILMS IF COMPARED TO THE TYPICAL YBCO CRITICAL CURRENT DENSITIES (J_C) DEPENDENCE FROM THE MAGNETIC FIELD. THE ANALYSIS OF ANGULAR DEPENDENCE OF PINNING FORCES EVIDENCED THE PRESENCE OF BZO INDUCED *C*-AXIS CORRELATED DEFECTS ONLY IN PLD DEPOSITED FILMS EVEN IF MOD FILMS SHOWED THE BEST PINNING FORCE DENSITY ENHANCEMENT, WITH AN IMPROVEMENT OF A FACTOR 15 FOR THE MAXIMUM PINNING FORCE AT 77K. HIGH FREQUENCY (~48 GHZ) SURFACE IMPEDANCE MEASUREMENTS HAVE BEEN PERFORMED IN ORDER TO EVALUATE THE DEPTH AND THE SHAPE OF THE PINNING POTENTIAL RESULTING FROM THE DIFFERENT PINNING LANDSCAPE OBTAINED IN PLD AND MOD SAMPLES. THE OBTAINED RESULTS REVEALED THAT WHILE FOR PLD SAMPLE THE REDUCTION IN THE VORTEX MOBILITY IS ASCRIBABLE TO A DEEPER AND NARROWER PINNING POTENTIAL WELLS, A DIFFERENT SCENARIO ARISES IN MOD SAMPLES. THE EFFECT OF BZO INTRODUCTION ON YBCO FILMS GROWN BOTH BY PLD AND MOD TECHNIQUES ON BUFFERED METALLIC SUBSTRATE HAS BEEN ALSO EVALUATED.

2MB-03

3D LANDSCAPE OF BAZRO3 NANORODS IN YBA2CU3O7-Δ FILMS ***R. L. S. EMERGO***[1], *F. J. BACA*[2], *J. Z. WU*[1], *T. J. HAUGAN*[3], *P. N. BARNES*[3]; [1]UNIVERSITY OF KANSAS, [2]UNIVERSITY OF KANSAS AND AIR FORCE RESEARCH LABORATORY, [3]AIR FORCE RESEARCH LABORATORY. — A THREE-DIMENSIONAL PINNING LANDSCAPE WAS DEVELOPED IN BZO-NRS DOPED YBCO FILMS BY IMPLEMENTING GROWTH ON VICINAL SUBSTRATES AND VARYING INTER-ROD SPACING. THE RESULTING ASYMMETRIC STRAIN ON YBCO LATTICE, AS DEMONSTRATED ON 5° VICINAL STO SUBSTRATES WITH BZO CONCENTRATION OF 2, 4, AND 6 VOL. %, WEAKENS THE UNIAXIAL ALIGNMENT OF BZO-NRS ALONG THE C-AXIS TYPICALLY OBSERVED IN THE NONVICINAL CASE AND LEADS TO THREE-DIMENSIONAL DISPERSION OF BZO-NRS. THE BENEFITS OF DISPERSING THE ALIGNMENT OF BZO-NRS WITH RESPECT TO UNI-DIRECTIONAL ALIGNMENT IN YBCO FILMS INCLUDE MUCH LESS DEGRADATION OF THE NORMAL-STATE TRANSPORT PROPERTIES AND T_C, AND MUCH IMPROVED J_C VALUES IN ALMOST ALL ORIENTATIONS OF THE APPLIED MAGNETIC FIELD.

THE AUTHORS ACKNOWLEDGE SUPPORTS FROM NSF AND AFOSR FOR THIS WORK. JZW WAS ALSO SUPPORTED BY DOE.

2MB-04

VORTEX DYNAMICS IN NANOSTRUCTURED TFA-GROWN YBCO FILMS STUDIED BY AC SUSCEPTIBILITY ***E. BARTOLOME***[1], *A. PALAU*[2], *T. PUIG*[2], *A. LLORDES*[2], *M. GISBERT*[2], *X. OBRADORS*[1]; [1]ESCOLA UNIVERSITARIA SALESIANA DE SARRIÀ, [2]INSTITUT DE CIÈNCIA DE MATERIALS DE BARCELONA-CSIC. — RECENTLY, DIFFERENT SUCCESSFUL APPROACHES HAVE MERGED TO CREATE ARTIFICIAL PINNING CENTERS IN YBCO, IN THE QUEST TO REACH COATED CONDUCTORS WITH HIGHER CURRENT PERFORMANCES. AN OPEN ISSUE IS TO UNDERSTAND HOW THE DIFFERENT DEFECTS AFFECT VORTEX PINNING AT HIGH MAGNETIC FIELDS AND TEMPERATURES, CLOSE TO THE IRREVERSIBILITY LINE. WE HAVE APPLIED A POWERFUL AC SUSCEPTIBILITY METHODOLOGY TO TACKLE THIS PROBLEM. WE PRESENT A FULL DESCRIPTION OF THE AC RESPONSE OF DIFFERENT SORTS OF NANOSTRUCTURED YBCO FILMS GROWN BY THE CHEMICAL SOLUTION GROWTH TFA-ROUTE: YBCO-BAZRO3 AND YBCO-Y2O3 NANOCOMPOSITES, AND YBCO FILMS WITH ADDITIONAL DEFECTS INTRODUCED BY SUBSTRATE NANODECORATION. BOTH THE BEAN AND CAMPBELL DYNAMIC REGIMES HAVE BEEN ANALYZED TO DETERMINE THE EFFECTIVE ENERGY BARRIER FOR THERMALLY ACTIVATED FLUX MOTION, UE, AND THE PINNING LABUSCH CONSTANT, AL. RESULTS EVIDENCE THAT BZO NANOCOMPOSITES PRESENT PECULIAR FIELD DEPENDENCES OF THESE PARAMETERS, THAT MAY BE ASCRIBED TO THE LARGER STRONG-ISOTROPIC PINNING CONTRIBUTION INDUCED BY THE ISOTROPIC MICROSTRAIN EMERGING FROM THE NANOPARTICLES IN THE YBCO MATRIX.

2MB-05

FORMATION OF BYZO NANOPANCAKES IN HTS $YBA_2CU_3O_{7-\Delta}$ FILMS AND THEIR EFFECT ON CRITICAL CURRENT DENSITY AND NONLINEAR MICROWAVE RESPONSE *V. S. FLIS, V. L. SVETCHNIKOV, O. A. KALENYUK, O. L. KASATKIN, V. O. MOSKALIUK, A. I. REBIKOV, C. G. TRETIATCHENKO,* ***V. M. PAN****;* G.V.KURDYUMOV INSTITUTE FOR METAL PHYSICS. — WE HAVE STUDIED NANOSTRUCTURE, ELECTRIC TRANSPORT AND MICROWAVE PROPERTIES OF HTS $YBA_2CU_3O_{7-\Delta}$ FILMS PREPARED BY PLD ON $LAALO_3$ SINGLE CRYSTAL SUBSTRATES USING TARGETS DOPED WITH $BAZRO_3$. TWO ESSENTIALLY DIFFERENT TYPES OF NANOPARTICLES ARE REVEALED BY HREM: "NANOPANCAKES" AND "NANORODS". A VARIABLE COMPOSITION OF NANOPANCAKES CORRESPONDS TO $BA_XY_{1-X}ZRO_Y$ (BYZO). THEY ARE 1-4 NM IN ***AB***-PLANE AND ONLY FEW ATOMIC LAYERS THICK. NANOPANCAKES ARE SURROUNDED WITH DEFORMED AREA AND NUMEROUS EDGE DISLOCATIONS ALONG [001] DIRECTION, WHICH ARE WELL SEEN IN HREM PICTURES AFTER FOURIER FILTERING. SUCH NANOPARTICLES SEEM TO BE RESPONSIBLE FOR SIGNIFICANT J_C ENHANCEMENT. NANOPANCAKES EVOLVE TO MUCH WIDER (20-40 NM) AND LONGER NANORODS AT HIGHER SUBSTRATE TEMPERATURES AND/OR SLOWER DEPOSITION. THERE ARE NO DISLOCATIONS AROUND NANORODS AS ELASTIC STRAINS ARE AVOIDED DUE TO SLIGHT INCLINATION OF THE NANOROD *C*-AXIS. TINY NANOPANCAKES ARE SUGGESTED TO BE COHERENTLY COUPLED WITH YBCO MATRIX, GENERATE NUMEROUS GROWTH DISLOCATIONS BEING ADDITIONAL FLUX PINNING CENTERS, AND RETARD THERMALLY ACTIVATED RELAXATION OF THE DISLOCATION NANOSTRUCTURE.

THIS WORK IS SUPPORTED BY THE NATIONAL ACADEMY OF SCIENCES OF UKRAINE AND BY THE MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE.

2MB-06**COOPERATIVE BEHAVIOR OF THE RANDOM AND CORRELATED PINNING IN ER123 FILMS WITH COLUMNAR DEFECTS** ***S. AWAJI****[1], M. NAMBA[1], K. WATANABE[1], H. KAI[2], M. MUKAIDA[2], S. OKAYASU[3];* [1]INSTITUTE FOR MATERIALS RESEARCH, TOHOKU UNIVERSITY, [2]KYUSHU UNIVERSITY, [3]JAPAN ATOMIC ENERGY AGENCY. — THE FLUX PINNING BEHAVIORS FOR HEAVY ION IRRADIATED ER123 FILMS ARE INVESTIGATED BASED ON THE DETAILED J_C (B, T, Θ) PROPERTIES. THE 200MEV $^{197}AU^{+15}$ IONS WITH THE MATCHING FIELD B_Φ OF 0.3 T AND 1.7 T WERE IRRADIATED ALONG C-AXIS AND 23° OFF C-AXIS. WE FOUND THAT THE DOUBLE PEAKS OF F_P CURVES FOR B//C APPEAR IN CASE OF THE MATCHING FIELD OF 0.3 T. IN ADDITION, THE PEAKS ON J_C (Θ) AT Θ =0° (B//C), WHICH ORIGINATE FROM THE COLUMNAR DEFECT, DECREASE WITH INCREASING MAGNETIC FIELD BUT INCREASE AGAIN NEAR THE IRREVERSIBILITY FIELD. IN ORDER TO EXPLAIN THESE COMPLICATED BEHAVIORS OF F_P AND J_C (Θ), WE PROPOSE THE COOPERATION MODEL OF THE C-AXIS CORRELATED AND RANDOM PINNINGS. IN THIS MODEL, THE C-AXIS CORRELATED PINNING BEHAVIOR WAS DESCRIBED BY THE COMBINATION OF THE LINEAR SUMMATION IN LOW FIELD REGION BELOW B_Φ AND PLASTIC FLOW ABOVE B_Φ. THE COOPERATION WAS DESCRIBED BY THE ROOT MEAN SQUARE OF THE C-AXIS CORRELATED AND RANDOM PINNINGS. WE FOUND THAT THIS MODEL CAN DESCRIBE THE OBSERVED DOUBLE PEAK BEHAVIOR OF F_P(B) AND ANGULAR DEPENDENCE OF J_C RELATED TO THE C-AXIS CORRELATED PINNING.

2MB-07

FOCUSED ION BEAM ENGINEERED NANOSTRUCTURES AS PROMISING TOOLS FOR IMPROVING AND CONTROLLING FLUX PINNING IN YBCO FILMS GROWN BY CHEMICALS SOLUTION DEPOSITION METHODS ***C. M. MONTON****, A. PALAU, J. ZABALETA, R. F. LUCCAS, X. GRANADOS, N. MESTRES, X. OBRADORS, T. PUIG;* ICMAB-CSIC. — THE TECHNOLOGICAL APPLICATION OF HTC SUPERCONDUCTORS, SC, IN POWER OR ELECTRONIC DEVICES DEPENDS ON ECONOMICAL AND TECHNICAL FACTORS. IN THE FIRST CASE SCALABLE GROWTH TECHNIQUES LIKE CHEMICAL SOLUTION DEPOSITION HAVE BEEN IMPROVED GIVING RISE TO HIGH QUALITY $YBA_2CU_3O_4$, FILM [1]. THE TECHNICAL FACTOR CAN BE SOLVED BY REDUCING THE DISSIPATION OF UNWANTED FLUX MOTION BY INTRODUCING STRONG PINNING SITES, WHICH ''TRAP'' THE VORTICES IN THE SC. FOR THAT PURPOSE, BY MEANS OF HIGH RESOLUTION NANOLITHOGRAPHY TECHNIQUES LIKE FOCUSED ION BEAM (FIB) WE HAVE EXPLORED DIFFERENT ARTIFICIAL ARRAYS OF NANO-PINNING SITES. CHANNELS PERFORMED BY FIB ON THE SC FILM PROVIDE EFFECTIVE PINNING PROPERTIES, WHEN AN EXTERNAL CURRENT IS APPLIED PARALLEL TO THEM. VORTEX VISUALIZATION OF THESE NANOFABRICATED FILMS, USING BITTER MAGNETIC DECORATION, HAS REVEALED THAT FIB CHANNELS INTRODUCE LINEAR ORDER IN THE VORTEX LATTICE. ADDITIONALLY, VORTEX DEPINNIG CAN BE CONTROLLED BY PATTERNING FIB ASYMMETRIC PINNING POTENTIALS (ARRAYS OF TRIANGULAR ANTI-DOTS). THEY INDUCE ENHANCED ASYMMETRIC PINNING PROPERTIES WHICH DEPEND ON THE CURRENT AND APPLIED MAGNETIC FIELD ORIENTATIONS. CONSEQUENTLY, OUR WORK DEMONSTRATES THAT THE MENTIONED HIGH RESOLUTION NANOLITHOGRAPHY TECHNIQUES ARE VERY PROMISING TOOLS TO ANALYZE THE VORTEX PINNING MECHANISMS OF HTC SC FILMS.[1] J.GUTIERREZ ET AL. NATURE PHYS. 6, 367 (2007)

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2MC-01

(INVITED) **PROGRESS WITH NB_3SN CONDUCTORS FOR FUSION AND PARTICLE ACCELERATOR APPLICATIONS** ***J. A. PARRELL****[1], Y. ZHANG[1], M. B. FIELD[1], S. HONG[2], Y. HUANG[1], H. MIAO[1], M. MEINESZ[1];* [1]OXFORD SUPERCONDUCTING TECHNOLOGY, [2]HJC ENTERPRISES. — THE CRITICAL CURRENT DENSITY (J_C) OF NB_3SN STRAND HAS BEEN SIGNIFICANTLY IMPROVED OVER THE LAST SEVERAL YEARS, THROUGH THE DEVELOPMENT OF INTERNAL TIN PROCESSES. FOR MANY APPLICATIONS, HIGH J_C INTERNAL TIN STRAND HAS DISPLACED STRAND MADE BY THE BRONZE PROCESS. HOWEVER FOR MANY APPLICATIONS, HIGH J_C ALONE IS NOT SUFFICIENT. FOR FUSION APPLICATIONS SUCH AS ITER, WE HAVE DEVELOPED SINGLE-BARRIER INTERNAL TIN STRANDS HAVING NON-CU J_C VALUES OVER 1100 A/MM^2 (12 T, 4.2 K) WITH HYSTERESIS LOSSES LESS THAN 800 MJ/CM^3 OVER NON-CU VOLUME. WE WILL PRESENT EARLY RESULTS FROM OUR PRODUCTION CAMPAIGN FOR

ITER. FOR HIGH FIELD MAGNET APPLICATIONS, HIGHER J_C VALUES ARE ACHIEVED USING A DISTRIBUTED BARRIER DESIGN. WE HAVE CONTINUED DEVELOPMENT OF HIGH J_C STRAND MADE WITH NB-47TI RODS TO SUPPLY THE DOPANT, AND ARE WORKING ON OPTIMIZATION OF THE TI CONTENT. THIS NB-TI STRAND MAINTAINS A J_C VALUE OF 3000 A/MM^2 (12 T, 4.2 K), BUT HAS IMPROVED HIGHER FIELD PERFORMANCE COMPARED WITH OUR STANDARD NB-TA MATERIAL, REACHING 1700 A/MM^2 AT 15 T. TO REDUCE THE EFFECTIVE FILAMENT DIAMETER IN THESE HIGH J_C STRANDS, THE NUMBER OF SUBELEMENT RODS INCORPORATED INTO THE FINAL RESTACK BILLET HAS BEEN INCREASED TO 127 IN ROUTINE PRODUCTION, AND RESULTS WILL BE PRESENTED ON EXPERIMENTAL 217 STACK BILLET CONFIGURATIONS.

2MC-02

HIGH CURRENT NB_3SN WIRE DEVELOPED THROUGH THE CONDUCTOR DEVELOPMENT PROGRAM OF DOE ***D. R. DIETDERICH***[1]*, M. G. T. MENTINK*[2]*, A. GODEKE*[1]*;* [1]LAWRENCE BERKELEY NATIONAL LABORATORY, [2]LAWRENCE BERKELEY NATIONAL LABORATORY AND UNIVERSITY OF TWENTE. — DOE-HEP WILL CONTINUE THE DRIVE TO OBTAIN BOTH SMALLER SUB-ELEMENTS AND HIGHER CRITICAL CURRENT DENSITY FOR FIELDS OF 15T OR GREATER IN ACCELERATOR MAGNETS. THIS PAPER WILL REVIEW THE HISTORY OF THE EFFORTS TO DECREASE THE SUB-ELEMENT SIZE AND "EFFECTIVE FILAMENTS" IN NB_3SN WIRES. THIS INCLUDES THE ATTEMPTS TO INTERNAL PARTITIONING OF THE SUB-ELEMENTS BY VARIOUS TECHNIQUES, SUCH AS ADDING TA FOIL OR RODS AND ROWS OF CU. THESE EFFORTS WERE NOT ENTIRELY SUCCESSFUL. THESE PRIOR EFFORTS SUGGEST THAT THE ONLY METHOD TO DECREASE THE SUB-ELEMENTS SIZE IS TO REDUCE THEIR PHYSICAL SIZE BY MAKING WIRES WITH A GREATER NUMBER OF SUB-ELEMENTS. THE SUB-ELEMENT PRESENTLY BEING USED FOR THE CDP WAS INITIALLY DEVELOPED FOR WIRES WITH 61 SUB-ELEMENTS. IT HAS BEEN EXTENDED TO WIRE WITH 127 SUB-ELEMENTS BUT IT IS NOT OPTIMUM FOR WIRE WITH 217 OR MORE SUB-ELEMENTS. THE CDP THEREFORE INITIATED A REDESIGN OF THE SUB-ELEMENT FOR WIRES WITH 217 OR MORE SUB-ELEMENTS. WIRES ARE ALSO BEING DEVELOPED FOR A TRANSITION FROM TA TO TI DOPING. THERE ARE TWO MAIN DRIVERS: ONE IS RAW MATERIALS COST REDUCTION AND THE OTHER IS PERHAPS BETTER HIGH FIELD PERFORMANCE. RECENT MEASUREMENTS OF TI-DOPED WIRES DEVELOPED UNDER THE CDP PROGRAM HAVE ALSO SHOWN A HIGHER TENSILE FRACTURE STRAIN LIMIT THAN TA DOPED WIRES. BETTER HIGH FIELD PERFORMANCE, AND IMPROVED STRAIN TOLERANCE WILL HAVE A SIGNIFICANT IMPACT ON NB_3SN MAGNET DESIGN AND OPERATION LIMITS.

THIS WORK WAS SUPPORTED BY THE DIRECTOR, OFFICE OF SCIENCE, HIGH ENERGY PHYSICS, U.S. DEPARTMENT OF ENERGY UNDER CONTRACT NO. DE-AC02-05CH11231.

2MC-03

COARSE NB_3SN GRAIN FORMATION AND PHASE SEQUENCE DURING THE REACTION OF A HIGH SN CONTENT INTERNAL TIN STRAND ***C. E. SCHEUERLEIN***[1]*, I. PONG*[1]*, M. DI MICHIEL*[2]*, L. OBERLI*[1]*, G. ARNAU*[1]*, R. FLÜKIGER*[3]*, F. BUTA*[4]*, L. BOTTURA*[1]*;* [1]CERN, GENEVA, [2]ESRF, GRENOBLE, [3]UNIVERSITY OF GENEVA AND CERN, [4]UNIVERSITY OF GENEVA. — IN THE FRAME OF THE NED CONDUCTOR DEVELOPMENT PROGRAM DIFFERENT PROTOTYPE INTERNAL TIN NB_3SN STRANDS WITH HIGH SN CONTENT HAVE BEEN PRODUCED. THE NON-CU CRITICAL CURRENT DENSITY (J_C) OF AROUND 1500 A/MM^2@4.2 K AT 12 T OF ONE OF THESE STRANDS REMAINED BELOW THE TARGETED J_C VALUE. METALLOGRAPHIC EXAMINATION REVEALED THAT ONE REASON FOR THE COMPARATIVELY LOW J_C OF THIS STRAND IS THE FORMATION OF A SIGNIFICANT FRACTION OF COARSE GRAINED NB_3SN PHASE AROUND THE INDIVIDUAL FILAMENTS WITHIN THE SUBELEMENTS. THE PHASE SEQUENCE DURING THE REACTION HEAT TREATMENT HAS BEEN DETERMINED *IN-SITU* BY HIGH ENERGY SYNCHROTRON X-RAY DIFFRACTION AS WELL AS *EX-SITU* BY ENERGY DISPERSIVE X-RAY SPECTROSCOPY IN A SCANNING ELECTRON MICROSCOPE (SEM) IN ORDER TO BETTER UNDERSTAND THE REASONS FOR THE COARSE GRAIN FORMATION. SIMILAR TO WHAT IS OBSERVED IN THE TUBULAR TYPE STRANDS, NB_3SN COARSE GRAIN FORMATION OCCURS IN THE FILAMENT AREAS THAT HAD BEEN TRANSFORMED INTO $NBSN_2$ AND NB_6SN_5, PRIOR TO NB_3SN FORMATION, AND IT ACCOUNTS FOR AN ESTIMATED J_C REDUCTION OF ROUGHLY 20 %. THE EFFECT OF DIFFERENT TEMPERATURE RAMP RATES AND LONG LASTING LOW TEMPERATURE PLATEAUS ON THE SUCCESSIVE PHASE TRANSFORMATIONS IS DESCRIBED AND THE INFLUENCE OF THE SUBELEMENT LAYOUT ON THE FINAL AMOUNT OF COARSE GRAINED NB_3SN IS DISCUSSED.

2MC-04

PROGRESS OF NB3SN CONDUCTOR FABRICATION AT HYPER TECH RESEARCH ***X. PENG***[1]*, J. PHILLIPS*[1]*, M. RINDFLEISCH*[1]*, M. TOMSIC*[1]*, E. GREGORY*[2]*, M. D. SUMPTION*[3]*, E. W. COLLINGS*[3]*;* [1]HYPER TECH RESEARCH INC., [2]SUPERGENICS I LLC, [3]THE OHIO STATE UNIVERISTY. — NB3SN IS THE PRIMARY SUPERCONDUCTING MATERIAL FOR APPLICATIONS IN THE HIGH FIELDS (OVER 10 T), AND DEVELOPMENT EFFORTS ARE STILL BEING CARRIED OUT TO IMPROVE ITS PROPERTIES AND REDUCE THE COSTS. STANDARD ROD-IN-TUBE (RIT) BILLETS FOR HIGH ENERGY PHYSICS APPLICATIONS (HEP) AND GUN-DRILLED BILLETS FOR FUSION APPLICATIONS (ITER), ALONG WITH A NEWLY DEVELOPED TUBE TYPE CONDUCTOR ARE BEING DEVELOPED AT HYPER TECH RESEARCH INC. FOR HYPER TECH AND SUPERGENICS LLC I. FOR OUR RECENT HEP-RIT TYPE CONDUCTOR, 12 T, 4.2 K NON-CU CRITICAL CURRENT DENSITY (JC) OF 3450 A/MM2 HAS BEEN REACHED IN 61 AND 91 RESTACK OF EG36 STRANDS, AND FURTHER HEAT-TREATMENT OPTIMIZATION IS STILL POSSIBLE. FUSION CONDUCTORS HAVE REACHED 12 T JC VALUES OF 895 A/MM2 WITH LOSSES OF 310 MJ/CM3. IN THE NEW TUBE TYPE CONDUCTORS, 217 FILAMENT ARRAYS HAVE BEEN GENERATED WITH 12 T NON-CU JC VALUES OF ABOUT 2500 A/MM2. IN THIS PAPER, EFFORT WILL BE FOCUSED ON BOTH OF HEP-RIT TYPE CONDUCTOR AND GUN-DRILLED FUSION CONDUCTOR.

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2MC-05

NB3SN SUPERCONDUCTORS MADE BY AN ECONOMICAL TUBULAR PROCESS ***E. GREGORY***[1]*, X. PENG*[2]*, M. TOMSIC*[2]*, M. D. SUMPTION*[3]*, A. GHOSH*[4]*;* [1]SUPERGENICS I LLC, [2]HYPER TECH RESEARCH INC., [3]THE OHIO STATE UNIVERISTY, [4]BROOKHAVEN NATIONAL LABORATORY. — THE TUBULAR TECHNIQUE FOR ECONOMICAL PRODUCTION OF NB3SN MATERIAL WITH LARGE NUMBERS OF SUBELEMENTS IS BEING EXPLORED FURTHER BY SUPERGENICS I LLC AND HYPER TECH RESEARCH INC. THE NUMBER OF SUBELEMENTS HAS BEEN RAISED TO 919 BY INCREASING THE SIZE AT WHICH THE RESTACKING IS CARRIED OUT. THE PRODUCT EXHIBITED NO FABRICATION PROBLEMS AND WAS DRAWN DOWN AND TESTED AT A WIRE DIAMETER OF 0.42 MM, WHERE THE SUBELEMENTS ARE 10 μM IN DIAMETER. RECENTLY WE ARE INCREASING THE SUBELEMENT NUMBER TO 1387, WHICH WILL GIVE THE SUBELEMENT SIZE OF 13 μM IN 0.7 MM DIAMETER WIRE AND 8 μM IN 0.42 MM DIAMETER WIRE.HEAT TREATMENT OF DIFFERENT SUBELEMENT RESTACKS HAS BEEN INVESTIGATED INCLUDING BOTH COMPOSITIONAL AND HEAT TREATMENT CHANGES AND THE BEST RESULTS WITH JC AND STABILITY WILL BE PRESENTED.

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2MC-06

PROGRESS OF NB_3SN CONDUCTOR DEVELOPMENT FOR HIGH FIELD APPLICATIONS ***T. PYON****, H. KANITHI;* LUVATA WATERBURY, INC.. — INTERNAL-TIN PROCESSED NIOBIUM3-TIN CONDUCTORS WITH FURTHER IMPROVED PROPERTIES WERE FABRICATED, AND ITS OVERALL PERFORMANCE INCLUDING STRAIN CHARACTERISTICS IS PRESENTED. THE CONDUCTOR NEEDED FOR FUSION DEVICES IN PARTICULAR REQUIRES A RESPECTABLE LEVEL OF STRAIN LIMIT ALONG WITH SUBSTANTIALLY HIGH CURRENT CARRYING CAPACITY. IN AN ATTEMPT TO BETTER UNDERSTAND THE RELATIONSHIP BETWEEN PRIMARY STRAND DESIGN FACTORS AND MECHANICAL PROPERTIES OF WIRE, SEVERAL DIFFERENT PROTOTYPES OF STRAND WERE FABRICATED TO INVESTIGATE RESULTANT EFFECTS ON STRAND PROPERTIES OF EACH COMPOSITE DESIGN. A CONDUCTOR FOR HIGH ENERGY PHYSICS APPLICATIONS WAS FABRICATED THROUGH A NEW APPROACH, CALLED ROD-TO-RING (RTR) PROCESS IN AN EFFORT TO PRIMARILY IMPROVE FABRICABILITY OF THE COMPOSITE. THIS MATERIAL EMPLOYS AN ENHANCED DUAL BARRIER DESIGN, WHICH ALLOWS NIOBIUM LAYER TO BE REACTED ALL THE WAY THROUGH ENABLING TO IMPROVE CURRENT DENSITY. ADDITIONAL BENEFIT OF AN INCREASED RESIDUAL RESISTIVITY RATIO OF THE COMPOSITE WIRE CAN ALSO BE EXPECTED DUE TO REDUCED LOCAL CONTAMINATION OF COPPER MATRIX. COMPREHENSIVE RESULTS INCLUDING BOTH ELECTRICAL AND MECHANICAL ATTRIBUTES OF WIRES ARE DISCUSSED.

THIS WORK WAS PARTIALLY SUPPORTED BY THE US ITER PROGRAM UNDER THE CONTRACT FROM ORNL WITH THE U.S. DEPARTMENT OF ENERGY.

2MC-07

TRANSPORT, MAGNETIC, AND MICROSTRUCTURE STUDIES FOR ROD-IN-TUBE AND TUBE TYPE NB_3SN STRANDS OPTIMIZED FOR DIFFERENT OPERATIONAL REGIMES ***D. M. PUTNAM***[1]*, M. D. SUMPTION*[1]*, X. PENG*[2]*, M. TOMSIC*[2]*, T. COLLINGS*[1]*;* [1]THE OHIO STATE UNIVERSITY, [2]HYPER TECH RESEARCH, INC.. — TRANSPORT MEASUREMENTS OF HIGH PERFORMING RIT AND TUBE TYPE NB_3SN SUPERCONDUCTORS GIVEN HTS OPTIMIZED FOR 12 T, 4.2 K OPERATION WERE PERFORMED, AND NON-CU AND LAYER JC VALUES WERE COMPARED. THE RIT STRANDS HAD 61, 91, AND 127 SUBELEMENTS, AND THE TUBE TYPE STRANDS HAD UP TO 900 SUBELEMENTS; IN BOTH CASES THE STRANDS WERE 0.7 MM OD. WHILE NON-CU J_C VALUES FOR TUBE TYPE STRANDS WERE LOWER (REACHING 2450 A/MM^2 AT 4.2 K AND 12 T FOR TUBE TYPE STRANDS AS COMPARED TO 3450 A/MM^2 FOR RIT STRANDS), THE LAYER J_C VALUES WERE SIMILAR. SEM-BASED GRAIN SIZE AND STOICHIOMETRY ANALYSIS CONFIRMED SIMILAR PROPERTIES FOR THE A15 FINE GRAIN A15 REGIONS IN THESE CONDUCTORS. HT OPTIMIZATIONS FOR 15 T OPERATION (NEEDING B_{C2} IMPROVEMENT) AND 2 T OPERATION (NEEDING STABILITY IMPROVEMENT) WERE THEN INVESTIGATED FOR THE TWO CONDUCTOR TYPES. HIGHER REACTION TEMPERATURES WERE INVESTIGATED FOR THIS PURPOSE, WITH HTS IN THE 657-800C RANGE. FOR THESE STUDIES, SHORT SAMPLES WERE CUT FROM STRAIGHT SEGMENTS WHICH HAD BEEN ENCAPSULATED AND REACTED UNDER A PARTIAL PRESSURE OF AR. *M-H* LOOPS MEASUREMENTS ON THE SAMPLES WERE USED TO EXTRACT MAGNETIC J_C AS A FUNCTION OF *B* AND *T*. ADDITIONALLY, THE RESISTIVE TRANSITIONS WERE MEASURED FOR THESE SAMPLES, ALLOWING US TO OBTAIN B_{C2} AND B_{IRR} AS A FUNCTION OF TEMPERATURE.

2MP1A-01

EDGE-BARRIER PINNING IN SELF FIELD SUPERCONDUCTING THIN FILMS ***W. A. JONES***[1]*, P. N. BARNES*[1]*, M. J. MULLINS*[1]*, F. J. BACA*[2]*, R. L. S. EMERGO*[3]*, J. L. WU*[3]*, T. J. HAUGAN*[1]*;* [1]AIR FORCE RESEARCH LABORATORY, WPAFB, OHIO, 45433 USA, [2]LOS ALAMOS NATIONAL LABORATORY, LOS ALAMOS, NEW MEXICO, 87545 USA, [3]UNIVERSITY OF KANSAS, LAWRENCE, KANSAS, 66045 USA. — IT HAS BEEN PREVIOUSLY SUGGESTED THAT EDGE-BARRIER PINNING MIGHT CAUSE THE CRITICAL CURRENT DENSITY J_C MEASURED IN BRIDGED SUPERCONDUCTING FILMS TO INCREASE AS THE BRIDGES ARE NARROWED. SUBSEQUENT WORK BY OTHERS SUGGESTS THAT THIS EDGE-BARRIER EFFECT DOES NOT IMPACT BRIDGES OF MICRON SIZE OR LARGER. HOWEVER, WE PROVIDE A THEORETICAL ASSESSMENT AND SUPPORTING EXPERIMENTAL DATA THAT SUGGESTS EDGE-BARRIER PINNING CAN SIGNIFICANTLY ENHANCE J_C FOR BRIDGES OF A FEW MICRONS

OR EVEN TENS OF MICRONS IN WIDTH, SKEWING COMPARISON OF J_C AMONGST INSTITUTIONS USING DIFFERENT SIZE BRIDGES. THIS EFFECT IS NOTED STRONGLY IN SELF FIELD BUT BECOMES NEGLIGIBLE WHEN A SMALL MAGNETIC FIELD IS APPLIED. IN THE PRESENT STUDY, BRIDGES IN $YBA_2CU_3O_{7-\Delta}$ (YBCO) THIN FILMS WERE REPEATEDLY NARROWED TO AVOID ISSUES OF SAMPLE TO SAMPLE VARIATION. BRIDGE WIDTHS STARTING AT 500 μM WERE PATTERNED BY PHOTOLITHOGRAPHY, SUBSEQUENT NARROWING BELOW 50 μM WAS DONE BY FOCUSED ION BEAM MILLING. TRANSPORT J_C(77K) AND ROOM TEMPERATURE RESISTIVITY WAS DETERMINED AFTER EACH BRIDGE SIZE. THEORETICAL IMPLICATIONS OF THE NARROW BRIDGE EFFECT ON J_C(T) CURVE SHAPES WILL ADDITIONALLY BE DISCUSSED AS NOT SIMPLE SCALAR CHANGES. THIS STUDY SUGGESTS THAT THE BRIDGE WIDTH OF THE SAMPLE HAS TO BE TAKEN INTO CONSIDERATION AS WELL AS THE FILM THICKNESS FOR PROPER COMPARISON OF J_C.

2MP1A-02

CRITICAL CURRENT DENSITIES OF MOCVD TAPES FOR DIFFERENT CURRENT DIRECTIONS ***M. WEIGAND***[1]*, S. C. SPELLER*[2]*, G. M. HUGHES*[2]*, N. A. RUTTER*[1]*, S. LOZANO-PEREZ*[2]*, S. SAHONTA*[1]*, C. R. M. GROVENOR*[2]*, J. H. DURRELL*[1]*;* [1]UNIVERSITY OF CAMBRIDGE, [2]UNIVERSITY OF OXFORD. — THE CRITICAL CURRENT DENSITY JC OF AN IBAD-MOCVD COATED CONDUCTOR WAS MEASURED ON TRACKS PATTERNED LONGITUDINALLY (L) AND TRANSVERSELY (T) TO THE TAPE DIRECTION. DESPITE THE SAMPLES' VICINALITY NO DEPENDENCE OF JC ON TRACK DIRECTION WAS FOUND FOR H||C. IN ANGULAR OUT-OF-PLANE MEASUREMENTS THE PREVIOUSLY REPORTED ASYMMETRY DUE TO TILTED DEFECT PLANES WAS OBSERVED IN AN L TRACK, WHEREAS CURVES FROM A T TRACK WERE ALMOST PERFECTLY SYMMETRIC WITH SIMILARLY HIGH ABSOLUTE VALUES OF JC. AT LOW FIELDS THE EFFECTS OF SURFACE PINNING WERE SEEN. IN MEASUREMENTS WHERE THE MAGNETIC FIELD WAS SWEPT IN THE FILM PLANE THE ANISOTROPY WAS FOUND TO BE SIGNIFICANTLY HIGHER THAN FOR RABITS-MOD SAMPLES, WHICH WE EXPLAIN BY THE DIFFERENT MORPHOLOGY OF GRAIN BOUNDARIES IN THE TAPES, INVESTIGATED BY TEM. AT LOW TEMPERATURES JC OF A T TRACK EXHIBITED THE CLEAR SIGNATURE OF VORTEX CHANNELLING.AN ISOLATED GRAIN BOUNDARY SHOWED A HIGH CRITICAL CURRENT DENSITY IN AN IN-PLANE MEASUREMENT, WHICH WE ATTRIBUTE TO THE STRONG TEXTURE OF THE IBAD BUFFER.OUR RESULTS SHOW THAT IN MOST SCENARIOS JC IS EQUALLY AS GOOD PARALLEL AND PERPENDICULAR TO THE TAPE DIRECTION, WHICH IS PARTICULARLY RELEVANT FOR ROEBEL CABLES.

WE ARE GRATEFUL TO SUPERPOWER AND AMERICAN SUPERCONDUCTOR FOR SUPPLYING THE SAMPLES.

2MP1A-03

COMPARISON OF CURRENT LIMITING DEFECTS IN $YBA_2CU_3O_{7-X}$ AND $BA(FE_{1-X}CO_X)AS_2$ FILMS AND BULK $BI_2SR_2CA_1CU_2O_8$ FILAMENTS ***D. ABRAIMOV***[1]*, P. LI*[1]*, R. FEENSTRA*[2]*, X. LI*[3]*, M. RUPICH*[3]*, F. KAMETANI*[1]*, S. LEE*[4]*, C. EOM*[4]*, J. JIANG*[1]*, J. WEISS*[1]*, E. HELLSTROM*[1]*, D. C. LARBALESTIER*[1]*;* [1]NATIONAL HIGH MAGNETIC FIELD LABORATORY, [2]OAK RIDGE NATIONAL LABORATORY, [3]AMERICAN SUPERCONDUCTORS CORPORATION, [4]DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING, UNIVERSITY OF WISCONSIN. — CURRENT LIMITING DEFECTS IN SUPERCONDUCTORS GENERATE STRONG NON-UNIFORMITIES IN LOCAL ELECTRIC FIELDS (E) DUE TO THE NONLINEAR E(J) CHARACTERISTICS OF THE SUPERCONDUCTING STATE. THE LOW TEMPERATURE LASER SCANNING MICROSCOPE (LTLSM) CAN IMAGE (E(X,Y) WITH ABOUT 2-3 UM RESOLUTION OVER A WIDE RANGE OF **E**, T AND $\mathbf{H_{EXT}}$. WE FIRST REPORT THE EFFECTS OF CURRENT LIMITING DEFECTS IN $YBA_2CU_3O_{7-X}$ AND $BA(FE_{1-X}CO_X)AS_2$ FILMS. FOR $BA(FE_{1-X}CO_X)AS_2$ FILMS GROWN ON 3^O, 5^O, 9^O $SRTIO_3$ [001] TILT BICRYSTALS, WE FOUND THAT THE GRAIN BOUNDARY (GB) ELECTRIC FIELD WAS ENHANCED EVEN FOR 3^O MISORIENTATION. WE FOUND THAT E(X,Y) NEAR GBS WAS QUALITATIVELY SIMILAR TO THAT FOUND IN $YBA_2CU_3O_{7-X}$ COATED CONDUCTORS (CC). WE ARE NOW APPLYING THE LTLSM TO THE STUDY OF CURRENT FLOW ALONG INDIVIDUAL BUT POLYCRYSTALLINE $BI_2SR_2CA_1CU_2O_8$ FILAMENTS, COMBINING THE LTLSM IMAGES WITH ORIENTATION IMAGING MICROSCOPY IMAGES OF THE LOCAL GRAIN STRUCTURE. WE WILL DESCRIBE A MEANS OF SCANNING WITH VARIABLE HEIGHTS AND SUBSEQUENT STITCHING OF THE VOLTAGE RESPONSES. WE WILL COMPARE THE ROLE OF MORE COMPLEX GBS IN SUCH $BI_2SR_2CACU_2O_X$ FILAMENTS TO THE QUASI-IDEAL THIN FILM $YBA_2CU_3O_{7-\Delta}$ AND $BA(FE_{1-X}CO_X)$ BICRYSTALS.

2MP1A-04

INVESTIGATION ON THE IN-SITU HIGH TEMPERATURE RESISTANCE MEASUREMENT OF MONO-FILAMENT BI-2223/AG TAPES AT VARIOUS OXYGEN PARTIAL PRESSURES ***K. HUANG****, T. QU, Z. HAN, P. ZENG;* TSINGHUA UNIVERSITY. — IN THIS WORK, WE PROVED THAT THE IN-SITU HIGH TEMPERATURE RESISTANCE MEASUREMENT IS A NOVEL AND SENSITIVE METHOD FOR DETECTING THE PHASE TRANSFORMATION AMONG BI-2223/AG TAPES, ESPECIALLY FOR LEAD-RICH PHASES. BY ETCHING AWAY THE OUTSIDE METAL SHEATH, THE RESISTANCE OF THE CERAMIC FILAMENT INSIDE A MONO-FILAMENT BI-2223/AG TAPE CAN BE MEASURED AS A FUNCTION OF VARIOUS HEAT TREATMENT CONDITIONS, SUCH AS TEMPERATURE AND OXYGEN PARTIAL PRESSURE. THE HEAT TREATMENT PROCESS OF GREEN TAPES WAS INVESTIGATED BY USING THIS IN-SITU HIGH TEMPERATURE R-T MEASUREMENT AT VARIOUS OXYGEN PARTIAL PRESSURES (0.01 BAR TO 1 BAR). XRD PATTERNS OF KEY SAMPLES QUENCHED FROM SOME CHARACTERISTIC POINTS WERE ALSO MEASURED. IT WAS FOUND THAT THE PEAKS AND VALLEYS OF THE R-T CURVES CAN BE RELATED TO THE FORMATIONS AND DECOMPOSITIONS OF LEAD-RICH PHASES, SUCH AS THE (BI, PB)-2212 PHASE, THE 3321 PHASE AND THE LIQUID PHASE. FOR EXAMPLE, AT 8% OXYGEN PARTIAL PRESSURE IN OUR TAPES, THE 3321 FORMS AT AROUND 550 ^{O}C, AND THIS TEMPERATURE DECREASES AS THE OXYGEN PARTIAL PRESSURE INCREASES. THE FORMATION TEMPERATURE OF THE (BI,PB)-2212 PHASE AND THE LIQUID PHASE WERE 760 ^{O}C AND 810 ^{O}C, RESPECTIVELY. THEY BOTH

INCREASE WITH INCREASING OXYGEN PARTIAL PRESSURE. THROUGH THESE R-T CURVES, A STABILITY PHASE DIAGRAM FOR LEAD-RICH PHASES WAS DRAWN. WE BELIEVE THIS METHOD CAN ALSO BE APPLIED TO OTHER CERAMIC OXIDE SYSTEMS.

2MP1A-05

THICKNESS DEPENDENCE OF CRITICAL CURRENTS OF $SM_{1+X}BA_XCU_3O_Y$ COATED CONDUCTORS INVESTIGATED BY POLARIZED-RAMAN SCATTERING SPECTROSCOPY *G. KIM[1], **W. JO**[1], H. S. HA[2], S. S. OH[2], D. Y. PARK[3], H. CHEONG[3];* [1]EWHA WOMANS UNIVERSITY, [2]KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE (KERI), [3]SOGANG UNIVERSITY. — $SMBA_2CU_3O_{7-\Delta}$ (SMBCO) COATED CONDUCTORS WITH DIFFERENT THICKNESS FROM 1 MM TO 4 MM WERE FABRICATED ON IBAD-MGO TEMPLATES BY A DRUM-IN-DUAL-CHAMBER (EDDC) DEPOSITION SYSTEM. THE COATED CONDUCTORS WITH THICKNESS SMALLER THAN 3 MM SHOW CRITICAL TEMPERATURE OF 92 ~ 94 K AND CRITICAL CURRENT OF 150 ~ 500 A/CM-W AT 77 K AND SELF-FIELD. HOWEVER, THE CONDUCTOR WITH 4 MM SUDDENLY EXHIBITS NO CRITICAL CURRENT AT 77 K. IN ORDER TO INVESTIGATE THE PHONON MODES AND CATION DISORDERS OF THE SMBCO COATED CONDUCTORS, WE HAVE ANALYZED THE COATED CONDUCTORS USING RAMAN POLARIZATION SCATTERING SPECTROSCOPY, X-RAY DIFFRACTION (XRD), ELECTRONIC MICROSCOPY. ACCORDING TO THE XRD PATTERNS, THE SAMPLES SHOW (00*L*) PEAKS OF THE SMBCO PHASE. IN THE RAMAN DATA, THERE ARE COMMON WITH VIBRATION MODES WHICH ARE BA-BA STRETCHING, O(2)+/O(3)-, O(2)+/O(3)+, AND APICAL O(4) MODES. IN PARTICULAR, THE CONDUCTOR WITH 4 MM OF THICKNESS SHOWS PEAKS OF SECONDARY PHASES. IN ADDITION, POLARIZED RAMAN SPECTRA WERE OBTAINED TO INVESTIGATE CRYSTAL ORIENTATION AND GRAIN GROWTH BEHAVIORS. IT IS CONFIRMED THAT RAMAN SPECTROSCOPY IS VERY USEFUL TO INVESTIGATE THE QUALITY OF THE COATED CONDUCTORS.

2MP1A-06

JOSEPHSON EFFECT AND ANDREEV REFLECTION STUDIES ON 122 IRON PNICTIDE SINGLE CRYSTALS ***X. ZHANG**[1], S. R. SAHA[1], N. P. BUTCH[1], K. KIRSHENBAUM[1], J. PAGLIONE[1], R. L. GREENE[1], I. TAKEUCHI[1], Y. S. OH[2], Y. LIU[2], L. Q. YAN[2], K. H. KIM[2];* [1]UNIVERSITY OF MARYLAND, COLLEGE PARK, USA, [2]SEOUL NATIONAL UNIVERSITY, SEOUL, REPUBLIC OF KOREA. — TO INVESTIGATE THE NATURE OF SUPERCONDUCTIVITY AND TO EXPLORE POTENTIAL DEVICE APPLICATIONS, WE HAVE FABRICATED TWO TYPES OF JOSEPHSON JUNCTIONS USING VARIOUS SINGLE CRYSTALS OF 122 PNICTIDE SUPERCONDUCTORS: JUNCTIONS BETWEEN *S*-WAVE SUPERCONDUCTORS AND IRON PNICTIDE SUPERCONDUCTORS AND JUNCTIONS BETWEEN ELECTRON-DOPED AND HOLE-DOPED IRON PNICTIDE SUPERCONDUCTORS. CLEAR AC JOSEPHSON EFFECT AND FRAUNHOFER-LIKE MAGNETIC DIFFRACTION PATTERNS HAVE BEEN OBTAINED IN BOTH TYPES OF JUNCTIONS. THE OBSERVED *C*-AXIS JOSEPHSON COUPLING BETWEEN A 122 IRON PNICTIDE SUPERCONDUCTOR AND AN *S*-WAVE SUPERCONDUCTOR STRONGLY SUPPORTS THE PRESENCE OF AN *S*-WAVE COMPONENT IN THE IRON PNICTIDE SUPERCONDUCTOR. THE OBSERVED JOSEPHSON EFFECT IN THE *P-N* BICRYSTAL JUNCTIONS INDICATES THAT PHASE COHERENCE CAN BE ESTABLISHED BETWEEN THESE SUPERCONDUCTORS. SUCH A PHASE-COHERENT *P-N* STRUCTURE IS IMPORTANT FOR PERFORMING DEFINITIVE PHASE-SENSITIVE TESTS FOR THE PROPOSED *S*± SYMMETRY IN IRON PNICTIDE SUPERCONDUCTORS [1]. OUR POINT-CONTACT ANDREEV REFLECTION MEASUREMENTS INDICATE A UNIVERSAL AND ISOTROPIC COUPLING STRENGTH IN THE 122 FAMILY OVER A WIDE DOPING RANGE, INDEPENDENT OF THE SIGN OF THE DOPING.[1] D. PARKER AND I. I. MAZIN, PHYS. REV. LETT. **102**, 227007 (2009).

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2MP1A-07

PERFORMANCES OF TRAPPED MAGNETIC FIELD IN SUPERCONDUCTING BULK MAGNETS ACTIVATED BY PULSED FIELD MAGNETIZATION ***T. OKA**[1], H. YAMAZAKI[1], H. SEKI[1], J. OGAWA[1], S. FUKUI[1], T. SATOH[1], K. YOKOYAMA[2];* [1]NIIGATA UNIVERSITY, [2]ASHIKAGA INSTITUTE OF TECHNOLOGY. — MELT-TEXTURED LARGE GRAIN HIGH TEMPERATURE SUPERCONDUCTING MATERIALS HAVE A CHARACTERISTIC FEATURE SO AS TO TRAP THE APPLIED FIELDS FROM OUTSIDE, AND ACT AS TRAPPED FIELD MAGNETS YIELDING THE INTENSE MAGNETIC FIELDS WHICH REACH SEVERAL T IN THE OPEN SPACE ABOVE THE SAMPLE SURFACE. THE PERFORMANCES OF THE MAGNETS HAVE BEEN PRECISELY INVESTIGATED WHEN INTENSE PULSED MAGNETIC FIELDS GENERATED BY FEEDING THE CURRENTS OVER SEVERAL THOUSAND AMPERES TO THE PULSE COILS SETTLED AROUND THE CYLINDRICAL BULK MAGNET SAMPLE. IN THE EXPERIMENT THE CONDENSER BANK WITH LARGE CAPACITY OF 40-120 MF HAS BEEN ADAPTED TO APPLY THE MAGNETIC FIELDS UP TO 8.5 T TO THE GD-BA-CU-O-BASED BULK MAGNET WITH THE SIZE OF 30 MM IN DIAMETER. THE PERFORMANCE OF THE TRAPPED FIELD HAS REACHED 3.04 T ON THE SAMPLE SURFACE. THE MAGNETIC FIELDS SUCCESSIVELY INVADING INTO THE SAMPLE THROUGH THE PROCESS CALLED IMRA METHOD HAVE BEEN INVESTIGATED WITH RESPECT TO THE BEHAVIORS OF THE MAGNETIC FLUXES IN THE SAMPLE.PRESENTATION PREFERENCE; ORAL

2MP1B-01

DETECTION OF FINE PECULIARITIES OF THE HEAT CAPACITY OF YBACUO THIN FILMS BY IMAGING OF THEIR S/N PHASE TRANSITION BY A HIGHLY SENSITIVE SFCO-TECHNIQUE, USING A WELL FOCUSED LASER BEAM AS A PROBE ***S. GEVORGYAN**[1], G. KARAPETYAN[1], H. SHIRINYAN[2], S. MURADYAN[1], G. GEVORGYAN[1], A. POLYANSKII[3];* [1]YEREVAN STATE UNIVERSITY, FACULTY OF PHYSICS, ARMENIA, [2]NAS OF ARMENIA, INSTITUTE FOR PHYSICAL RESEARCHES, ARMENIA, [3]NHMF LABORATORY, FLORIDA STATE UNIVERSITY,

TALLAHASSEE, USA. — WE DISCUSS A "HYBRID" IMAGING METHOD BASED ON THE LASER SCANNING MICROSCOPY (LSM), IN COMBINATION WITH A RECENTLY INTRODUCED BY US SINGLE-LAYER FLAT-COIL-OSCILLATOR METHOD (SFCO-TECHNIQUE), CAPABLE OF IMAGING NORMAL-TO-SUPERCONDUCTIVE (N/S) PHASE TRANSITION OF THIN, FLAT HTSC MATERIALS WITH ABOUT 1-2 MICROMETER SPATIAL RESOLUTION. IT ENABLED TO DETECT WEAKLY EXPRESSED PECULIARITIES OF THE HEAT CAPACITY OF YBACUO THIN-FILM BRIDGES. IT ALLOWED ALSO VISUALIZING OF THE GRAIN STRUCTURE, AS WELL AS ITS TEMPERATURE DEPENDENCE IN THIN FILMS UNDER STUDY (WITH THE SAME SPATIAL RESOLUTION). THE METHOD USES A FOCUSED HE-NE LASER BEAM AS A PROBING SIGNAL, AND THE SFCO TECHNIQUE AS A HIGHLY SENSITIVE DETECTING TOOL. COMPARATIVE ANALYSIS OF THE RESULTS OBTAINED BY THESE "HYBRID" METHOD, IF COUPLED WITH MAGNETO-OPTICAL IMAGING DATA, MAY GIVE AN OPPORTUNITY TO DETERMINE INFLUENCE OF MANUFACTURE TECHNOLOGY ON THE QUALITY OF THIN HTSC MATERIALS. THAT IS OF PRIME IMPORTANCE FOR THE IMPROVEMENT OF PRODUCTION QUALITY OF INDUSTRIAL SC SYSTEMS WITH HIGH CRITICAL CHARACTERISTICS.

THE STUDY WAS SUPPORTED BY THE ARMENIAN NFSAT & U.S. CRDF FOUNDATIONS UNDER GRANTS ISIPA 01-04 AND UCEP 07/07. THE STUDY WAS SUPPORTED ALSO BY STATE SOURCES OF ARMENIA IN FRAMES OF THE AWARD 72-103.

2MP1B-02

PRECURSOR TO SUPERCONDUCTIVITY FINE EFFECTS: THEIR CRUCIAL ROLE FOR TRUE UNDERSTANDING OF THE NATURE OF SUPERCONDUCTIVITY ***S. GEVORGYAN****, V. GEVORGYAN;* YEREVAN STATE UNIVERSITY, FACULTY OF PHYSICS, ARMENIA. — THE PROBLEM OF ELECTRON PAIRING ABOVE THE MEISSNER EXPEL RAISED ONLY AFTER HTSC MATERIALS WERE DISCOVERED. IT IS ADMITTED NOW, THAT THERE IS NEED TO CONSIDER 2 PROCESSES FOR HTSC MATERIALS - THE ELECTRON PAIRING & ONSET OF THE PHASE COHERENCE - SEPARATELY & INDEPENDENTLY OF ONE ANOTHER. SO, SUPERCONDUCTIVITY IN HTSC REQUIRES BOTH PAIRING & PAIR CONDENSATION. OTHERWISE, IN HTSC ELECTRONS BECOME PAIRED ABOVE THE MEISSNER EXPEL & START FORMING CONDENSATE AT TC ONLY, WHILE IN LTSC IT IS ASSUMED, THAT THE PAIRING & PHASE COHERENCE AMONG PAIRS HAPPENS SIMULTANEOUSLY: DUE TO LARGE SIZES OF COOPER PAIRS THEIR WAVEFUNCTIONS ARE OVERLAPPING IN LTSC MATERIALS. HOWEVER, DETECTED BY US IN LTSC TIN "PARAMAGNETIC" PRECURSOR TO SC'Y, AND RELATED TO IT THERMAL EFFECT (NOTICED BEFORE TIN'S SPECIFIC-HEAT'S JUMP BY CORAK) PROVIDE AN ARGUMENT TO HAVE AN OPPOSITE OPINION REGARDING LTSCS. SO, WE ASSUME, THERE ARE NO DIFFERENCES BETWEEN HTSC & LTSC REGARDING THESE 2 PROCESSES: APPARENTLY, PAIRING & ONSET OF THE PHASE COHERENCE ARE SEPARATE & INDEPENDENT EVEN IN LTSC. DIFFERENCE IS IN TEMPERATURE SCALES. FOR LTSC, THE PROCESS RUNS IN 10MK, WHILE FOR HTSC - THE SCALE IS 1K. THIS IS THE REASON WHY SEPARATION OF THESE PROCESSES FOR LTSC WAS PROBLEMATIC SO FAR. WE DISCUSS HOW ONE MAY DO THAT FOR THE LTSC BY USE OF OUR SENSITIVE SFCO-TECHNIQUE.

THE STUDY WAS SUPPORTED BY THE ARMENIAN NFSAT & U.S. CRDF FOUNDATIONS UNDER GRANTS ISIPA 01-04 AND UCEP 07/07. THE STUDY WAS SUPPORTED ALSO BY STATE SOURCES OF ARMENIA IN FRAMES OF THE AWARD 72-103.

2MP1B-04

NUMERICAL INVESTIGATION ON APPLICABILITY OF INDUCTIVE METHOD/PERMANENT MAGNET METHOD TO J_C-MEASUREMENT IN HTS THIN FILM ***T. TAKAYAMA****, A. KAMITANI, K. HATTORI, A. SAITO, S. OHSHIMA;* YAMAGATA UNIVERSITY. — THE FOUR-PROBE METHOD IS GENERALLY USED TO MEASURE A CRITICAL CURRENT DENSITY J_C. HOWEVER, THE METHOD MAY LEAD TO DEGRADATION OF THE HTS CHARACTERISTICS. THUS, NONCONTACT METHODS HAVE BEEN DESIRED FOR MEASURING J_C.CLAASSEN ET AL. PROPOSED THE INDUCTIVE METHOD. BY APPLYING AN AC CURRENT TO A COIL PLACED JUST ABOVE AN HTS FILM, THEY MONITORED A HARMONIC VOLTAGE INDUCED IN THE COIL. CONSEQUENTLY, THEY FOUND THAT J_C CAN BE EVALUATED FROM A THRESHOLD CURRENT FOR ONSET OF THE THIRD-HARMONIC VOLTAGE. IN CONTRAST, OHSHIMA ET AL. PROPOSED THE PERMANENT MAGNET METHOD. WHILE MOVING A PERMANENT MAGNET PLACED ABOVE AN HTS FILM, THEY MEASURED AN ELECTROMAGNETIC FORCE ACTING ON THE FILM, AS A RESULT, THEY FOUND THAT THE MAXIMUM REPULSIVE FORCE F_M IS ALMOST PROPORTIONAL TO J_C. THIS MEANS THAT J_C CAN BE ESTIMATED BY MEASURING F_M.IN ORDER TO SIMULATE TWO NONCONTACT METHODS, A NUMERICAL CODE HAS BEEN DEVELOPED FOR ANALYZING THE TIME EVOLUTION OF A SHIELDING CURRENT DENSITY IN A NON-AXISYMMETRIC HTS FILM. BY USING THE CODE, TWO NONCONTACT METHODS ARE REPRODUCED NUMERICALLY. THE RESULTS OF COMPUTATIONS SHOW THAT, NEAR THE FILM EDGE, J_C CANNOT BE ACCURATELY EVALUATED BY MEANS OF THE INDUCTIVE METHOD. IN CONTRAST, EVEN IF THE MAGNET IS PLACED NEAR THE FILM EDGE, F_M IS ROUGHLY PROPORTIONAL TO J_C. THIS MEANS THAT J_C NEAR THE FILM EDGE CAN BE ESTIMATED BY USING THE PERMANENT MAGNET METHOD.

2MP1B-05

HIGH-PERFORMANCE SIMULATION OF SHIELDING CURRENT DENSITY IN HTS BY CONSTITUTIVE-RELATION RELAXATION METHOD ***A. KAMITANI***[1]***, T. TAKAYAMA***[1]***, S. IKUNO***[2]*; [1]YAMAGATA UNIVERSITY, [2]TOKYO UNIVERSITY OF TECHNOLOGY. — A HIGH-PERFORMANCE METHOD HAS BEEN PROPOSED FOR CALCULATING THE SHIELDING CURRENT DENSITY IN A HIGH-TEMPERATURE SUPERCONDUCTING THIN FILM. AFTER SPATIALLY DISCRETIZED, THE INITIAL-BOUNDARY-VALUE PROBLEM OF THE SHIELDING CURRENT DENSITY IS REDUCED TO A SYSTEM OF FIRST-ORDER ORDINARY DIFFERENTIAL EQUATIONS THAT HAS A STRONG NONLINEARITY. HOWEVER, THE SYSTEM CANNOT BE ALWAYS SOLVED BY MEANS OF THE RUNGE-KUTTA METHOD EVEN WHEN AN ADAPTIVE STEP-SIZE CONTROL ALGORITHM IS

INCORPORATED TO THE METHOD. IN ORDER TO SUPPRESS AN OVERFLOW IN THE ALGORITHM, THE FOLLOWING METHOD IS PROPOSED: THE J-E CONSTITUTIVE RELATION IS MODIFIED SO THAT ITS SOLUTION MAY SATISFY THE ORIGINAL CONSTITUTIVE RELATION. THROUGHOUT THE PRESENT STUDY, THE PROPOSED METHOD IS CALLED A CONSTITUTIVE-RELATION RELAXATION METHOD.A NUMERICAL CODE FOR ANALYZING THE SHIELDING CURRENT DENSITY HAS BEEN DEVELOPED ON THE BASIS OF THE CONSTITUTIVE-RELATION RELAXATION METHOD AND, AS AN APPLICATION OF THE CODE, TWO TYPES OF THE CONTACTLESS METHODS FOR MEASURING THE CRITICAL CURRENT DENSITY HAVE BEEN NUMERICALLY INVESTIGATED.

2MP1B-07

STRENGTH OF THE PHONON-COUPLING MODE IN LA2-XSRXCUO4, BI2SR2CACU2O8+X AND YBA2CU3O6+X: AN ESTIMATION FROM THE ARPES-NODAL MEASUREMENTS. ***H. S. RUIZ****, A. BADÍA-MAJÓS;* UNIVERSIDAD DE ZARAGOZA–C.S.I.C.. — RECENT ADVANCES IN HIGH RESOLUTION ANGLE-RESOLVED PHOTOEMISSION SPECTROSCOPIES HAVE SUGGESTED THAT A SIZEABLE ELECTRON-PHONON COUPLING EXISTS AS THE PRINCIPAL CAUSE FOR KINKS IN THE DISPERSION RELATIONS OF THE ELECTRONIC STATES. HERE, WE REPORT ON A SYSTEMATIC STUDY ABOUT THE INFLUENCE OF THE E-PH COUPLING PARAMETER “LAMBDA” IN THE ELECTRONIC QUASIPARTICLE DISPERSIONS ALONG THE NODAL DIRECTION FOR LSCO, BSCCO AND YBCO. OUR ANALYSIS SHOWS A REMARKABLE AGREEMENT BETWEEN THEORY AND EXPERIMENT FOR DIFFERENT SAMPLES AND AT DIFFERENT DOPING LEVELS. THIS INCLUDES OUR RECENTLY INTRODUCED THEORETICAL MODEL TO ADJUST THE EXPERIMENTAL DATA OF THE FERMIONIC BAND DISPERSION [1]. IN LSCO, THE COUPLING CONSTANT \LAMBDA, CALCULATED CONSISTENTLY WITH THE NODAL KINK DISPERSIONS, REPRODUCES THE OBSERVED CRITICAL TEMPERATURES TC, THE GAP RATIO 2\DELTA/KBTC, AND OTHER PARAMETERS WHICH HAVE BEEN STUDIED FROM SEVERAL EQUATIONS. IT WILL BE CONCLUDED THAT THE STRONG RENORMALIZATION OF THE BAND STRUCTURE CAN BE EXPLAINED IN TERMS OF THE PHONON COUPLING MODE, AND MUST THEREFORE BE INCLUDED IN ANY MICROSCOPIC THEORY OF SUPERCONDUCTIVITY. NEVERTHELESS, IT SEEMS UNAVOIDABLE TO CONSIDER ADDITIONAL MECHANISMS THAT JUSTIFY THE HIGHER CRITICAL TEMPERATURES OBSERVED IN BSCCO AND YBCO SAMPLES.[1] PHYS. REV. B 79, 054528 (2009).

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2MP1B-08

MAPPING OF THE TRANSVERSAL RESISTIVITY MATRIX MEASURED ON NBTI AND NB_3SN SUPERCONDUCTING STRANDS ***V. CORATO****, L. MUZZI, U. BESI VETRELLA, C. FIAMOZZI ZIGNANI, A. DELLA CORTE;* ENEA. — THE KNOWLEDGE OF THE MATRIX TRANSVERSE RESISTIVITY IN SUPERCONDUCTING STRANDS IS A KEY POINT FOR DESCRIBING THE COUPLING LOSSES IN AC REGIME, OR PREDICTING THE NB_3SN WIRES PERFORMANCES IN PRESENCE OF BENDING STRAIN. A 4-PROBES METHOD HAS BEEN IMPLEMENTED AT ENEA IN ORDER TO OBTAIN A DIRECT MEASUREMENT OF THE RESISTANCE BETWEEN TWO SELECTED FILAMENT BUNDLES IN INTERNAL TIN NB_3SN MULTI-FILAMENTARY WIRES [1]. HERE WE EXTEND THE MEASUREMENTS TO NB_3SN STRANDS WITH DIFFERENT LAYOUT OR PRODUCTION TECHNIQUE, INCLUDING A STUDY ON THE EFFECT OF THE HEAT TREATMENT ON THE INTER-FILAMENT RESISTIVITY. FOR STRANDS WITH EITHER A DISTRIBUTED TA-NB DIFFUSION BARRIER DESIGN, OR WITH A SINGLE TA DIFFUSION BARRIER BETWEEN THE FILAMENTARY REGION AND THE STABILIZING COPPER SHELL, A DETAILED MAPPING OF THE TRANSVERSAL RESISTIVITY MATRIX HAS BEEN ACHIEVED, WITH IMPORTANT APPLICATIONS IN THE STUDY OF THERMAL INSTABILITIES AS A FUNCTION OF THE STRAND LAYOUT. FINALLY, THE EFFECT OF THE CU/NON CU RATIO INTO THE STRAND CROSS SECTION HAS BEEN STUDIED IN NBTI WIRES. THE TEMPERATURE AND MAGNETIC FIELD DEPENDENCE OF THE RESISTIVITY HAS BEEN MEASURED FOR ALL SAMPLES.[1] V. CORATO, L. MUZZI, U. BESI VETRELLA, AND A. DELLA CORTE, “DIRECT MEASUREMENT OF INTER-FILAMENT RESISTANCE IN NB3SN STRANDS”, J. APPL. PHYS. 105, 0939301-5 (2009).

2MP1B-10

SAMPLE LENGTH EFFECT ON MAGNETIZATION MEASUREMENTS OF STATE OF THE ART NB3SN WIRES ***B. BORDINI****[1], D. BESSETTE[2], L. BOTTURA[1], A. DEVRED[1], M. JEWELL[2], D. RICHTER[1], C. SENATORE[3];* [1]CERN, [2]ITER-IO, [3]UNIVERSITY OF GENEVA. — MAGNETIZATION MEASUREMENTS ARE RELEVANT TESTS FOR THE CHARACTERIZATION OF SUPERCONDUCTORS FOR ACCELERATOR AND FUSION MAGNETS. IN PRACTICE, THEY ARE THE ONLY MEASUREMENTS THAT ALLOW ESTIMATING THE CRITICAL CURRENT DENSITY AT LOW FIELDS, THE EFFECTIVE FILAMENT SIZE AND THE HYSTERESIS LOSSES. FOR THIS PURPOSE, CERN, IN COLLABORATION WITH THE UNIVERSITY OF GENEVA, HAS CARRIED OUT MAGNETIZATION MEASUREMENTS ON NB3SN WIRES FOR ITER (BRONZE STRAND) AND FOR ACCELERATOR MAGNETS (PIT, RRP STRANDS). THE FIELD DEPENDENT MAGNETIZATION HAS BEEN DETERMINED USING TWO SET-UPS: A STANDARD VSM AND A SPECIAL SYSTEM USED FOR THE PRODUCTION CONTROL OF LHC STRAND CAPABLE OF MEASURING STRAIGHT SAMPLES UP TO 20 CM LONG. SAMPLES OF DIFFERENT LENGTH HAVE BEEN TESTED TO CHECK THE DIFFERENT COUPLING BETWEEN THE FILAMENTS. UNEXPECTEDLY, IT WAS FOUND THAT THE MAGNETIZATION IS STRONGLY DEPENDENT ON THE SAMPLE LENGTH EVEN FOR SOME TYPES OF BRONZE WIRES. IN THIS PAPER, THE RESULTS, WHICH WERE OBTAINED FOR DIFFERENT TYPE OF STRANDS AND SAMPLE LENGTHS FROM THE TWO SET-UPS, ARE REPORTED AND COMPARED. FINALLY THE MAGNETIZATION CURVES ARE USED TO DETERMINE THE LOW-FIELD JC AND THE EFFECTIVE FILAMENT SIZE.

2MP1C-01

MEASUREMENT OF TRANSPORT CHARACTERISTICS IN HTS CONDUCTORS BY USING HTS CURRENT TRANSFORMER ***S. KAWABATA****, T. HIRAYAMA, Y. KIRIHARA;* KAGOSHIMA UNIVERSITY. — IN ORDER TO REALIZE HTS POWER MACHINES AND DEVICES WITH HIGH PERFORMANCES, IT IS IMPORTANT TO EVALUATE THE CHARACTERISTICS OF HTS CONDUCTORS QUANTITATIVELY. WE DEVELOPED A COMPACT MEASUREMENT SYSTEM OF THE TRANSPORT CHARACTERISTICS IN HTS CONDUCTORS. THIS SYSTEM ENABLES US TO MEASURE THE TRANSPORT CURRENT LOSSES AND THE CURRENT DISTRIBUTIONS IN THE STRAIGHT HTS CONDUCTORS UP TO THE CURRENT CAPACITY OF 1 KA CLASS. THE MEASUREMENT OF TRANSPORT CURRENT LOSSES IS DONE BY THE POYNTING VECTOR METHOD. THE DISTRIBUTION OF POYNTING VECTORS AROUND THE SAMPLE CONDUCTOR CAN BE OBTAINED BY USING MANY SETS OF BOTH A POTENTIAL LEAD AND A PICKUP COIL. THE MEASUREMENT OF CURRENT DISTRIBUTIONS IS PERFORMED BY USING PICKUP COILS. IN THIS SYSTEM, A HTS CURRENT TRANSFORMER IS USED TO FEED CURRENT TO THE SAMPLE CONDUCTOR FOR THE MEASUREMENT. THE SECONDARY CURRENT OF THIS CURRENT TRANSFORMER CAN BE INDUCED AT ABOUT 1KA AT 77K WHEN THE PRIMARY CURRENT IS 40A. THE SAMPLE CONDUCTOR IS CONNECTED WITH THE SECONDARY COIL OF THIS CURRENT TRANSFORMER. AS A SAMPLE CONDUCTOR, WE USED A PARALLEL CONDUCTOR CONSISTED OF 16 AG-SHEATHED BI-2223 MULTIFILAMENTARY TAPES. ON THE BASIS OF THE MEASURED RESULTS OF TRANSPORT CURRENT LOSSES AND CURRENT DISTRIBUTIONS, THE USEFULNESS OF THIS MEASUREMENT SYSTEM IS DISCUSSED.

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2MP1C-02

EXPERIMENTAL CHARACTERIZATION OF THE ELECTRICAL RESISTANCE OF COATED CONDUCTORS AT HIGH CURRENT DENSITIES AND VARIABLE TEMPERATURE ***C. LACROIX****[1], J. COULOMBE[2], F. SIROIS[2], F. ROY[3], B. DUTOIT[3], J. CAVE[1];* [1]IREQ - HYDRO-QUEBEC, [2]ECOLE POLYTECHNIQUE DE MONTREAL, [3]ECOLE POLYTECHNIQUE FEDERALE DE LAUSANNE. — SUPERCONDUCTING FAULT CURRENT LIMITERS (SFCLS) ARE ONE OF THE MOST PROMISING APPLICATIONS OF HIGH TEMPERATURE SUPERCONDUCTORS (HTS) IN POWER SYSTEMS, ESPECIALLY IN THE FORM OF THIN FILMS OR LONG LENGTHS OF COATED CONDUCTORS. IN ORDER TO PROGRESS TOWARDS ROBUST AND RELIABLE DESIGNS, A VERY GOOD KNOWLEDGE OF THE ELECTRICAL PROPERTIES OF HTS IN THE OVER-CRITICAL CURRENT REGIME IS REQUIRED. HOWEVER, THE CHARACTERIZATION OF HTS MATERIALS IN THIS REGIME IS DIFFICULT, AS IT INVOLVES STRONG HEATING EFFECTS THAT CAN DAMAGE THE SAMPLE. IN THIS PAPER, WE USED AN ULTRA-FAST (1000 A, 10 US) REGULATED CURRENT PULSE COUPLED WITH A PRESSURIZED LIQUID NITROGEN CRYOSTAT IN ORDER TO OBTAIN THE RESISTANCE OF FULL-SIZE COATED CONDUCTORS (FROM VARIOUS MANUFACTURERS) AS A FUNCTION OF THE CURRENT AND THE TEMPERATURE. THE CRYOSTAT PRESSURE COULD BE VARIED BETWEEN 0.4 BAR AND 5 BARS, ALLOWING WORKING IN SATURATED OR SUB-COOLED NITROGEN OVER A TEMPERATURE RANGE OF 70 K TO 93 K. THIS CORRESPONDS TO THE PRACTICAL RANGE OF APPLICATION OF COATED CONDUCTORS IN LIQUID NITROGEN. THE RESULTS OBTAINED CONSTITUTE VALUABLE MATERIAL DATA TO BE USED WITH NUMERICAL MODELING TOOLS, SUCH AS FINITE ELEMENT PROGRAMS USED TO DESIGN AND OPTIMIZE SFCLS.

WORK FUNDED BY FQRNT, NSERC, MDEIE AND EUROPEAN UNION SEVENTH FRAMEWORK PROGRAMME (FP7/2007 - 2013) UNDER GRANT AGREEMENT NO. 241285.

2MP1C-03

NON-DESTRUCTIVE TESTING OF EACH LAYER IN GDBCO IBAD-PLD COATED CONDUCTOR BY USING A HIGH-SPEED SCANNING LASER OBSERVATION SYSTEM ***T. HATO****, S. ADACHI, T. MACHI, N. CHIKUMOTO, M. YOSHIZUMI, S. LEE, K. TANABE;* SRL-ISTEC. — RECENTLY THERE HAS BEEN MUCH PROGRESS IN FABRICATION TECHNOLOGY FOR LONG-LENGTH COATED CONDUCTORS (CCS), AND PRODUCTION OF CCS OVER 500-1000 M-LENGTH HAS BEEN REPORTED. HOWEVER, FURTHER IMPROVEMENT IN THE PRODUCTION YIELD OF LONG-LENGTH CCS SEEMS NECESSARY TO DECREASE THEIR ACTUAL TECHNICAL COST. WITH THE AIM OF CLARIFYING THE ORIGIN OF LOCAL DEFECTS IN CCS AND FEEDBACK TO THE FABRICATION PROCESS, WE HAVE EXAMINED THE DISTRIBUTION OF DEFECTS IN EACH LAYER OF A CC WHICH HAS AG/GDBCO /CEO2/LAMNO3(LMO)/IBAD-MGO/ GD2ZR2O7(GZO)/HASTELLOY STRUCTURE BY MEANS OF A HIGH-SPEED SCANNING LASER OBSERVATION SYSTEM. THE SYSTEM DETECTS ANOMALIES IN HEIGHT OF THE SURFACE AND REFLECTIVITY DUE TO EXISTENCE OF LOCAL DEFECTS SUCH AS DEPRESSIONS, PRECIPITATES, SCRATCHES, DUST, AND INHOMOGENEOUS PHYSICAL PROPERTIES. THE CC TAPE IS FED FROM REEL TO REEL, AND THE DIGITAL AND PICTURE DATA OF THE AREA WITH DEFECTS ARE STORED IN MEMORIES AT THE MAXIMUM MEASURING SPEED OF 100M/H. DISTRIBUTION OF LOCAL DEFECTS IN THE SUPERCONDUCTING LAYER HAS BEEN EXAMINED BY MEANS OF A VARIOUS REEL-TO-REEL NONDESTRUCTIVE EVALUATION SYSTEMS WITH A HALL SENSOR ARRAY, A SQUID GRADIOMETER ARRAY, AND MAGNETO-OPTICAL IMAGING. BY COMPARING THE DATA OF DEFECTS EVALUATED BY THESE TESTING SYSTEMS, WE DISCUSS THE WAY OF FABRICATING LONG-LENGTH CCS WITH A HIGHER YIELD.

THIS WORK WAS SUPPORTED BY NEDO.

2MP1C-04

DETECTION OF CRITICAL CURRENT DENSITY DISTRIBUTION OF YBCO COATED CONDUCTORS BY PERMANENT MAGNET METHOD ***S. OHSHIMA****[1], K. UMEZU[1], K. HATTORI[1], H. YAMADA[1], A. SAITO[1], T. TAKAYAMA[1], A. KAMITANI[1], Y. TAKANO[2], T. SUZUKI[2], M. YOKOO[2], S. IKUNO[3];* [1]YAMAGATA UNIVERSITY, [2]TOHOKU SEIKI INDUSTRIES, [3]TOKYO UNIVERSITY OF TECHNOLOGY. — SOME TECHNIQUES TO BE ABLE TO

MEASURE THE CRITICAL CURRENT DENSITY (JC) OF THE SUPERCONDUCTING THIN FILMS BY NONDESTRUCTIVE AND NONCONTACT ARE REPORTED. HOWEVER, THE TECHNIQUE WITH HIGH ACCURACY, EASY AND SHORT TIME TO MEASURE HAS NOT BEEN REPORTED YET. WE HAVE REPORTED THAT THE JC OF THE SUPERCONDUCTING THIN FILMS CAN BE MEASURED BY THE PERMANENT MAGNET METHOD. THIS TECHNIQUE HAS AN EXCELLENT FEATURE COMPARED WITH OTHER JC MEASUREMENT METHOD. WE CHECKED WHETHER JC OF YBCO COATED CONDUCTOR TAPES WAS ABLE TO BE MEASURED BY THE PERMANENT MAGNET METHOD. THE SAMPLE USED IS YBCO THIN FILM (IC OF 300A) FORMED ON THE HASTEROY TAPE. AS A RESULT, IT WAS FOUND THAT THE PERMANENT MAGNET METHOD IS SUITABLE TO MEASURE THE CRITICAL CURRENT DENSITY DISYRIBUTION OF YBCO COATED CONDUCTORS. IN ADDITION, IT WAS CLARIFIED TO BE ABLE TO SPECIFY A LOCAL PLACE WHERE IC HAD DECREASED. THE PERMANENT MAGNET METHOD IS SUITABLE FOR EVALUATING THE YBCO COATED CONDUCTORS.

THIS RESEARCH WAS PARTIALLY SUPPORTED BY THE JAPAN SOCIETY AND TECHNOLOGY AGENCY; RESEARCH FOR PROMOTING TECHNOLOGICAL SEEDS.

2MP1C-05

SCREENING OF AXIAL DC MAGNETIC FIELDS BY USING SUPERCONDUCTING LOOPS OF SECOND GENERATION COATED CONDUCTORS WITHOUT JOINTS ***J. F. FAGNARD***[1]*, M. DIRICKX*[1]*, B. VANDERHEYDEN*[2]*, P. VANDERBEMDEN*[2]*, G. LEVIN*[3]*;* [1]SUPRATECS, CISS DEPARTMENT, ROYAL MILITARY ACADEMY, B-1000 BRUSSELS, BELGIUM, [2]SUPRATECS, DEPARTMENT OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE, UNIVERSITY OF LIEGE, B-4000 LIEGE, BELGIUM, [3]PROPULSION DIRECTORATE, AIR FORCE RESEARCH LABORATORY, WRIGHT-PATTERSON AFB, OHIO 45433, USA. — THE PERFORMANCES OF SECOND GENERATION (2G) YBCO COATED CONDUCTORS FOR SCREENING DC MAGNETIC FIELDS AT 77 K ARE INVESTIGATED EXPERIMENTALLY. AN UNINTERRUPTED SUPERCONDUCTING PATH IS ACHIEVED BY SPLITTING TWO SECTIONS OF A SLIT 2G TAPE IN ORDER TO OBTAIN A LOOP WITHOUT JOINT. SEVERAL LOOPS ARE STACKED TOGETHER TO OBTAIN A COIL ACTING AS A MAGNETIC SCREEN. PERSISTENT CURRENTS IN THIS COIL ARE SHOWN TO SHIELD EFFICIENTLY MAGNETIC FIELDS THAT ARE APPLIED AT VERY LOW SWEEP RATES (500 μT/S). THE SHIELDING PROPERTIES ARE CHARACTERIZED BY MEASURING THE SHIELDING FACTOR OF THE SCREEN, I.E. THE RATIO BETWEEN THE MAGNETIC FIELD WITH AND WITHOUT SCREEN. IN A COIL MADE OF A SINGLE LAYER OF COATED CONDUCTORS, THE SHIELDING FACTOR AT THE CENTER OF THE COIL IS SHOWN TO EXCEED 10 FOR AN APPLIED DC MAGNETIC FLUX DENSITY OF 5 MT. THE UNIFORMITY OF THE SHIELDING FACTOR ALONG THE AXIS OF THE SCREEN IS ALSO INVESTIGATED; RESULTS SHOW THE MAGNETIC FIELD IS ATTENUATED BY A FACTOR LARGER THAN 3 NEAR THE OPEN ENDS. BOTH THE MAXIMUM FIELD AMPLITUDE THAT CAN BE SHIELDED AND THE SHIELDING FACTOR OF THE COIL CAN BE ENHANCED BY INCREASING THE NUMBER OF CONCENTRIC COILS. THE KEY ADVANTAGES OF THIS SHIELDING TECHNIQUE ARE (I) THE MODERATE WEIGHT COMPARED TO MAGNETIC SCREENS MADE OF BULK MATERIALS AND (II) THE POSSIBILITY OF SHIELDING LARGER VOLUMES BY USING LONGER SECTIONS OF YBCO COATED CONDUCTORS.

2MP1C-06

CURRENT AND FIELD DISTRIBUTION IN MEANDERED COATED CONDUCTORS FOR ROEBEL CABLES ***J. EMHOFER*[1]*,*** *HENGSTBERGER*[1]*, M. EISTERER*[1]*, H. W. WEBER*[1]*, S. TERZIEVA*[2]*, W. GOLDACKER*[2]*, R. A. BADCOCK*[3]*, AND N. J. LONG*[3]*,* [1]*VIENNA UNIVERSITY OF TECHNOLOGY, ATOMINSTITUT, AUSTRIA* [2]*KARLSRUHE INSTITUTE OF TECHNOLOGY, INSTITUT FUER TECHNISCHE PHYSIK, GERMANY* [3]*INDUSTRIAL RESEARCH LTD, LOWER HUTT, NEW ZEALAND* — ALTERNATING CURRENTS OR FIELDS IN COILS, TRANSFORMERS OR GENERATORS MAY LEAD TO HIGH LOSSES IN SUPERCONDUCTING CABLES. THE MAIN CONTRIBUTIONS TO THESE AC-LOSSES ARE HYSTERESIS LOSSES OF THE SUPERCONDUCTOR AND COUPLING LOSSES BETWEEN THE STRANDS. THE HYSTERESIS LOSSES CAN BE REDUCED BY DECREASING THE WIDTH OF THE TAPES. THE RESULTING SMALLER CROSS SECTION OF THE INDIVIDUAL FILAMENTS COULD LEAD TO A STRONG REDUCTION IN PERFORMANCE, IF THE TAPE IS NOT HOMOGENEOUS AND THE CURRENT CANNOT FLOW AROUND LOCAL DEFECTS ANY LONGER. HENCE, DETECTING LOCAL DEFECTS BEFORE CUTTING AND ASSEMBLING BECOMES VERY IMPORTANT. WITH OUR SCANNING TECHNIQUES, WE VISUALIZE THE FIELD PENETRATION AND THE CURRENT FLOW WITHIN DIFFERENT TWO DIMENSIONAL STRUCTURES LIKE ROEBEL STRANDS. THE EFFECT OF DIFFERENT LOCAL DEFECTS ON THE CURRENT DISTRIBUTION IN ROEBEL SINGLE STRANDS IS EXAMINED. DIRECT MEASUREMENTS OF THE CONDUCTOR PERFORMANCE WITH RESPECT TO ITS GEOMETRY ARE IMPORTANT FOR FINDING THE BEST SOLUTIONS FOR FUTURE CABLE DESIGNS.

2MP1C-07

ANGULAR DEPENDENCE OF THE CRITICAL CURRENT IN COATED CONDUCTORS: COMPARISON OF TRANSPORT AND MAGNETISATION MEASUREMENTS ***F. HENGSTBERGER****, M. CHUDY, H. W. WEBER;* ATOMINSTITUT, VIENNA UNIVERSITY OF TECHNOLOGY. — THE CRITICAL CURRENT ANISOTROPY IN COATED CONDUCTORS IS USUALLY DETERMINED FROM TRANSPORT MEASUREMENTS. IT WAS SHOWN RECENTLY THAT - AS A RESULT OF THE THIN FILM GEOMETRY - ALSO MAGNETISATION MEASUREMENTS PROVIDE THIS INFORMATION WHEN HYSTERESIS LOOPS ARE RECORDED AT OBLIQUE FIELDS.IN THIS PAPER WE COMPARE THESE TWO METHODS AND PERFORM ANGULAR DEPENDENT TRANSPORT AND MAGNETISATION MEASUREMENTS ON COATED CONDUCTORS. WE FIND THAT THE ELECTRIC FIELD DEPENDENCE MUST BE CONSIDERED AND EXTRAPOLATE THE TRANSPORT CURRENT-VOLTAGE DEPENDENCE TO THE LOW ELECTRIC FIELDS OF A HYSTERESIS LOOP. AFTER FINDING REASONABLE AGREEMENT BETWEEN BOTH TECHNIQUES AT TEMPERATURES, WHERE DISSIPATION DOES NOT AFFECT TRANSPORT MEASUREMENTS, WE TAKE ADVANTAGE OF THE CONTACT-LESS MAGNETISATION MEASUREMENTS AND

EXPLORE THE EVOLUTION OF THE C-AXIS PEAK AT LOW TEMPERATURES.

2MP1C-08

SPATIAL HOMOGENEITY IN 600 A/CM-W CLASS $GDBA_2CU_3O_{7-\Delta}$ COATED CONDUCTOR OBTAINED BY PLD PROCESS ***A. MATSEKH***[1]*, M. INOUE*[1]*, T. KISS*[1]*, Y. IIJIMA*[2]*, T. SAITOH*[2]*, T. IZUMI*[3]*;* [1]KYUSHU UNIVERSITY, [2]FUJIKURA LTD., [3]SUPERCONDUCTIVITY RESEARCH LABORATORY, ISTEC. — BY THE IMPROVEMENT OF PROCESS CONDITION, THICK FILM (2.5 MM) GDBCO COATED CONDUCTORS HAVE BEEN OBTAINED STABLY WITH CRITICAL CURRENTS OF I_C = 620 A/CM-W. WE APPLIED LOW-TEMPERATURE LASER SCANNING MICROSCOPY (LTLSM) ALONG WITH LASER-INDUCED THERMOELECTRIC (LITE) IMAGING TO INVESTIGATE DEFECTS AND SPATIAL HOMOGENEITY IN THESE SAMPLES. OUR RESULTS SHOW VERY GOOD HOMOGENEITY OF LOCAL T_C AND J_C IN THE SAMPLE.USING LTLSM, WE SUCCEEDED TO ESTIMATE LOCAL *R-T* TRANSITION AS WELL AS *I-V* CHARACTERISTICS AND THEIR SPATIAL DISTRIBUTION. WITHIN THE SUPERCONDUCTING TRANSITION BY MEASURING TEMPERATURE DEPENDENCE OF LOCAL SAMPLE'S RESPONSE AND 2D IMAGES AT CONSTANT TEMPERATURES, WE HAD SHOWN THAT SPATIAL VARIATION OF T_C IS LESS THAN 0.2 K. FROM ANALYZING BIAS CURRENT DEPENDENCES OF FLUX-FLOW DISSIPATION IMAGES, WE HAD SHOWN SPATIAL J_C VARIATION IS ALSO VERY SMALL.BY USING LITE IMAGING, WE COULD SHOW HOMOGENOUS RESPONSE FROM THE GDBCO LAYER IN ALL SAMPLES. HOWEVER, FEW INHOMOGENEITIES WERE STILL OBSERVABLE IN SOME OF THE BRIDGES, SUGGESTING THAT SUCH DEFECTS ARE DISTRIBUTED WITH A CERTAIN SPATIAL DENSITY WITHIN THE CONDUCTOR. BY APPLYING LITE IMAGING TO A WIDE AREA IT IS POSSIBLE TO OBTAIN SPATIAL FREQUENCY AND STATISTICAL DISTRIBUTION OF SUCH OBSTACLES. THESE RESULTS WOULD BECOME IMPORTANT FOR THE APPLICATIONS UTILIZING STRIATED TAPES, SINCE IT CAN REVEAL MINIMUM WIDTH OF A SINGLE FILAMENT.

THIS STUDY WAS SUPPORTED IN PART BY "NEDO AS THE PROJECT FOR DEVELOPMENT OF MATERIALS & POWER APPLICATION OF COATED CONDUCTORS: M-PACC" AND ALSO BY "JSPS: KAKENHI (20360143)".

2MP1C-10

ELECTRICAL AND MAGNETIC CHARACTERIZATION OF BSCCO AND YBCO HTS TAPES FOR FAULT CURRENT LIMITER APPLICATION *J. S. LAMAS*[1]*, **C. A. BALDAN***[2]*, C. Y. SHIGUE*[2]*, A. SILHANEK*[3]*, V. MOSHCHALKOV*[3]*;* [1]UNIVERSITY OF GENT, [2]UNIVERSIDADE SÃO PAULO, USP, BRAZIL, [3]UNIVERSITY OF LEUVEN. — SEVERAL HIGH TEMPERATURE SUPERCONDUCTORS (HTS) TAPES HAVE BEEN DEVELOPED SINCE THE LATE EIGHTIES. DUE TO THE NEW TECHNIQUES APPLIED FOR THEIR PRODUCTION, HTS TAPES ARE BECOMING FEASIBLE AND PRACTICAL FOR MANY APPLICATIONS. IN THIS WORK, WE PRESENT THE TEST RESULTS OF FIVE COMMERCIAL HTS TAPES FROM THE BSCCO AND YBCO FAMILY (SHORT SAMPLES OF 200 MM). WE HAVE MEASURED AND ANALYZED THEIR INTRINSIC AND EXTRINSIC PROPERTIES AND COMPARED THEIR BEHAVIORS AIMING A FAULT CURRENT LIMITER (FCL) APPLICATION. ELECTRICAL MEASUREMENTS WERE PERFORMED TO DETERMINE THROUGH THE V-I RELATIONSHIP UNDER DC AND AC MAGNETIC FIELDS THE CRITICAL CURRENT AND THE N-INDEX OF THE TAPES AND BY THE MEASUREMENT OF RESISTANCE AS A FUNCTION OF TEMPERATURE UP TO ROOM TEMPERATURE. THE MAGNETIC CHARACTERISTICS WERE ANALYZED THROUGH SUSCEPTIBILITY CURVES AS A FUNCTION OF TEMPERATURE. AS TRANSPORT CURRENT GENERATES A MAGNETIC FIELD SURROUNDING THE HTS MATERIAL, THE MAGNETIC MEASUREMENTS INDICATE THE MAGNETIC FIELD SUPPORTED BY THE TAPES UNDER A PEAK CURRENT 1.5 TIMES HIGHER THAN THE CRITICAL CURRENT (IC). BY PULSED CURRENT TESTS THE RECOVERY TIME AND THE ENERGY/VOLUME DURING A CURRENT FAULT WERE ALSO ANALYZED. HENCE, THESE RESULTS WERE COMPARED AMONG THE TAPES AND ARE IN AGREEMENT WITH THE DATA FOUND IN THE LITERATURE GIVING THE MOST APPROPRIATE PERFORMANCE CONDUCTOR FOR A FCL DEVICE (IPEAK = 4 KA) TO BE USED IN A 220 V-60 HZ GRID.

THIS RESEARCH WAS SUPPORTED BY CPFL PAULISTA.

2MP1D-02

RESTORATION OF MAXIMUM GRADIENT BY LASER RE-MELTING A CAVITY PIT ***M. GE****, G. WU, J. RUAN, T. H. NICOL, L. D. COOLEY;* FERMI NATIONAL ACCELERATOR LABORATORY. — SURFACE DEFECTS INSIDE SRF CAVITY SUCH AS PIT HAVE BEEN CONSIDERED AS ONE OF THE MAIN ISSUES LIMITED CAVITY RF PERFORMANCE, THE MAGNETIC FIELD ENHANCED AT THE EDGE OF PIT COULD CAUSE CAVITY SURFACE HEATING LOCALLY AND LEAD THE WHOLE CAVITY QUENCH IF THE TEMPERATURE EXCEED ABOVE TC. LASER REPAIR TECHNIQUE IS A PROMISING SOLUTION TO PUSH CAVITY GRADIENT BY RE-MELTING THE SURFACE DEFECTS. WE DESCRIBE THE TECHNICAL APPROACHING OF LASER TECHNIQUE, AND DEMONSTRATE IT RESTORED CAVITY GRADIENT TO 39.5MV/M.

I AM GRATE FOR J. OZELIS, E. HARMS, D. A. SERGATSKOV'S HELP

2MP1D-03

PROCESSING ADVANCES SUGGESTED BY RESULTS OF SINGLE-CELL SUPERCONDUCTING RF CAVITY RESEARCH AT FERMILAB ***L. COOLEY***[1]*, D. BICE*[1]*, M. CHAMPION*[1]*, C. COOPER*[1]*, H. EDWARDS*[1]*, M. GE*[1]*, C. GINSBURG*[1]*, E. HARMS*[1]*, J. OZELIS*[1]*, A. ROMANENKO*[1]*, A. ROWE*[1]*, D. SERGATSKOV*[1]*, G. WU*[1]*, S. GERBICK*[2]*, M. KELLEY*[2]*;* [1]FERMILAB, [2]ARGONNE NATIONAL LABORATORY. — FERMILAB IS CONDUCTING A VIGOROUS SINGLE-CELL RESEARCH PROGRAM TO OPTIMIZE CAVITY PROCESSING, EXPLORE ALTERNATE PROCESSING ROUTES, QUALIFY FACILITIES, AND PURSUE NEW IDEAS. A NEW INTEGRATED PROCESSING APPARATUS DEDICATED TO SINGLE-CELL RESEARCH WILL BE DESCRIBED, WHICH WILL BECOME OPERATIONAL DURING FY2010. EXPERIMENTS TO USE TUMBLING IN PLACE OF ACID ETCHING FOR BULK NIOBIUM REMOVAL, USING A NEW TUMBLING MACHINE, SUCCEEDED IN

ACHIEVING CAVITY GRADIENT OF >40 MV/M, WELL ABOVE THE 35 MV/M ILC TARGET. IDENTIFICATION AND REPAIR OF LARGE DEFECTS SUCH AS WELD PITS WAS SHOWN TO BE FEASIBLE BY USING A LASER TO RE-MELT SUSPECT AREAS. THE IMPACT OF FLAWS IN NIOBIUM SHEETS, WHICH ARE DETECTED BY EDDY-CURRENT SCANNING, WAS ASSESSED USING TWO SPECIALLY-MANUFACTURED CAVITIES THAT LOCATE KNOWN DEFECTS IN REGIONS OF HIGH MAGNETIC FIELD. THE IMPLICATIONS OF THE DIFFERENT PERFORMANCE OF THE CAVITIES ABOVE FOR FORMING AND PROCESSING WILL BE DISCUSSED.

WORK AT FERMILAB SUPPORTED BY THE U.S. DEPARTMENT OF ENERGY UNDER CONTRACT NO. DE-AC02-07CH11359. WORK AT ANL SUPPORTED UNDER CONTRACT NO. DE-AC02-06CH11357.

2MP1D-04

CHARACTERIZATION OF FIELD PENETRATION IN SUPERCONDUCTING MULTI-LAYERS SAMPLES ***C. Z. ANTOINE***[1]*, S. BERRY*[1]*, M. AURINO*[2]*, J. JACQUOT*[2]*, J. VILLEGIER*[2]*, G. LAMURA*[3]*, A. ANDREONE*[4]*;* [1]CEA, IRFU/SACM, [2]CEA, INAC, [3]CNR-SPIN-GE, [4]CNR-SPIN-NA. — BEST RF BULK NIOBIUM ACCELERATING CAVITIES ARE NOW CLOSE TO THEIR ULTIMATE LIMITS AT RF EQUATORIAL MAGNETIC FIELD H ≈ 200 MT. IN 2006 GUREVICH PROPOSED TO USE NANOSCALE LAYERS OF SUPERCONDUCTING MATERIALS WITH HIGH VALUES OF HC > HC (NB) FOR MAGNETIC SHIELDING OF BULK NIOBIUM TO INCREASE THE BREAKDOWN FIELD OF NB RF CAVITIES.WE HAVE DEPOSITED HIGH QUALITY "MODEL" SAMPLES BY DC MAGNETRON REACTIVE SPUTTERING ON R-PLANE CUT SAPPHIRE SUBSTRATES. A 250 NM LAYER OF NIOBIUM FIGURES THE BULK MATERIAL AS IN RF CAVITIES. SUCH NB LAYERS WERE COATED WITH A SINGLE OR MULTIPLE STACKS OF NBN LAYERS (25 NM OR 12 NM) SEPARATED BY 15 NM MGO BARRIERS, AND CHARACTERIZED BY X-RAYS REFLECTIVITY AND DC TRANSPORT MEASUREMENTS. SIMILAR NBN/ALN MULTILAYER STRUCTURES WERE ALSO PREPARED.THE DC MAGNETIZATION CURVES HAVE BEEN MEASURED IN A SQUID SYSTEM IN ORDER TO OBSERVE THE FIRST MAGNETIC PENETRATION FIELD H_{C1}. THE SAMPLES EXHIBIT A NON POINT DIPOLE BEHAVIOR AND A STRONG TRANSVERSE SIGNAL THAT HAVE BEEN ANALYZED USING A SPECIFIC FITTING PROCEDURE. FOR COMPARISON, H_{C1} WAS ALSO MEASURED WITH A LOCAL PROBE METHOD BASED ON 3^{RD} HARMONIC ANALYSIS. THE NB SAMPLES COATED WITH NBN MULTI-LAYERS CLEARLY EXHIBIT A HIGHER FIRST PENETRATION FIELD AND A HYSTERESIS LOOP DIFFERENT FROM NB SAMPLE WITHOUT COATING.

2MP1D-05

MIGRATION OF QUENCH LOCATION IN SRF CAVITY ***D. A. SERGATSKOV****, M. GE, G. WU, J. P. OZELIS, L. D. COOLEY;* FERMILAB. — BY DOING A SERIES OF HIGH-PRECISION TEMPERATURE MEASUREMENTS ON AQUENCH-LIMITED SUPERCONDUCTING RF CAVITY WE OBSERVE THAT THE ORIGIN OFTHE QUENCH MIGRATES BETWEEN DIFFERENT LOCATIONS ALONG THE EQUATOR OFTHE CAVITY. THE EFFECT BECOMES THE MOST PRONOUNCED WHEN THE EXPERIMENTIS DONE IN NORMAL HELIUM JUST A FEW MILLIKELVIN ABOVE THE SUPERFLUIDTRANSITION. WE WILL DESCRIBE THE EXPERIMENTAL PROCEDURE AND OFFER SOMEPLAUSIBLE EXPLANATION OF THE OBSERVED EFFECT.

2MP1D-07

EFFECTS OF MATERIAL PROPERTIES ON THE ELASTOPLASTIC BUCKLING OF AN SRF CAVITY UNDER EXTERNAL PRESSURE ***M. LIN****, C. WANG, L. CHANG, M. YEH;* NATIONAL SYNCHROTRON RADIATION RESEARCH CENTER. — AN SRF CAVITY IS GENERALLY MANUFACTURED WITH A SHELL STRUCTURE TO DECREASE THE INNER SURFACE TEMPERATURE AND CONSEQUENTLY TO DECREASE THE RF SURFACE RESISTANCE. DURING OPERATION, THE SRF CAVITY IS IMMERSED IN A BATH OF LIQUID HELIUM, WHILE ITS INTERIOR IS MAINTAINED AT AN ULTRA-HIGH VACUUM. THE CAVITY IS THUS LOADED UNDER AN EXTERNALLY PRESSURIZED CONDITION AND REQUIRES EXPLICIT CALCULATION AND ESTIMATION ON BUCKLING TO PROVE ITS STRUCTURAL STRENGTH. AS BEING LOADED TO A CONDITION OF GREAT STRESS, THE NONLINEAR BEHAVIOR OF THE STRESS-STRAIN CURVE OF THE NIOBIUM GENERATES AN ELASTOPLASTIC BUCKLING BEHAVIOR DIFFERENT FROM ELASTIC BUCKLING. WITH VARIED PROCEDURES FOR FORMATION AND TREATMENT, NIOBIUM'S STRESS-STRAIN CURVE CAN BE ALTERED, THUS MODIFYING THE BUCKLING BEHAVIOR. IN THIS WORK A 500-MHZ SRF CAVITY IS ILLUSTRATED TO INVESTIGATE ITS BUCKLING BEHAVIOR UNDER EXTERNAL PRESSURE, FOR WHICH VARIOUS STRESS-STRAIN CURVES ARE APPLIED. FINITE-ELEMENT SOFTWARE (ANSYS) IS USED TO CALCULATE THE LIMIT PRESSURE AND POST-BUCKLING BEHAVIOR, WITH AN INCREMENTAL ARC-LENGTH CONTROL SCHEME TO INCLUDE EFFECTS OF THE NONLINEARITIES OF BOTH THE GEOMETRY AND THE MATERIAL PROPERTY. WE FOUND THAT NOT ONLY THE LIMIT PRESSURE BUT ALSO THE BUCKLING MODE COULD BE ALTERED WITH THE ASSIGNED MATERIAL PROPERTY. THE SAFETY CONDITIONS OF AN SRF CAVITY WITH VARIED STRESS-STRAIN CURVES CAN THUS BE SPECIFIED.

2MP1D-08

SEARCH FOR SUPERCONDUCTIVITY IN NANOSTRUCTURES: DOPED CARBON NANOTUBES, MGB2 BASED NANOSTRUCTURES AND FULLERIDE NANOCOMPOSITES FOR LIGHTWEIGHT WIRES ***A. A. ZAKHIDOV***[1]*, A. KUZNETSOV*[1]*, A. HOWARD*[1]*, M. LIMA*[1]*, U. GOSKUN*[1]*, E. CASTILLO MARTINEZ*[1]*, J. CARRETERO GONZALEZ*[1]*, J. REPPERT*[2]*, K. YANG*[2]*, A. RAO*[2]*, D. PROBER*[3]*, L. PFEFFERLE*[3]*, M. SALAMON*[1]*, R. BAUGHMAN*[1]*;* [1]UNIVERSITY OF TEXAS AT DALLAS, [2]CLEMSON UNIVERSITY, [3]YALE UNIVERSITY. — THIS PRESENTATION SUMMARIZES THE RESULTS OF EFFORTS OF UTD-YALE-CLEMSON PROGRAM OF AFOSR ON THE SEARCH OF SUPERCONDUCTIVITY IN NANOSTRUCTURES.RECENTLY SIGNATURES OF MEISSNER EFFECT WITH TC = 12 K HAVE BEEN OBSERVED IN BORON-DOPED CNTS AT SMALL B-CONCENTRATIONS. CONFIRMING THIS SC TC IN B-SWCNTS BY TRANSPORT AND OTHER MEASUREMENTS AND OPTIMIZING DOPING WITH THE GOAL

TO INCREASE TC IS ONE OF THE PROGRAM GOALS. WE PRESENT THE RESULTS OF B-DOPING BY SEVERAL METHODS, INCLUDING ION-IMPLANTATION, SPARK PLASMA SINTERING, CVD DURING AND AFTER SYNTHESIS, ETC. ANOTHER TASK IS DOPING CNTS BY NITROGEN, PHOSPHOROUS AND SULFUR. SEPARATE TASK IS TO SYNTHESIZE BORON NANOTUBES (BNT) DOPED BY MG AND CREATE MGB2 NANOTUBES WITH HIGHER TC THAN IN THE BULK MGB2. SEVERAL TYPES OF BNT ARE CREATED IN ALUMINA AND OTHER TEMPLATES, AS WELL AS B-CNTS, N-CNTS, DOPED BY DIFFERENT APPROACHES. AS A SEPARATE TASK ALKALI-FULLERIDE NANOCOMPOSITES WITH CNT AND GRAPHENES ARE CREATED. THE RESULTS OF SQUID MAGNETIZATION AND LOW FIELD MICROWAVE ABSORPTION (LFMA), AND ALSO TRANSPORT ON SOME OF B-CNTS AND BNTS SHOWS MAGNETIZATION RESEMBLING SC-ING MEISSNER EFFECT. ON THE OTHER HAND M(T) BEHAVIOR IN THE PRESENCE OF MAGNETIC NANOCLUSTERS OF CATALYST RESIDUALS (FE, NI OR CO) IN CNT AND BNT HAS BEEN FOUND TO MASK STRONGLY TRUE SC BEHAVIOR. TO RESOLVE THIS PROBLEM ROUTES WITH NON-MAGNETIC CATALYSTS (RH/PD, PB) AND CNT SHEETS WITH NO FE DEVELOPED

THIS WORK IS SUPPORTED BY AFOSR GRANT FA 9550-09-1-0384 ON THE SEARCH OF NOVEL SUPERCONDUCTING NANOSTRUCTURES

2MP1E-01

ATTEMPT TO FABRICATE LONG LENGTH NB_3AL WIRE BY METASTABLE SOLID-SOLUTION-STRAND RESTACKING METHOD ***N. BANNO***[1], *T. TAKEUCHI*[1], *K. NAKAGAWA*[2]; [1]NATIONAL INSTITUTE FOR MATERIALS SCIENCE, [2]HITACHI CABLE LTD.. — WE HAVE BEEN DEVELOPING A NEW TYPE NB_3AL WIRE FOR THE APPLICATION TO THE FUSION REACTOR MAGNET, ESPECIALLY TO THE NEXT DEMO REACTOR, WHERE THE WIRES ARE SEVERELY REQUIRED NOT ONLY HIGH CRITICAL CURRENT DENSITY BUT ALSO VERY SMALL MAGNETIZATION LOSSES. THE MAGNETIZATION LOSS BASICALLY DECREASES LINEARLY BY REDUCING THE SUPERCONDUCTING FILAMENT DIAMETER, SO THAT IN ORDER TO ACHIEVE LOW LOSSES, MINIMIZATION OF THE FILAMENT DIAMETER IS A KEY ISSUE. IN THE NEW TECHNIQUE PRESENTED HERE, THE METASTABLE NB-AL SOLID-SOLUTION PHASE MULTIFILAMENTALY STRANDS OBTAINED BY A RAPID-HEATING AND QUENCHING (RHQ) PROCESS ARE RE-STACKED INTO A STABILIZING CU TUBE. THIS METHOD SIMULTANEOUSLY WOULD OVERCOME THE COMPLEX STABILIZATION PROCESS IN NB_3AL PRODUCTION AND BE SUITABLE FOR THE INDUSTRIALIZATION. HENCE HERE WE DISCUSSED SOME ELEMENTAL TECHNOLOGIES RELATED TO THE RESTACKING METHOD, TO ACHIEVE LONG LENGTH NB_3AL WIRES BEYOND A FEW KILOMETERS IN FUTURE. AS A FIRST EXPERIMENTAL PRODUCTION, WE FABRICATED A RE-STACKING PROCESSED NB_3AL WIRE OVER 40 M WITHOUT ANY BREAKAGE.

THIS WORK WAS SUPPORTED BY INDUSTRIAL TECHNOLOGY RESEARCH GRANT PROGRAM IN 2009 FROM NEW ENERGY AND INDUSTRIAL TECHNOLOGY DEVELOPMENT ORGANIZATION (NEDO) OF JAPAN.

2MP1E-02

DEVELOPMENT OF TA-MATRIX NB_3AL STRAND AND CABLE FOR HIGH-FIELD ACCELERATOR MAGNET APPLICATION ***K. TSUCHIYA***[1], *A. KIKUCHI*[2], *T. TAKEUCHI*[2], *N. BANNO*[2], *Y. IIJIMA*[2], *S. NIMORI*[2], *T. NAKAMOTO*[1], *Y. KURODA*[3], *T. TAKAO*[3], *K. NAKAGAWA*[4], *E. BARZI*[5], *R. YAMADA*[5]; [1]KEK, [2]NIMS, [3]SOPHIA UNIVERSITY, [4]HITACHI CABLE, LTD., [5]FERMILAB. — RAPID HEATING/QUENCHING AND TRANSFORMATION (RHQT) PROCESSED NB_3AL WIRES HAVE A BETTER STRAIN TOLERANCE THAN NB_3SN WIRES AND HAVE COMPETITIVE HIGH-FIELD PROPERTIES. THEREFORE, THEY MIGHT BE A PROMISING CANDIDATE FOR USE IN FUTURE HIGH-FIELD ACCELERATOR MAGNETS. FOR THIS REASON, WE HAVE BEEN DEVELOPING RHQT-PROCESSED NB_3AL WIRES FOR A NUMBER OF YEARS.RECENTLY WE HAVE FABRICATED TA-MATRIX NB_3AL STRAND AND CARRIED OUT A TRIAL FABRICATION OF RUTHERFORD-TYPE CABLE. THE STRANDS CONSIST OF 222 FILAMENTS EMBEDDED IN A TA-MATRIX AND AN EXTERNAL CU STABILIZER. THE DIAMETER OF THE STRAND WAS 1 MM. USING THE 250 M LONG STRAND, 8 M LONG 27-STRAND CABLE HAVING A PACKING FACTOR OF ~85 % WAS MANUFACTURED WITH A COOPERATION OF KEK-NIMS-FERMILAB. THIS PAPER DESCRIBES THE DETAILS OF FABRICATION, MECHANICAL AND SUPERCONDUCTING PROPERTIES OF THE STRAND AND CABLE.

2MP1E-03

THE JELLY ROLLED NB/AL COMPOSITE PRECURSOR WITH TANTALUM INTER-FILAMENT MATRIX ***A. KIKUCHI***[1], *K. NAKAGAWA*[2], *K. TSUCHIYA*[3], *T. NAKAMOTO*[3], *K. SASAKI*[3], *H. TAKIGAWA*[3], *T. TAKEUCHI*[1], *A. YAMAMOTO*[3]; [1]NATIONAL INSTITUTE FOR MATERIALS SCIENCE, [2]HITACHI CABLE LTD., [3]HIGH ENERGY ACCELERATOR RESEARCH ORGANIZATION. — THE RHQT (RAPID HEATING/QUENCHING AND TRANSFORMATION) PROCESSED NB3AL STRANDS WITH TANTALUM INTER-FILAMENT MATRIX ARE PREFERABLE AS IT REDUCES MAGNETIC INSTABILITY IN LOW FIELDS. SUPERCONDUCTING FILAMENT COUPLING CAN BE AVOIDED BECAUSE OF THE WEAK SUPERCONDUCTIVITY OF TANTALUM AT LOW TEMPERATURES. HOWEVER, WHEN TANTALUM SHEETS ARE USED AS A PART OF THE RAW MATERIALS, THE WIRE BREAKAGE FREQUENTLY HAPPENS AT THE STAGE OF THE PRODUCTION OF JELLY ROLLED NB/AL COMPOSITE PRECURSOR. IN GENERAL, THE EXTRUSION FOR NB/AL PRECURSORS IS PERFORMED AT ROOM TEMPERATURE BECAUSE OF THE RATHER LOW MELTING-POINT (660 OC) OF ALUMINUM. THUS, THE EXTRUSION RATIO WAS LESS THAN 5.0 TO PREVENT FRICTIONS UNDER THE FACILITY LIMIT. THEREFORE, THE WIRE BREAKAGE MAY COME FROM THE DE-BONDING OF JELLY ROLLED COMPOSITE FILAMENTS DUE TO A SMALL EXTRUSION RATIO. THE OTHER POSSIBILITY CONSIDERED COULD BE POORER COLD-WORKABILITY OF THE TANTALUM ITSELF. IN THIS PAPER, WE WILL REPORT DETAILS OF THE JELLY ROLLED NB/AL COMPOSITE PRECURSOR WITH TANTALUM INTER-FILAMENT MATRIX. THEIR MICROSTRUCTURES AND MECHANICAL PROPERTIES ON NEIGHBORHOOD OF THE WIRE BREAKAGE WERE STUDIED AS WELL AS THOSE OF RAW MATERIALS.

THE AUTHORS WOULD LIKE TO THANK DRS. LUCIO ROSSI AND GIJS DE RIJK OF CERN FOR THEIR KIND SUPPORT TO THIS WORK.

2MP1E-04

SUPERCONDUCTING PROPERTIES AND MICROSTRUCTURE OF V_3GA WIRES USING HIGH GA CONTENT $TIGA_3$ AND V_2GA_5 COMPOUNDS ***Y. HISHINUMA***[1]*, A. KIKUCHI*[2]*, T. TAKEUCHI*[2]*, K. MATSUDA*[3]*, H. TANIGUCHI*[4]*, A. NISHIMURA*[1]*;* [1]NATIONAL INSTITUTE FOR FUSION SCIENCE, [2]NATIONAL INSTITUTE FOR MATERIALS SCIENCE, [3]UNIVERSITY OF TOYAMA, [4]OSAKA ALLOYING WORKS CO. LTD. — V_3GA COMPOUND HAS A SHORTER RADIOACTIVE DECAY TIME COMPARED WITH NB-BASED COMPOUNDS AND IT WILL BE ONE OF THE CANDIDATE SUPERCONDUCTING MAGNET MATERIALS FOR AN ADVANCED FUSION SYSTEM INCLUDING SHUTDOWN SCENARIO AND MATERIAL RECYCLE. RECENTLY, WE SUCCEEDED IN DEVELOPING NEWLY V_3GA MULTIFILAMETARY WIRES FABRICATED VIA THE POWDER IN-TUBE (PIT) PROCESS USING THE HIGH GA CONTENT CU-GA BINARY PHASE COMPOUNDS. WE ALSO FOUND THAT THE HIGH GA CONTENT INTO PRECURSOR PROMOTED TO FORM THE STOICHIOMETRY V_3GA PHASE AND IT WAS EFFECTIVE TO IMPROVE SUPERCONDUCTING PROPERTIES. IN THIS STUDY, WE TRIED TO EXPLORE THE OTHER HIGH GA CONTENT COMPOUND IN ORDER TO IMPROVE JC PROPERTY AND WIRE DEFORMATION. THE HIGHER GA CONTENT COMPOUNDS SUCH AS $TIGA_3$ AND V_2GA_5 WERE PREPARED BY ARC-MELTING AND POST-ANNEALING. THESE INGOTS WERE CRUSHED BY THE HAND-MILLING AND THEY WERE PACKED INTO METAL V TUBE TIGHTLY. THESE PRECURSOR WIRES WERE DRAWN BY THE CASSETTE ROLLER DIES. THE VOLUME FRACTION OF V_3GA PHASE WAS INCREASED WITH ELEVATING HEAT TREATMENT TEMPERATURE, AND WE ALSO CONFIRMED THAT CU ADDITION INTO $TIGA_3$ AND V_2GA_5 COMPOUNDS PROMOTED TO FORM V_3GA PHASE. THE DEFERENCE OF THE SUPERCONDUCTING PROPERTIES AND MICROSTRUCTURE IN THE V_3GA WIRE BETWEEN $TIGA_3$, V_2GA_5 AND CU-GA COMPOUNDS WILL BE DESCRIBED.

THIS WORK WAS FINANCIALLY PERFORMED WITH THE NIFS PROGRAM (UCFF005) AND, PART OF THIS WAS ALSO SUPPORTED BY THE MEXT, GRANT-IN-AID FOR YOUNG SCIENTISTS (B), 2009.

2MP1E-05

V_3GA MULTIFILAMENT STRAND BY THE PIT APPROACH ***L. R. MOTOWIDLO****, J. DISTIN;* SUPRAMAGNETICS, INC.. — POWDER-IN-TUBE (PIT) V_3GA MULTIFILAMENT CONDUCTORS HAVE BEEN FABRICATED UTILIZING JET MILLED COPPER-GALLIUM POWDERS. IN THIS PAPER, WE REPORT THE CRITICAL CURRENT AND STRAIN PROPERTIES. IN ADDITION, HIGH RESOLUTION SEM OF THE GRAIN MORPHOLOGY SHOW VARIATIONS IN GRAIN SIZE FOR HEAT TREATMENT TEMPERATURES STUDIED FROM $600^{O}C$ TO $750^{O}C$

THIS WORK WAS FUNDED BY A DOE FUSION SBIR

2MP1E-06

MODELING OF NB_3SN CONDUCTOR DIMENSION CHANGES DURING HEAT TREATMENT ***D. BOCIAN***[1]*, G. AMBROSIO*[1]*, E. BARZI*[1]*, A. BONASIA*[2]*, A. GHOSH*[3]*, A. NOBREGA*[1]*, C. SCHEUERLEIN*[2]*, M. WAKE*[4]*, R. WALSH*[5]*, M. WHITSON*[1]*;* [1]FERMI NATIONAL ACCELERATOR LABORATORY, P.O. BOX 500, BATAVIA, IL 60510-0500, USA, [2]CERN, CH 1211, GENEVA 23, SWITZERLAND, [3]BROOKHAVEN NATIONAL LABORATORY, UPTON, NY 11973, USA, [4]HIGH ENERGY ACCELERATOR RESEARCH ORGANIZATION (KEK), TSUKUBA, IBARAKI 305-0801 JAPAN, [5]NATIONAL HIGH MAGNETIC FIELD LABORATORY, TALLAHASSEE, FL 32310-3706, USA. — DURING THE HEAT TREATMENT OF NB_3SN COILS SEVERAL INTERMETALLICS PHASES DEVELOP IN CONDUCTOR BEFORE NB_3SN FORMATION. CHANGES OF MATERIAL PROPERTIES DURING HEAT TREATMENT INTRODUCE STRAINS IN THE COIL.THE GOAL OF THIS STUDY IS TO MODEL THE THERMAL EXPANSION AND CONTRACTION OF NB_3SN STRANDS AND CABLES DURING REACTION. IN ORDER TO MODEL PROPERLY THE DIMENSIONAL CHANGES OF CONDUCTOR SEVERAL MEASUREMENTS WERE PERFORMED ON STRANDS AND CABLES. IN THIS PAPER THE RESULTS OF SIMULATION AND MEASUREMENT OF RRP NB_3SN CONDUCTOR USED IN LARP LONG QUADRUPOLE ARE DISCUSSED. SOME CONCLUSIONS ARE DRAWN ON THE NB_3SN COIL ELEMENTS BEHAVIOR DURING HEAT TREATMENT.

2MP1F-01

DESIGN ASPECTS OF DUAL NB-TA DIFFUSION BARRIERS FOR NB_3SN CONDUCTORS ***K. T. HARTWIG***[1]*, S. BALACHANDRAN*[1]*, R. BARBER*[2]*, T. PYON*[3]*, R. GRIFFIN*[4]*;* [1]TEXAS A&M UNIVERSITY, [2]SHEAR FORM, INC., [3]LUVATA WATERBURY, INC., [4]TEXAS A&M UNIVERSITY - QATAR. — TANTALUM (TA) DIFFUSION BARRIERS USED IN ADVANCED NB3SN SUPERCONDUCTORS DEFORM NONUNIFORMLY DURING WIRE DRAWING. IF THE WIRE DIAMETER BECOMES TOO SMALL, THIS BEHAVIOR LEADS TO TA LAYER RUPTURE WHICH IN TURN LEADS TO EITHER WIRE FRACTURE OR CONTAMINATION OF THE STABILIZER COPPER (CU). TO AVOID SUCH PROBLEMS, COMMERCIAL MANUFACTURERS DESIGN THE TA LAYER THICKNESS TO RETAIN INTEGRITY AT THE TARGET WIRE DIAMETER. A STRATEGY SOMETIMES USED TO MITIGATE THE TA LAYER RUPTURE PROBLEM IS TO PLACE A SACRIFICIAL LAYER OF NIOBIUM (NB) NEXT TO THE TA TO ACT AS A MECHANICAL TRANSITION ZONE BETWEEN THE SOFTER CU-NB COMPOSITE AND THE HARDER TA. THIS APPROACH CAN PROMOTE MORE UNIFORM CO-DEFORMATION OF THE TA LAYER ENABLING THINNER TA LAYERS AND A REDUCED CHANCE OF LAYER RUPTURE, AND HAS THE ADDED BENEFIT OF PROVIDING ADDITIONAL NB FOR CONVERSION TO NB_3SN. A THINNER TA LAYER TRANSLATES TO LESS TA VOLUME AND LESS COST. THE OBJECTIVE OF OUR RESEARCH IS TO FABRICATE NB AND TA SHEET MATERIALS BY SEVERE PLASTIC DEFORMATION METHODS, WHICH ENABLE MANUFACTURE OF NB_3SN CONDUCTORS WITH TA DIFFUSION BARRIERS A FEW MICRONS THICK. WE REPORT RESULTS ON CU-NBTA DUAL BARRIER COMPOSITE CONDUCTORS FABRICATED FROM FINE-GRAINED NB AND TA SHEETS, AND DRAWN TO PRODUCE MICRON THICK

LAYERS. THE EFFECTS OF INITIAL SHEET THICKNESS, LAYER ARCHITECTURE (SINGLE, DUAL AND SANDWICH) AND INITIAL TA TEXTURE ARE DISCUSSED.

THIS MATERIAL IS BASED UPON WORK SUPPORTED BY THE DEPARTMENT OF ENERGY UNDER AWARD NUMBER DE-SC0002082.

2MP1F-02

RESULTS OF INVESTIGATIONS OF 500 KG NB_3SN BRONZE STRAND PRODUCED IN RUSSIAN FEDERATION FOR ITER PROJECT ***I. ABDYUKHANOV***[1], *A. SHIKOV*[1], *A. VOROBYEVA*[1], *V. PANTSYRNYY*[1], *N. BELIAKOV*[1], *E. DERGUNOVA*[1], *K. MAREEV*[1], *M. NASIBULIN*[1], *S. ZERNOV*[2], *K. ABRAMUSHIN*[3], *D. ANISHUK*[3]; [1]BOCHVAR RESEARCH INSTITUTE OF INORGANIC MATERIALS, [2]JSC «TVEL», [3]JSC «CHEPETSKY MECHANICAL PLANT». — THE RESULTS OF INVESTIGATIONS OF FIRST 500 KG NB_3SN BRONZE STRAND ARE PRESENTED. THIS BATCH OF STRANDS WAS MEANT FOR THE PRODUCTION OF 100 M OF TOROIDAL FIELD CONDUCTOR IN THE FRAME OF FULFILLMENT THE PHASE II OF PROCUREMENT ARRANGEMENT BETWEEN RUSSIAN DOMESTIC AGENCY AND INTERNATIONAL ORGANIZATION ITER. IN ORDER TO PROVIDE THE INDUSTRIAL-SCALE PRODUCTION OF STRANDS DESIGN DOCUMENTATION AND ALL NECESSARY QUALITY ASSURANCE DOCUMENTS WERE DEVELOPED. THE DEVELOPED INDUSTRIAL TECHNOLOGY OF NB_3SN STRAND PRODUCTION WAS APPLIED IN CHEPETSKY MECHANICAL PLANT (JSC «CMP»). STRANDS WERE PRODUCED IN JSC «CMP» FROM FINAL BILLETS WITH DIAMETER OF 200 MM. THE MICROSTRUCTURE INVESTIGATIONS OF PRODUCED STRANDS WERE PERFORMED BEFORE AND AFTER DIFFUSION ANNEALING BY OPTICAL MICROSCOPY, X-RAY MICROPROBE ANALYSIS AND X-RAY ANALYSIS. MECHANICAL PROPERTIES OF ANNEALED NB_3SN STRANDS WERE INVESTIGATED. CURRENT-CARRYING CAPABILITY OF NB_3SN STRANDS AT 12 T, 4.22 K WERE STUDIED. IT WAS SHOWN, THAT ALL PRODUCED STRANDS MET ALL THE REQUIREMENTS, IN PARTICULAR I_C WAS FROM 200 TO 225 A; HYSTERESIS LOSSES WERE FROM 160 TO 190 MJ/CM^3 (± 3 T).

2MP1F-03

THE EFFECT OF TWIST PITCH ON HYSTERESIS LOSS AND *IC* OF NB_3SN STRANDS FOR ITER ***C. LI***[1], *S. DU*[1], *X. LIU*[1], *Y. FENG*[1], *P. ZHANG*[2], *J. LIU*[1], *C. XIAO*[1], *J. GUAN*[1], *X. SUN*[1], *X. WAN*[1]; [1]WESTERN SUPERCONDUCTING TECHNOLOGIES, CO. LTD.,; NATIONAL ENGINEERING LABORATORY FOR SUPERCONDUCTING MATERIALS PREPARATION., [2]WESTERN SUPERCONDUCTING TECHNOLOGIES CO.LTD; NATIONAL ENGINEERING LABORATORY FOR SUPERCONDUCTING MATERIALS PREPARATION; NORTHWEST INSTITUTE FOR NONFERROUS METAL RESEARCH; STATE KEY LAB. OF SOLIDIFICATION PROCESSING, NORTHWESTERN POLYTECHNICAL UNIVERSITY.. — NB_3SN SUPERCONDUCTOR IS USED IN HIGH FIELD WHICH MORE THAN 10T FOR THE OUTSTANDING PROPERTIES. IT IS USED TO FABRICATING MAGNETIC SYSTEM OF INTERNATIONAL THERMAL-NUCLEAR EXPERIMENT REACTOR (ITER) FOR THE FUSION REACTION OF TRITIUM AND DEUTERIUM. ACCORDING TO THE REQUIREMENTS OF ITER THE NB_3SN STRANDS MUST HAVE A HIGH I_C (I_C≥190 A AT 12 T AND 4.22 K WITH 0.1 MV/CM) WITH A LOW HYSTERESIS LOSS (HYSTERESIS LOSS PER STRAND UNIT VOLUME NO MORE THAN 500 MJ/CM^3 AT 4.22 K OVER A ± 3 T CYCLE). FOR WELL WORKING OF THIS SYSTEM, THE STRANDS MUST HAVE A TWIST PITCH IN A RANGE OF 13~17 MM. IN THIS PAPER, THE INTERNAL TIN STRANDS WITH A TWIST PITCH OF 13.4 MM, 14.8 MM, 15.4 MM, 16.2 MM AND 17.3 MM WARE DESIGNED USING WESTERN SUPERCONDUCTING TECHNOLOGIES CO., LTD. (WST) ITER NB_3SN STRANDS. THE EFFECT OF TWIST PITCH ON HYSTERESIS LOSS AND I_C WERE INVESTIGATED. AS A RESULT, THE HYSTERESIS LOSS CAN BE REDUCED MORE OBVIOUSLY THAN I_C. THE HYSTERESIS LOSS OF SOME TWISTED STRANDS OVERSTEPPED THE REQUIREMENT OF ITER EVEN THOUGH THE TWIST PITCHES IN THE RANGE OF ITER.

THE AUTHORS GRATEFULLY ACKNOWLEDGE THE COLLABORATION OF YU WU, FANG LIU, FENG LONG ET AL. (IPP) AND YAN ZHANG (PKU) WHO HAVE PROVIDED THE IC AND MAGNETIZATION MEASUREMENTS.

2MP1F-04

NB_3SN WIRE QUALITY ASSURANCE TESTS FOR THE SERIES-CONNECTED HYBRID MAGNETS ***J. LU***[1], *K. HAN*[1], *I. R. DIXON*[1], *Y. ZHANG*[2], *M. B. FIELD*[2], *J. A. PARRELL*[2]; [1]NATIONAL HIGH MAGNETIC FIELD LABORATORY, [2]OXFORD INSTRUMENTS SUPERCONDUCTING TECHNOLOGY. — THE SERIES-CONNECTED HYBRID MAGNETS UNDER CONSTRUCTION FOR THE HELMHOLTZ-ZENTRUM BERLIN (HZB) AND THE NATIONAL HIGH MAGNETIC FIELD LABORATORY (NHMFL) USE TOTAL OF ABOUT 500 KM OF HIGH J_C NB_3SN RRP WIRES. THE QUALITY ASSURANCE (QA) OF NB_3SN WIRES IS VITALLY IMPORTANT TO THE SUCCESS OF THE MAGNETS. IN ADDITION TO THE QA TESTS PERFORMED AT THE WIRE MANUFACTURER, THE NHMFL CARRIED OUT AN INCOMING QUALITY ASSURANCE TEST PROGRAM. IN THE PAPER, THE DATA FROM THE INCOMING QA TESTS ARE PRESENTED. SOME ISSUES AND THEIR CAUSES OF SOME PARAMETERS ARE STUDIES IN DETAIL, AND THE RESULTS WILL BE DISCUSSED ACCORDINGLY.

2MP1F-05

CRITICAL CURRENT DENSITY AND MICROSTRUCTURE OF THE HYBRID BRONZE PROCESSED NB_3SN CONDUCTOR ***A. KIKUCHI***[1], *Y. YOSHIDA*[1], *Y. TANIGUCHI*[2], *K. TACHIKAWA*[3]; [1]NATIONAL INSTITUTE FOR MATERIALS SCIENCE, [2]OSAKA ALLOYING WORKS CO. LTD., [3]TOKAI UNIVERSITY. — COMMERCIAL BRONZE PROCESSED NB_3SN WIRES SHOW RELATIVELY LOW CRITICAL CURRENT DENSITY (JC). THE MAIN REASON COMES FROM THE LIMIT OF SN CONCENTRATION IN THE BRONZE MATRIX. HIGH JC CAN BE OBTAINED ON THE INTERNAL-SN AND POWDER-IN-TUBE PROCESSED WIRES, BUT THEIR EFFECTIVE FILAMENT SIZES ARE GENERALLY LARGE, ALTHOUGH IT SHOULD BE MINIMIZED FOR THE FUSION APPLICATION. NEW HIGH JC WIRES BASED ON THE BRONZED PROCESS WITH FINE MULTI-FILAMENTS ARE STRONGLY REQUIRED. WE PROPOSED HYBRID BRONZED PROCESS, WHICH WAS HAVING THE HYBRID CONFIGURATION OF THE BRONZE,

THE INTERNAL-SN AND THE POWDER-IN-TUBE PROCESSES. IN THIS NEW PROCESS, THE BRITTLE TI2SN3 POWDERS ARE USED AS AN ADDITIONAL TIN SOURCE FOR THE ALPHA BRONZE MATRIX. AFTER THE REACTION, SIGNIFICANTLY THICK $(NB,TI)_3SN$ LAYERS WERE FORMED, AND THEY SHOWED NO CONCENTRATION GRADIENT OF SN AND TI. THE QUANTITATIVE ANALYSIS REVEALED THAT THE CONCENTRATION OF TI IN THE THICK NB_3SN LAYER WAS APPROXIMATELY 1.7-2.0 AT%. AND THEIR TC WAS APPROXIMATELY 17.5 K, WHICH IS COMPARABLE VALUE WITH THE COMMERCIAL BRONZE PROCESSED WIRES. IN THIS PAPER, THE CRITICAL CURRENT DENSITY AND THE FLUX PINNING FORCE UNDER THE MAGNETIC FIELDS WERE INVESTIGATED. NB3SN LAYER JC OF THE HYBRID BRONZE PROCESSED WIRE WAS COMPARED TO THOSE OF THREE MAJOR PROCESSED NB3SN WIRES.

A PART OF THIS STUDY WAS SUPPORTED BY A GRANT-IN-AID FOR SCIENTIFIC RESEARCH (NO. 21760566) FROM THE MINISTRY OF EDUCATION, CULTURE, SPORTS, SCIENCE AND TECHNOLOGY (MEXT) IN JAPAN.

2MP1F-06

HEAT TREATMENT INFLUENCE ON THE MICROSTRUCTURE AND PERFORMANCE OF INTERNAL-TIN ROUTE NB3SN SUPERCONDUCTING STRAND ***J. LIU[1]***, *X. TANG[2], J. LI[1], T. WANG[1], C. LI[1], C. XIAO[1], J. GUAN[1], X. SUN[1], X. WAN[1], X. LIU[1], Y. FENG[1], P. ZHANG[3];* [1]WESTERN SUPERCONDUCTING TECHNOLOGIES, CO. LTD; NATIONAL ENGINEERING LABORATORY FOR SUPERCONDUCTING MATERIALS PREPARATION, [2]WESTERN SUPERCONDUCTING TECHNOLOGIES, CO. LTD;NATIONAL ENGINEERING LABORATORY FOR SUPERCONDUCTING MATERIALS PREPARATION; NORTHWEST INSTITUTE FOR NONFERROUS METAL RESEARCH, [3]WESTERN SUPERCONDUCTING TECHNOLOGIES, CO. LTD; NATIONAL ENGINEERING LABORATORY FOR SUPERCONDUCTING MATERIALS PREPARATION; NORTHWEST INSTITUTE FOR NONFERROUS METAL RESEARCH; STATE KEY LAB. OF SOLIDIFICATION PROCESSING, NORTHWESTERN POLYTECHNICAL UNIVERSITY. — MULTI-FILAMENTARY NB_3SN STRAND HAS BEEN PREPARED BY INTERNAL-TIN ROUTE. THE HEAT TREATMENTS HAVE BEEN CONDUCTED IN A VACUUM FURNACE WITH DIFFERENT DURATIONS OF 55, 75 AND 100 HOURS AT 650 ^{O}C. IT HAS BEEN FOUND THAT BOTH THE CRITICAL CURRENT AND HYSTERESIS LOSS OF THE STRAND INCREASE WITH THE HEAT TREATMENT TIME AT 650 ^{O}C. THE CRITICAL CURRENTS FOR 55, 75 AND 100 HOURS AT 650 ^{O}C ARE 237A, 261A AND 275A, RESPECTIVELY. THE CORRESPONDING HYSTERESIS LOSSES PER VOLUME UNIT ARE 334 MJ/CM^3, 515 MJ/CM^{3}AND 612 MJ/CM^3, RESPECTIVELY. THESE RESULTS CAN BE EXPLAINED VIA THEIR MICROSTRUCTURE AFTER HEAT TREATMENT. IT IS OBSERVED THAT, ESPECIALLY FOR THE OUTERMOST SUBELEMENTS, THE AREA RATIO OF UNREACTED NB DECREASES WHEN THE DURATION AT 650 ^{O}C IS INCREASED. THUS THE CRITICAL CURRENT IS IMPROVED FOR THE MASS INCREASE OF NB_3SN. AND IT ALSO CAN BE DEDUCED THAT THE OUTERMOST SUBELEMENTS CONTRIBUTE MORE THAN THE INNER ONES TO THE HYSTERESIS LOSSES BECAUSE OF GREATER ASYMMETRIC DEFORMATION, WHICH CAN BE ADJUSTED BY OPTIMIZING CONDUCTOR DESIGN AND DRAWING PROCESS. THESE RESULTS ARE VERY BENEFICIAL TO THE LARGE-SCALE PRODUCTION OF ITER TYPE NB_3SN STRAND.

THE AUTHORS ARE GRATEFUL TO THE MEMBERS IN ALSTOM MAGNETS AND SUPERCONDUCTORS APPLICATION (MSA) IN FRANCE FOR THEIR HELP. THE AUTHORS ALSO WOULD LIKE TO THANK NIST FOR THE CRITICAL CURRENT MEASUREMENTS.

2MP1F-07

DEVELOPMENT OF NB_3SN INTERNAL TIN STRANDS WITH ENHANCED CURRENT CAPACITY AND IMPROVED MECHANICAL PROPERTIES ***S. SUDYEV****, V. PANTSYRNYY, A. VOROBYEVA, N. BELIAKOV, V. SERGEEV;* BOCHVAR RESEARCH INSTITUTE OF INORGANIC MATERIALS. — THE CURRENT CARRYING CAPACITY OF DIFFERENT DESIGN INTERNAL TIN STRANDS AT HIGH MAGNETIC FIELDS WAS INVESTIGATED. TWO HIGH CRITICAL CURRENT DENSITY INTERNAL TIN NB3SN STRANDS WITH DIFFERENT LEVEL OF MECHANICAL PROPERTIES HAVE BEEN DESIGNED. THE INCREASE OF MECHANICAL STRENGTH HAS BEEN ATTAINED BY THE REPLACING OF THE PART OF STABILIZING COPPER BY STRENGTHENING ELEMENTS MADE OF "IN SITU" MICROCOMPOSITE CU-NB RODS. THE ANALYSIS OF THE MECHANICAL PROPERTIES OF THE STRANDS IN VIRGIN STATE AND AFTER THE REACTION HEAT TREATMENT HAS BEEN DONE. THE MICROSTRUCTURE OF STRANDS COMPONENTS INCLUDING NB3SN FILAMENTS HAS BEEN INVESTIGATED. THE RESULTS OF CURRENT CARRYING CAPACITY MEASUREMENTS OF 0.6 MM IN DIAMETER STRANDS IN MAGNETIC FIELDS UP TO 20 T (4.2 K; 0.1 MV/CM) AND HYSTERESIS LOSSES MEASUREMENTS (± 3 T CYCLES) ARE PRESENTED. IT WAS SHOWN THAT FOR THE STRAND WITH ENHANCED MECHANICAL STRENGTH THE CRITICAL CURRENT DENSITIES ATTAINED WERE 2580 A/MM2 AND 235 A/MM2 AT 12 T AND 20 T ACCORDINGLY AND FOR THE STRAND WITHOUT STRENGTHENING ELEMENTS THE CRITICAL CURRENT DENSITIES WERE EQUAL TO 2250 A/MM2 AND 500 A/MM2 AT 12 T AND 20 T ACCORDINGLY. THE CORRELATION OF THE MICROSTRUCTURE AND SUPERCONDUCTING PROPERTIES OF THE STRANDS DESIGNED ARE DISCUSSED.

2MP1F-08

OBSERVATIONS ON TITANIUM DIFFUSION IN ITT TYPE NB_3SN SUPERCONDUCTORS ***C. V. RENAUD, JR.****, W. T. NACHTRAB, T. WONG;* SUPERCON, INC.. — TITANIUM DOPING HAS BEEN SUCCESSFULLY EMPLOYED TO INCREASE HIGH FIELD CRITCAL CURRENT DENSITY (JC) IN INTERNAL TIN (IT) TYPE CONDUCTORS. TITANIUM DOPING IS ACHIEVED BY PLACING NB-47TI RODS WITHIN THE FILAMENT ARRAY. DOPING OCCURS DURING REACTION HEAT TREATMENT AS A RESULT OF TITANIUM DIFFUSING FROM THE NB-47TI SOURCE INTO THE NIOBIUM FILAMENTS. WE HAVE INVESTIGATED DOPING OF INTERNAL-TIN-TUBE (ITT) TYPE CONDUCTORS USING NB-47TI RODS PLACED IN HOLES DRILLED INTO THE NIOBIUM ANNULUS OF EACH FILAMENT. THE TITANIUM DISTRIBUTION AT VARIOUS STAGES DURING REACTION HEAT TREATMENT

WAS INVESTIGATED BY SEM/EDS. WE OBSERVED THAT THERE IS MINIMAL TITANIUM DIFFUSION INTO THE NIOBIUM UNTIL THE NB3SN REACTION FRONT REACHES THE NB-47TI SOURCE, AND THAT THERE IS A SIGNIFICANT LOSS OF TITANIUM TO THE RESIDUAL FILAMENT CORE. THE RESULTING DISTRIBUTION OF TITANIUM AND ITS EFFECT ON HIGH FIELD JC WILL BE DISCUSSED.

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2MP1F-09

TEXTURE INFLUENCES ON NB FILAMENT DEFORMATION PERFORMANCE ***S. BALACHANDRAN***[1]*, R. E. BARBER*[2]*, Y. HUANG*[3]*, H. MIAO*[3]*, J. A. PARRELL*[3]*, R. B. GRIFFIN*[4]*, K. T. HARTWIG*[1]*;* [1]TEXAS A&M UNIVERSITY, [2]SHEAR FORM INC, [3]OXFORD INSTRUMENTS- SUPERCONDUCTING TECHNOLOGY, [4]TEXAS A&M UNIVERSITY,QATAR. — ONE OF THE POSSIBILITIES BEING EXPLORED FOR OBTAINING HIGH JC NB-SN CONDUCTORS IS TO INCREASE THE NB FRACTION IN THE SUB-ELEMENTS. INTERNAL TIN CONDUCTORS MANUFACTURED BY OXFORD INSTRUMENTS HAVE ADOPTED THE ROD RESTACK PROCESS (RRP®) SUCCESSFULLY TO ACHIEVE THIS END. HOWEVER, INCREASING THE NB FRACTION IN RRP SUB-ELEMENTS REQUIRES A DECREASE IN THE CU THICKNESS BETWEEN NB MONOFILAMENTS. IRREGULAR DEFORMATION OF THE NB FILAMENTS LEADS TO NON-UNIFORM THINNING OF SURROUNDING CU AND NB FILAMENT MERGING WITH POSSIBLE EVENTUAL WIRE BREAKAGE. THE DEFORMATION OF THE INITIAL NB FILAMENTS IS LARGELY DEPENDENT ON THE PRECURSOR BAR MICROSTRUCTURE. THE AUTHORS HAVE DEMONSTRATED THAT A FINER STARTING NB GRAIN SIZE LEADS TO BETTER FILAMENT ROUNDNESS. THE ABILITY TO OBTAIN UNIFORMITY IN THE NB MICROSTRUCTURE, IN TERMS OF FINER GRAIN SIZE AND TEXTURE, IS CRUCIAL FOR OBTAINING REPEATABLE GOOD DEFORMATION CHARACTERISTICS IN NB FILAMENTS. THE AUTHORS PRESENT RESULTS ON THE EFFECTS OF TEXTURE ON THE ROBUSTNESS OF MAINTAINING FILAMENT ROUNDNESS DURING WIRE MANUFACTURE BASED ON MONOFILAMENT EXTRUSION AND DRAWING EXPERIMENTS INVOLVING RECRYSTALLIZED NB BARS OF APPROXIMATELY 20-30 µM UNIFORM GRAIN SIZE AND DIFFERENT INITIAL TEXTURES RANGING FROM A MODERATE {100} TO A RANDOM TEXTURE.

US DEPARTMENT OF ENERGY, SBIR PROGRAM.CONTRACT#: DE-FG02-08ER85026

2MP1F-10

DEVELOPMENT OF METALLOGRAPHIC PROCEDURES FOR IMAGING CABLE-IN-CONDUIT CONDUCTORS ***M. C. JEWELL***[1]*, P. J. LEE*[2]*, H. BAJAS*[3]*, C. SANABRIA*[2]*, W. STARCH*[2]*, D. C. LARBALESTIER*[2]*;* [1]ITER ORGANIZATION, [2]APPLIED SUPERCONDUCTIVITY CENTER, NATIONAL HIGH MAGNETIC FIELD LABORATORY, FLORIDA STATE UNIVERSITY, [3]ÉCOLE CENTRALE PARIS (ECP). — IN RECENT YEARS A LARGE SET OF DATA HAS BEEN DEVELOPED THAT SPECIFIES THE STRAIN BEHAVIOR OF NB3SN STRANDS UNDER AXIAL TENSION AND COMPRESSION, BENDING, AND STRAND PINCHING, INCLUDING BOTH REVERSIBLE AND IRREVERSIBLE EFFECTS. HOWEVER, EXTRAPOLATING THESE RESULTS TO PREDICT THE BEHAVIOR OF NB3SN CABLE-IN-CONDUIT CONDUCTORS (CICC) HAS BEEN HAMPERED BY A BASIC UNCERTAINTY OF THE DEGRADATION MECHANISMS ACTING IN THE CONDUCTOR, INCLUDING THE RELATIVE WEIGHT OF REVERSIBLE (ELASTIC STRAIN) AND IRREVERSIBLE (FILAMENT BREAKAGE) EFFECTS. TO BETTER ASSESS THE REAL FILAMENT DAMAGE THAT EXISTS IN SUCH CONDUCTORS, WE HAVE DEVELOPED A SET OF METALLOGRAPHIC TECHNIQUES TO ALLOW DIRECT IMAGING OF NB3SN STRANDS AND FILAMENTS WITHIN VARIOUS RECENT DESIGNS OF CICC: EDIPO (FORMERLY EFDA DIPOLE) PROTOTYPE CONDUCTOR, SAMAN CONDUCTOR, AND ITER TF MODEL COIL (TFMC) CONDUCTOR, ALL AFTER EXPOSURE TO FULL LOADING IN ELECTROMAGNETIC TESTING. THE TECHNIQUES HAVE BEEN USEFUL FOR A VARIETY OF CONDUCTOR ASSESSMENTS, INCLUDING CABLE LAYOUT, MACROSCOPIC STRAND DEFORMATION, LOCAL VOID FRACTION, AND MICROSCOPIC DEFORMATION SUCH AS FILAMENT CRACKING, THUS OPENING A NEW CHARACTERIZATION ROUTE TO AID INTERPRETATION OF CONDUCTOR PERFORMANCE. A SEPARATE PAPER WILL PRESENT THE DETAILED INVESTIGATION OF CRACK FORMATION ON CONDUCTORS AND EXTRACTED STRANDS USING THIS TECHNIQUE.

THE AUTHORS WISH TO THANK PIERLUIGI BRUZZONE AT CRPP FOR PROVIDING THE EFDA DIPOLE SAMPLES, AND PATRICK DECOOL AT CEA CADARACHE FOR PROVIDING THE SAMAN AND TFMC SAMPLES. ADDITIONAL METALLOGRAPHIC WORK WAS PERFORMED BY SHANE BOLAND.

2MP1G-01

THE PERFORMANCE OPTIMIZATION OF NBTI SUPERCONDUCTING COMPOSITE WIRE FOR ITER PROJECT ***J. LI***[1]*, P. ZHANG*[2]*, X. LIU*[1]*, Y. FENG*[1]*, T. WANG*[1]*, W. LIU*[1]*, S. DU*[1]*, S. ZHU*[1]*, L. YAN*[1]*, H. GAO*[1]*, G. GRUNBLATT*[3]*, G. HOANG*[3]*, C. VERWAERDE*[3]*;* [1]WESTERN SUPERCONDUCTING TECHNOLOGIES CO.,LTD.;NATIONAL ENGINEERING LABORATORY FOR SUPERCONDUCTING MATERIALS PREPARATION, [2]WESTERN SUPERCONDUCTING TECHNOLOGIES CO.,LTD.;NATIONAL ENGINEERING LABORATORY FOR SUPERCONDUCTING MATERIALS PREPARATION;NORTHWEST INSTITUTE FOR NONFERROUS METAL RESEARCH;STATE KEY LAB. OF SOLIDIFICATION PROCESSING, NORTHWESTERN POLYTECHNICAL UNIVERSITY, [3]ALSTOM. — AS A JOINT INTERNATIONAL RESEARCH AND DEVELOPMENT PROJECT, ITER AIMS TO DEMONSTRATE THE SCIENTIFIC AND TECHNICAL FEASIBILITY OF FUSION POWER. NBTI SUPERCONDUCTING WIRE HAS BEEN SELECTED FOR USE IN THE POLOIDAL FIELD (PF) CONDUCTOR, COOLED WITH SUPERCRITICAL HELIUM IN THE TEMPERATURE RANGE OF 4.5-5 K. SUBSEQUENTLY, THE ITER ORGANIZATION PUT FORWARD A NEW REQUIREMENT THAT IMPROVING THE CRITICAL CURRENT DENSITY AT 6.5K FOR ITER SAFE OPERATION.NBTI SUPERCONDUCTING STRAND HAS BEEN FABRICATED WITH THE HIGHEST YET RECORDED 5T, 6.5K CRITICAL CURRENT DENSITY FOR CONVENTIONALLY

PROCESSED NBTI. THE PERFORMANCE AT 4T, 6.5K IS REACHED 994A/MM2, WHICH HAS MET THE ITER NEW REQUIREMENT, BUT THE PERFORMANCE AT 5T AND 6T LESS THAN THE ITER REQUIREMENT. BASED ON THE PRESENTLY AVAILABLE DATABASE, A CONSISTENT DESIGN OF THE PF CONDUCTOR COULD BE PERFORMED IF WE ACCEPT A REDUCTION OF THE 1.5K TEMPERATURE MARGIN.

THE AUTHORS ARE GRATEFUL TO THE MEMBERS IN ALSTOM MAGNETS AND SUPERCONDUCTORS APPLICATION (MSA) IN FRANCE FOR THEIR HELP. THE AUTHORS ALSO WOULD LIKE TO THANK NIST FOR THE CRITICAL CURRENT MEASUREMENTS.

2MP1G-02

TESTING AND ANALYSIS OF THE CRITICAL CURRENT AND MAGNETIZATION FOR NBTI STRAND ***S. ZHU**, J. LI, W. LIU, H. GAO, L. YAN, H. XIE, T. WANG, X. LIU, Y. FENG;* WESTERN SUPERCONDUCTING TECHNOLOGIES CO.,LTD;NATIONAL ENGINEERING LABORATORY FOR SUPERCONDUCTING MATERIALS PREPARATION. — THE INCREASING DEMAND FOR HIGH FIELD MAGNETIC DEVICES HAS FOCUSED ATTENTION ON FILAMENTARY NBTI SUPERCONDUCTORS, WESTERN SUPERCONDUCTING TECHNOLOGIES CO.,LTD (WST) HAS PRODUCED NBTI AND NB3SN SUPERCONDUCTING STRANDS, AND THE NBTI STRAND IS THE KEY COMPONENT OF THE ITER (INTERNATIONAL THERMONUCLEAR EXPERIMENTAL REACTOR) MAGNETS. ACCORDING TO THE DESIGN CRITERIA, THE PERFORMANCE OF THE COILS IN OPERATION IS STRICTLY TIED TO THE STRAND PROPERTIES, AND WERE TESTED BY THE MEASUREMENTS OF THE CRITICAL CURRENT AT 0.1MV/CM, FOR THE FIELD VALUES 4T,4.5T,5T,5.7T,7T AND 8T OVER THE TEMPERATURE 4.22K. TO CHOOSE THE SUITABLE OPERATING PARAMETERS AND DETERMINE THE STABILITY MARGIN OF MAGNET SYSTEMS, IT IS VERY IMPORTANT TO KNOW THE EFFECT OF MAGNETIC FIELD ON THE SUPERCONDUCTING PROPERTIES. FOR THAT PURPOSE THE MAGNETIC FIELD DEPENDENCE OF THE CRITICAL CURRENT WAS CARRIED OUT BY ONLY ONE MEASUREMENT AT DIFFERENT FIELDS. FROM THIS CURVE FOLLOWS THE PINNING FORCE AS A FUNCTION OF THE FIELD AND THE POSSIBILITY TO FIT THE FIELD DEPENDENCE OF THE CRITICAL CURRENT TO OTHER FORMALISMS. AT LAST PAPER DISCUSS THE EFFECT OF DIFFERENT TWIST PITCH ON THE HYSTERESIS LOSSES OF NBTI COMPOSITE SUPERCONDUCTING WIRES.

THE AUTHORS GRATEFULLY ACKNOWLEDGE THE COLLABORATION OF YU WU, FANG LIU, FENG LONG ET AL. (IPP) AND YAN ZHANG (PKU) WHO HAVE PROVIDED THE IC AND MAGNETIZATION MEASUREMENTS.

2MP1G-03

DIRECT MEASUREMENT OF INTERFILAMENT RESISTANCE IN SUPERCONDUCTING MULTIFILAMENTARY NBTI AND NB_3SN STRANDS ***C. ZHOU**, E. P. A. VAN LANEN, D. VELDHUIS, H. H. J. TEN KATE, M. J. DHALLE, A. NIJHUIS;* UNIVERSITY OF TWENTE. — ***ABSTRACT*** INTERFILAMENT TRANSVERSE RESISTANCES ARE REQUIRED TO PROVIDE A BETTER QUANTITATIVE DESCRIPTION OF THE CURRENT REDISTRIBUTION PROCESSES INSIDE STRANDS. THIS IS PARTICULARLY IMPORTANT FOR THE ANALYSIS OF THE INFLUENCE OF THE STRAIN AND CRACK DISTRIBUTION PATTERNS IN NB_3SN FILAMENTS ON THE SHAPE OF THE V-I CURVES. THE STRAIN IN THE FILAMENTARY REGION VARIES SPATIALLY AND PERIODICALLY WHEN SUBJECTED TO MECHANICAL AXIAL AND TRANSVERSE LOADING IN CICCS AS USED FOR ITER OR HIGH FIELD MAGNETS. IN SEVERE CASES, THE SAME OCCURS FOR CRACKS IN THE FILAMENTS THAT ARE INITIATED WHEN EXCEEDING THE IRREVERSIBILITY LIMIT. IN THE PAST, SEVERAL INDIRECT METHODS HAVE BEEN USED TO ASSESS THE INTERFILAMENT RESISTANCE. THE MAIN AIM OF THIS WORK IS TO APPLY A DIRECT METHOD FOR MEASUREMENT OF THE INTERFILAMENT TRANSVERSE AND FILAMENT-MATRIX RESISTIVITY. IN THIS PAPER, WE PROPOSE TWO DIRECT CONVENIENT FOUR-POINT VOLTAGE-CURRENT METHODS FOR INTERFILAMENT TRANSVERSE RESISTANCE MEASUREMENTS BELOW 10 K WITH DIFFERENT BACKGROUND MAGNETIC FIELD. IN ADDITION TO FEM SIMULATIONS WE ALSO DEVELOPED A 3D STRAND MODEL TO SIMULATE THE CURRENT AND VOLTAGE DISTRIBUTION FOR THE MEASURED INTERFILAMENT TRANSVERSE AND FILAMENT-MATRIX RESISTIVITY. WE REPORT ON THE EXPERIMENTAL METHODS, THEIR MAIN RESULTS, AND THE SIMULATION RESULTS FROM THE 3D STRAND MODEL.

2MP2A-02

METALLIC ENVELOPES FOR LONG-LENGTH HTS COATED CONDUCTORS: OPTIMAL MEANS AND FUNCTIONALITY *A. RUTT, M. WASCHULEWSKI, K. SCHLENGA,* ***A. USOSKIN**;* BRUKER HTS GMBH. — PROTECTION OF HTS COATED CONDUCTORS VIA METALLIC LAYERS RELATES TO ONE OF THE MOST VIABLE TASKS THAT SHOULD ULTIMATELY ENABLE THE REAL APPLICATIONS OF 2G SUPERCONDUCTING TAPES. THREE ASPECTS OF SUCH PROTECTION ARE EQUALLY IMPORTANT: (I) CHEMICAL AND (II) MECHANICAL PROTECTION OF THE CC SURFACE AS WELL AS (III) ELECTRICAL STABILIZATION OF THE COATED CONDUCTOR. THE ELECTRICAL STABILIZATION IS OF HIGHEST IMPORTANCE WHEN THE COATED CONDUCTOR CARRIES HIGH POWER DENSITY DURING OR AFTER QUENCH EVENT. DIFFERENT ROUTES FOR METALLIC PROTECTION OF CCS ARE DEVELOPED AND EMPLOYED IN LONG LENGTH TAPE PRODUCTION. COMPARISON OF DIFFERENT TECHNIQUES BASED ON GALVANIC PLATING, VACUUM DEPOSITION AND LAMINATION IS GIVEN IN ORDER TO DISTINGUISH WHICH METHOD OR COMBINATION OF METHOD IS MORE EFFICIENT IN PARTICULAR CASES OF APPLICATION IN CABLES, MOTORS OR CURRENT LIMITING DEVICES. AN ATTEMPT TO IDENTIFY A COST EFFECTIVE PROCESSING ROUTE FOR LONG-LENGTH AND LARGE SCALE PRODUCTION IS PERFORMED.

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2MP2A-03

DEVELOPMENT OF A NUMERICAL PROGRAM FOR OPTIMIZATION OF 2G HTS CONDUCTOR ***S. HWANG**[1], K. KIM[1], Y. CHOI[1], M. AHN[2], H. KIM[3], H. LEE[1], S. HAHN[4];* [1]KOREA

UNIVERSITY, KOREA, [2]KUNSAN NATIONAL UNIVERSITY, KOREA, [3]KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE, KOREA, [4]FRANCIS BITTER MAGNET LABORATORY (FBML), MIT, USA. — CONDUCTOR PROPERTIES-MECHANICAL, THERMAL, AND ELECTRICAL-ARE KEY INFORMATION IN THE DESIGN AND OPTIMIZATION OF SUPERCONDUCTING COILS. PARTICULARLY IN THOSE DEVICES USING 2G HTS CONDUCTORS WHOSE BASE MATERIALS (FOR EXAMPLE, SUBSTRATE OR STABILIZER) AND DIMENSION ARE ADJUSTABLE, A DESIGN PROCESS FOR CONDUCTOR OPTIMIZATION IS ONE OF THE IMPORTANT FACTORS TO ENHANCE SUPERCONDUCTING SYSTEM PERFORMANCE WITH REDUCED CONDUCTOR COST. RECENTLY, WE DEVELOPED A NUMERICAL PROGRAM THAT CAN BE USED FOR 2G HTS CONDUCTOR OPTIMIZATION. FOCUSED ON FIVE MAJOR PROPERTIES SUCH AS ELECTRICAL RESISTIVITY, HEAT CAPACITY, THERMAL CONDUCTIVITY, Z-VALUE, AND ENTHALPY, THE PROGRAM INCLUDES ELECTRONIC DATABASE OF MAJOR BASE MATERIALS AND CALCULATES THE EQUIVALENT PROPERTIES OF THE 2G HTS CONDUCTOR WITH THE INPUT OF EACH COMPONENT'S DIMENSIONS. IN THIS STUDY, THE DEVELOPED PROGRAM IS INTRODUCED AND VERIFIED ITS VALIDITY BY COMPARISON BETWEEN EXPERIMENTAL AND SIMULATED RESULTS WITH SEVERAL 2G HTS CONDUCTORS. ALSO, THE CONDUCTOR PROPERTIES WITH VARIOUS BASE MATERIALS AND THEIR DIMENSIONS ARE ESTIMATED USING THE DEVELOPED PROGRAM.

THIS STUDY WAS SUPPORTED BY A KOSEF GRANT FUNDED BY THE KOREA GOVERNMENT (MEST 2009-0085369), AND BY A GRANT FROM THE CAST OF THE 21ST CENTURY FRONTIER R&D PROGRAM FUNDED BY THE MEST, KOREA.

2MP2A-04

MICROSTRUCTURAL AND ELECTRICAL PROPERTIES OF LASER MACHINED 2G HTS TAPES ***J. LEE***[1]*, H. KIM*[1]*, J. SONG*[1]*, M. AHN*[2]*, Y. OH*[3]*, H. LEE*[1]*;* [1]KOREA UNIVERSITY, KOREA, [2]KUNSAN NATIONAL UNIVERSITY, KOREA, [3]K-JOINS COMPANY, KOREA. — THE STRUCTURE AND SUPERCONDUCTING PROPERTIES OF THE 2G HTS TAPE STRONGLY DEPENDS ON ITS OXYGEN CONTENT. DEGRADATION OF ITS SUPERCONDUCTING PROPERTIES CAN OCCUR BY OXYGEN DIFFUSION OUT OF A SUPERCONDUCTOR DURING HEAT-TREATMENT. THIS IS AN INEVITABLE PROCESS FOR A SUPERCONDUCTING JOINT USING THE MELTING DIFFUSION TECHNIQUE. THEREFORE, AN ADDITIONAL OXYGEN ANNEALING PROCESS AT LOW TEMPERATURES (500 ~ 600 °C) IN AN OXYGEN RICH ENVIRONMENT WILL BE NECESSARY TO RESTORE THE SUPERCONDUCTING PROPERTIES OF THE HEAT TREATED SAMPLES. DUE TO THE LOW SOLUBILITY AND DIFFUSIVITY OF OXYGEN IN THE BUFFER AND SUBSTRATE MATERIALS, IT IS NECESSARY TO SECURE THE DIFFUSION PATH OF THE OXYGEN FOR A SUPERCONDUCTING JOINT. IN THIS STUDY, WE EXAMINED THE ELECTRICAL PROPERTIES OF THE REBCO CCS BEFORE AND AFTER LASER MACHINING TO DEVELOP THE OXYGEN DIFFUSION PATHS SUCH AS MICRO-HOLES AND CHINKS ON THE SURFACE OF THE REBCO CC. THE APPLICABILITY OF THE LASER MACHINING TECHNIQUE FOR A SUCCESSFUL SUPERCONDUCTING JOINT OF THE 2G HTS TAPES IS ALSO DISCUSSED.

THIS STUDY WAS SUPPORTED BY A KOREA SCIENCE AND ENGINEERING FOUNDATION (KOSEF) GRANT FUNDED BY THE KOREA GOVERNMENT (MEST 2009-0085369).

2MP2A-05

USING N-VALUE ANALYSIS FOR DETERMINATION OF POSITION-DEPENDENT PROPERTY VARIABILITY IN LONG-LENGTH COATED CONDUCTORS ***J. O. WILLIS***[1]*, J. Y. COULTER*[1]*, M. W. RUPICH*[2]*;* [1]LOS ALAMOS NATIONAL LABORATORY, [2]AMERICAN SUPERCONDUCTOR CORPORATION. — WE MEASURE THE CURRENT VOLTAGE (I-V) CHARACTERISTICS OF HIGH TEMPERATURE SUPERCONDUCTOR COATED CONDUCTORS (HTS CCS) AS A FUNCTION OF MAGNETIC FIELD, MAGNETIC FIELD ANGLE, TEMPERATURE, AND POSITION ALONG MULTI-METER LENGTH PRACTICAL WIRES. THE CRITICAL CURRENT (IC) DATA ARE ANALYZED TO DETERMINE CONDUCTOR UNIFORMITY, FOR QUALITY ASSURANCE, AND FOR FEEDBACK TO THE MANUFACTURING PROCESS WHEN AN OFF-NORMAL PROCESS EVENT HAS OCCURRED. WE REPORT ON AN EXPANSION OF THIS ANALYSIS TO INCLUDE THE BEHAVIOR OF THE POWER LAW EXPONENT (N) OF THE VOLTAGE-CURRENT RELATIONSHIP, V~I^N, AS A FUNCTION OF MAGNETIC FIELD AMPLITUDE AND ANGLE, TEMPERATURE, AND POSITION FOR LONG CCS. AMERICAN SUPERCONDUCTOR PROVIDED SECTIONS OF WIRE, FABRICATED BY THE MOD / RABITS PROCESS, THAT HAD H||AB PLANE IC VARIATIONS ALONG THE LENGTH TO EXAMINE WITH THIS TECHNIQUE. THESE VARIATIONS WERE CONFIRMED BY LANL. WE ALSO FIND CORRELATIONS BETWEEN IC AND N THAT ARE INDICATIVE OF THESE POSITION-DEPENDENT MICROSTRUCTURAL / PINNING PROPERTY VARIATIONS. WE DESCRIBE THE APPLICABILITY OF THIS NEW N-VALUE ANALYSIS TO IMPROVING THE UNDERSTANDING OF PRACTICAL CONDUCTOR PERFORMANCE AND TO ENSURING THE QUALITY OF COMMERCIAL WIRES.

THIS WORK WAS SUPPORTED BY THE U.S. DEPARTMENT OF ENERGY, OFFICE OF ELECTRICITY DELIVERY AND ENERGY RELIABILITY.

2MP2A-06

QUANTIFICATION OF PINNING ENHANCEMENTS IN PRODUCTION COATED CONDUCTORS FABRICATED BY MOCVD / IBAD ***J. Y. COULTER***[1]*, J. E. DACKOW*[2]*, Y. XIE*[2]*, D. W. REAGOR*[1]*, F. BACA*[1]*, T. G. HOLESINGER*[1]*, L. CIVALE*[1]*;* [1]LOS ALAMOS NATIONAL LABORATORY, [2]SUPERPOWER, INC.. — THE FIELD DEPENDENCE IN RESEARCH SIZE COATED CONDUCTORS HAS BEEN ENHANCED BY THE INCLUSION OF DOPANTS, AND PERFORMANCE BETWEEN SAMPLES IS COMPARED USING ALPHA, THE POWER LAW COEFFICIENT OF THE FIELD DEPENDENCE, DESCRIBED BY IC ~ ICO * H ^ -ALPHA. RECENTLY, SUPERPOWER, INC. BEGAN TO INCLUDE ZIRCONIUM DOPING IN THE PINNING CHEMISTRY OF PRODUCTION TAPE. TO DETERMINE THE EFFICACY AND UNIFORMITY OF THE CHANGES, SAMPLES SEPARATED BY

~400M WERE CUT FROM A 560M+ LONG TAPE AND CHARACTERIZED BY TRANSPORT CRITICAL CURRENT AT 75 K AND FIELD ORIENTATION ANGLE FOR FIELDS UP TO ~ 1T. THE IC DATA WERE ANALYZED AS A FUNCTION OF ANGLE FOR - ALPHA ~ LOG (IC) / LOG (H) OVER THE RANGE 0.2T - 0.8T. THE RESULTS ARE A MAP OF THE ANISOTROPIC FIELD DEPENDENCE AND A REDUCTION OF THE IC(H, ANGLE) DATA TO ALPHA (ANGLE) ALLOWING PIECE TO PIECE PERFORMANCE COMPARISON. COMPARED TO MANY SAMPLES FROM AN UNDOPED TAPE, THE H||C-AXIS FIELD DEPENDENCE HAS BEEN REDUCED FROM ALPHA ~ 0.5 TO 0.35 WITH MINIMAL AFFECT ON THE H||AB PLANE, WHICH EXHIBITS AN ALPHA OF ~ 0.45. WHEN CONSIDERING UNIFORMITY; THE ALPHA (ANGLE) CURVES ARE SIMILAR IN SHAPE AND MAGNITUDE FOR ADJACENT PIECES AND SHOW SLIGHT VARIATIONS FOR REGIONS SEPARATED BY 400M. WE WILL DESCRIBE THE CHARACTERIZATION SYSTEM AND ITS APPLICABILITY TO THE GENERAL CASE OF COATED CONDUCTORS AND PRESENT THE RESULTS, WHICH DEMONSTRATE PERFORMANCE MODIFICATIONS TO PRODUCTION COATED CONDUCTOR WIRE.

WORK SUPPORTED BY THE U.S. DEPARTMENT OF ENERGY OFFICE OF ELECTRICITY DELIVERY AND ENERGY RELIABILITY

2MP2A-07

CHEMICAL AND MICROSTRUCTURAL CHARACTERIZATION OF CE-, HO-, AND NB-DOPED MOCVD $YBA_2CU_3O_{6+X}$ *Z. CHEN[1], **V. A. MARONI**[1], D. J. MILLER[1], N. J. ZALUZEC[1], A. J. KROPF[1], T. AYTUG[2], C. CANTONI[2], M. PARANTHAMAN[2];* [1]ARGONNE NATIONAL LABORATORY, [2]OAK RIDGE NATIONAL LABORATORY. — METAL-ORGANIC CHEMICAL VAPOR DEPOSITED (MOCVD) $YBA_2CU_3O_{6+X}$ (YBCO) FILMS DOPED WITH VARYING AMOUNTS OF CE, HO, AND NB WERE EXAMINED BY TRANSMISSION ELECTRON MICROSCOPY (TEM), X-RAY ABSORPTION SPECTROSCOPY (XAS), AND RAMAN MICRO-SPECTROSCOPY. THE FILMS WERE PREPARED ON BUFFERED, METAL TEMPLATES PROVIDED BY SUPERPOWER, INC. TEM ON THE YBCO FILMS FOR ALL THREE DOPANT ELEMENTS REVEALED HORIZONTALLY ALIGNED PRECIPITATES AND ASSOCIATED STACKING FAULTS THAT INCREASED IN NUMBER AND SIZE WITH INCREASING DOPANT CONTENT. XAS DATA FOR THE HO- AND NB-DOPED SAMPLES SHOWED THAT (1) MOST OF THE HO APPEARED IN THE FILM AS $(Y,HO)_2O_3$ PRECIPITATES BUT A SUBSTANTIAL FRACTION OF THE HO ENTERED THE YBCO LATTICE (PRESUMABLY ON Y SITES) AND (2) VIRTUALLY ALL THE NB PRECIPITATED AS A YBA_2NBO_6-LIKE PHASE WITH ONLY A SMALL FRACTION ENTERING THE YBCO LATTICE. RAMAN SPECTROSCOPY DETECTED VARYING AMOUNTS OF CATION DISORDER WHICH FOR A GIVEN CONCENTRATION OF DOPANT INCREASED IN THE ORDER NB < HO < CE. OUR WORK INDICATES THAT MOCVD YBCO FILMS ARE CAPABLE OF ACCEPTING VARIOUS TYPES OF PINNING ELEMENTS, WITH THE IN-FIELD J_C ENHANCEMENTS CLOSELY RELATED TO THE COMPOSITION, DISTRIBUTION, AND MICROSTRUCTURE OF THE PINNING PRECIPITATES, AND THE LEVEL OF INDUCED DISORDER IN THE MATRIX.

RESEARCH SUPPORTED BY THE U.S. DEPARTMENT OF ENERGY, OFFICE OF ELECTRICITY DELIVERY AND ENERGY RELIABILITY, ADVANCED CABLES AND CONDUCTORS AND OFFICE OF SCIENCE, OFFICE OF BASIC ENERGY SCIENCES UNDER CONTRACT DE-AC02-06CH11357.

2MP2A-08

EXPERIMENTAL ANALYSIS OF UNEQUAL VOLTAGE DISTRIBUTION ON A SINGLE YBCO COATED CONDUCTOR AFFECTED BY INHOMOGENEOUS CRITICAL CURRENTS IN LIQUID NITROGEN AND SUB-COOLED LIQUID NITROGEN ***S. CHU**, J. JANG, S. CHOI, Y. KIM, K. CHANG, T. KO;* YONSEI UNIVERSITY. — IN ORDER TO DESIGN A LARGE SCALE SUPERCONDUCTING FAULT CURRENT LIMITER (SFCL) FOR POWER GRIDS, A SINGLE LONG-LENGTH YBCO COATED CONDUCTOR (CC) WIRE IS PREFERRED. HOWEVER THIS SINGLE YBCO CC WIRE COULD CAUSE A PROBLEM OF UNEQUAL VOLTAGE DISTRIBUTION BETWEEN THE PARTS IN THE LONG WIRE AT QUENCH CAUSED BY FAULTS. INHOMOGENEOUS CRITICAL CURRENTS OF THE YBCO CCS IN THE SFCL CAN BE ONE OF THE REASONS. FURTHERMORE, SUB-COOLED LIQUID NITROGEN (LN_2) CONDITION IS USUALLY USED FOR INCREASING OPERATING CURRENT CAPACITY OF THE SFCL. HOWEVER THIS SUB-COOLED CONDITION CAN WORSEN THE INHOMOGENEITY OF THE YBCO CCS. THEREFORE, IT IS IMPORTANT TO UNDERSTAND THE RELATION BETWEEN THE UNEQUAL VOLTAGE DISTRIBUTION AND THE INHOMOGENEOUS CRITICAL CURRENTS IN THE SINGLE LONG LENGTH YBCO CC. IN THIS PAPER, EXPERIMENTS WITH SAME SINGLE YBCO CC WIRE WERE CONDUCTED VARYING TEMPERATURE CONDITION, LN_2 AND SUB-COOLED LN_2. IN BOTH EXPERIMENTS, THE CRITICAL CURRENTS AND VOLTAGE DISTRIBUTIONS GENERATED BY FAULTS AT SHORT-CIRCUIT TESTS WERE MEASURED. IT WAS OBSERVED THAT THE INHOMOGENEOUS CONDITION IMPACT ON THE UNEQUAL VOLTAGE DISTRIBUTION.

THIS WORK WAS SUPPORTED BY THE HUMAN RESOURCES DEVELOPMENT PROGRAM OF THE KOREA INSTITUTE OF ENERGY TECHNOLOGY EVALUATION AND PLANNING (KETEP) GRANT FUNDED BY THE KOREA GOVERNMENT MINISTRY OF KNOWLEDGE ECONOMY. (NO. 2007-P-EP-HM-E-08-0000)

2MP2A-09

ELECTROMECHANICAL PROPERTY INVESTIGATION OF STRIATED REBCO CC TAPES IN PURE TORSION MODE *H. SHIN[1], **M. J. DEDICATORIA**[1], D. HA[2], S. OH[2];* [1]ANDONG NATIONAL UNIVERSITY, [2]KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE. — IN SUPERCONDUCTING CABLE APPLICATIONS, STRIATION OF REBCO COATED CONDUCTORS IS BEING CONSIDERED TO REDUCE AC LOSS. REDUCTION OF AC LOSS IN A YBCO FILM WITH LASER PATTERNED FILAMENTS HAS BEEN REPORTED. IN PRACTICAL APPLICATIONS, STRIATED REBCO CC TAPES SHOULD ALSO EXHIBIT ACCEPTABLE TOLERANCE TO MECHANICAL STRESS/STRAINS. IN THE ASPECT OF ELECTROMECHANICAL PROPERTIES, IT HAS BEEN

REPORTED ELSEWHERE THAT STRIATED MOCVD-IBAD YBCO CC TAPES SHOWED A COMPARABLE AXIAL STRAIN EFFECT WITH NON STRIATED SAMPLES. HOWEVER, REPORTS ON THE ELECTROMECHANICAL PROPERTIES OF CC TAPES IN BENDING OR TORSION MODE ARE STILL LIMITED. IN THIS STUDY, THE I_C DEGRADATION BEHAVIOR OF CU STABILIZED REBCO COATED CONDUCTOR (CC) IN TORSION MODE WAS INVESTIGATED. THE CC TAPE HAS BEEN LASER SCRIBED TO PRODUCE MULTI-FILAMENTS. THE MECHANICAL PROPERTIES OF STRIATED CC TAPES HAVE BEEN MEASURED AT 77 K. THE TORSIONAL ANGLE DEPENDENCE OF I_C IN THE SAMPLES HAS BEEN INVESTIGATED USING A SAMPLE HOLDER WHICH GIVES TORSIONAL DEFORMATION TO CC TAPES. I-V CURVES WERE MEASURED AT 77K AND AT SELF FIELD IN WHICH N-VALUES COULD BE ALSO DERIVED FROM EACH CURVE. THE ANGLE OF TWIST, Θ, CORRESPONDING TO THE IRREVERSIBLE LIMIT DEFINED BY THE 99% I_C RECOVERABILITY WAS DETERMINED. THE N-VALUE - Θ BEHAVIOR IN THE REBCO CC TAPE WAS ALSO SHOWN AND COMPARED WITH THE BEHAVIOR OF NORMALIZED I_C - Θ BEHAVIOR.

THIS WORK WAS SUPPORTED BY A GRANT FROM THE CENTER FOR APPLIED SUPERCONDUCTIVITY TECHNOLOGY UNDER THE DAPAS PROGRAM FUNDED BY THE MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY, REPUBLIC OF KOREA.

2MP2B-01

DEVELOPMENT OF A SUPERCONDUCTING JOINING TECHNIQUE FOR YBCO COATED CONDUCTORS (CCS) BY MELTING DIFFUSION UNDER A CONTROLLED OXYGEN PARTIAL PRESSURE ***H. KIM***[1]*, J. LEE*[1]*, J. SONG*[1]*, Y. OH*[2]*, H. LEE*[1]*;* [1]KOREA UNIVERSITY, KOREA, [2]K-JOINS COMPANY, KOREA. — THE DEVELOPMENT OF A SUPERCONDUCTING JOINT FOR YBCO CCS IS NECESSARY IN THE FOLLOWING CASES WHERE: 1) SHORT YBCO CCS ARE JOINED TOGETHER TO EXTEND THE WHOLE LENGTH OF THE JOINED CC AND BE WOUND INTO A COIL, 2) JOINING BETWEEN SUPERCONDUCTING MAGNET COILS IS REQUIRED TO CONNECT COILS OF WOUND YBCO CCS TO EACH OTHER, AND 3) BOTH ENDS OF A TERMINAL ARE CONNECTED TO EACH OTHER TO ESTABLISH A SUPERCONDUCTING CLOSED LOOP FOR A PERSISTENT CURRENT MODE OPERATION. THIS PAPER DISCUSSES NEW SUPERCONDUCTING JOINING TECHNIQUES THAT USE HEAT TREATMENT UNDER A REDUCED OXYGEN PARTIAL PRESSURE AND AN ADDITIONAL OXYGENATION ANNEALING PROCESS IN AN OXYGEN RICH ENVIRONMENT. THE SILVER (AG) STABILIZER LAYER ON TOP OF THE SUPERCONDUCTING LAYER WAS ELIMINATED IN ORDER TO MAKE DIRECT CONTACT FOR A SUCCESSFUL JOINT BETWEEN YBCO-YBCO. THE JOINT CHARACTERISTICS WERE EVALUATED IN TERMS OF THE JOINT RESISTANCES, CRITICAL CURRENTS AND INDEX NUMBERS. THE MORPHOLOGY AND STRUCTURE OF THE SAMPLES WERE ANALYZED BY SEM AND XRD, RESPECTIVELY.

THIS STUDY WAS SUPPORTED BY A KOREA SCIENCE AND ENGINEERING FOUNDATION (KOSEF) GRANT FUNDED BY THE KOREA GOVERNMENT (MEST 2009-0085369).

2MP2B-02

A COMPARISON OF JOINT PROPERTIES BETWEEN $YBA_2CU_3O_{7-X}$ COATED CONDUCTORS WITH DIFFERENT CURVATURE ***H. KIM***[1]*, K. CHANG*[1]*, Y. KIM*[1]*, H. JO*[1]*, K. KIM*[2]*, H. LEE*[2]*, T. KO*[1]*;* [1]YONSEI UNIVERSITY, [2]KOREA UNIVERSITY. — IN ORDER TO FABRICATE A HIGH T_C SUPERCONDUCTING (HTS) COIL FORMING A MAGNET, IT IS OFTEN CONSISTED OF SEVERAL STACKED PANCAKES OR SOLENOIDS. IN THIS CASE, IT IS NECESSARY FOR TAPES WOUND AROUND EACH TYPE TO CONNECT EACH OTHER WITH LOW SPLICE RESISTANCE. HOWEVER, CONTACTED AREA BETWEEN TWO TAPES DIFFERS ON THE USE OF SITUATIONS. IN THIS PAPER, IT IS MADE COMPARISON OF ELECTRICAL PROPERTIES WITH MUTUAL INFLUENCES BETWEEN PRESSURE AND BENDING STRAIN APPLIED TO SPLICED TAPES. AFTER-CURVED TAPE SPLICING ON A FLAT PLATE IS PERFORMED AND CHARACTERISTICS OF JOINED SAMPLES SUCH AS RESISTANCE AND CRITICAL CURRENT ARE MEASURED FROM A *V-I* CURVE. FURTHERMORE, MICROPHOTOGRAPH ANALYSIS OF A JOINED SURFACE IS CARRIED OUT TO EXAMINE THAT HOW WELL JOINT BETWEEN TWO TAPES ARE ACCOMPLISHED. WE ALSO DREW THE PREFERRED JOINT CONDITION THROUGH ABOVE RESULTS.

THIS RESEARCH WAS SUPPORTED BY NATIONAL RESEARCH LAB. PROGRAM THROUGH THE KOREA SCIENCE AND ENGINEERING FOUNDATION FUNDED BY THE MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY (R0A-2007-000-20063-0)

2MP2B-03

EXPERIMENTAL ANALYSIS ON THE JOINT CHARACTERISTICS BETWEEN DOUBLE PANCAKE COILS USING YBCO COATED CONDUCTORS ***K. CHANG***[1]*, H. JO*[1]*, Y. KIM*[1]*, M. AHN*[2]*, T. KO*[1]*;* [1]YONSEI UNIVERSITY, [2]KUNSAN NATIONAL UNIVERSITY. — IN THESE DAYS, SOME RESEARCHES ON THE HYBRID (HTS INSERT COIL/LTS BACKGROUND COIL) NUCLEAR MAGNETIC RESONANCE (NMR) HAVE BEEN CONDUCTED. MAGNETIC FIELD HOMOGENEITY IS VERY IMPORTANT IN THE NMR AND IN THAT CASE, THE DIRECTION OF THE JOINT PART BETWEEN A STACK OF DP COILS CAN CAUSE THE HOMOGENEITY PROBLEM SO THAT THE JOINT CHARACTERISTICS BETWEEN THE DP COILS ARE IMPORTANT. ON THE OTHER HAND, YBCO COATED CONDUCTOR TAPES ARE FABRICATED IN VARIOUS WIDTHS SO IT CAN BE USED AS AN AUXILIARY SUPERCONDUCTING TAPE AT THE JOINT PART BETWEEN THE DP COILS FOR MAGNETIC FIELD HOMOGENEITY. THE JOINT CHARACTERISTICS BETWEEN THE DP COILS CAN VARY WITH THE CONDITIONS OF THE AUXILIARY TAPE SUCH AS A NUMBER, A WIDTH, AND A DIRECTION OF THE TAPE. IN THIS WORK, WE CONDUCTED JOINT EXPERIMENTS UNDER VARIOUS CONDITIONS OF THE AUXILIARY TAPE AND ANALYZED THE JOINT CHARACTERISTICS. THE JOINT METHOD IN THIS WORK CAN BE USED TO FABRICATE THE INSERT COILS IN NUCLEAR MAGNETIC RESONANCE.

THIS STUDY WAS SUPPORTED BY THE KOREA SCIENCE AND ENGINEERING FOUNDATION (KOSEF) GRANT FUNDED BY THE KOREA GOVERNMENT (MEST 2009 - 0085369).

2MP2B-04

RESISTANCE OF YBCO SOLDER JOINTS ***J. LU**, K. HAN, W. R. SHEPPARD, K. W. PICKARD, W. D. MARKIEWICZ;* NATIONAL HIGH MAGNETIC FIELD LABORATORY. — THE NATIONAL HIGH MAGNETIC FIELD LABORATORY (NHMFL) IS FUNDED FOR CONSTRUCTION OF A 32 T ALL SUPERCONDUCTING MAGNET. THE HIGH FIELD INSERT COIL IS MADE BY YBCO COATED CONDUCTOR. DUE TO THE LIMITED YBCO CONDUCTOR PIECE LENGTH, SOLDER JOINTS ARE NECESSARY. IN ORDER FOR THE MAGNET TO ACHIEVE LOW COST OPERATION, IT IS IMPORTANT TO MINIMIZE THE RESISTANCE AT SOLDER JOINTS. IN THIS PAPER, WE PREPARED 40 MM LONG LAP SOLDER JOINTS MADE BY 4 MM WIDE SUPERPOWER YBCO CONDUCTORS. JOINT SAMPLES MADE FROM DIFFERENT CONDUCTOR BATCHES ARE SOLDERED WITH SN63 PB37 SOLDER AT DIFFERENT SOLDERING TEMPERATURES USING DIFFERENT SOLDERING FLUXES. THE RESISTANCE MEASUREMENTS WERE PERFORMED AT BOTH 77 K AND 4.2 K IN DIFFERENT MAGNETIC FIELDS WITH DIFFERENT ORIENTATIONS. THE MAIN PARAMETERS INFLUENCING JOINT RESISTANCE WILL BE DISCUSSED.

2MP2B-05

A STABILIZER DESIGN OF YBCO COATED CONDUCTOR FOR THE PASSIVE PROTECTION OF A HTS CURRENT LEAD ***K. CHANG**[1], S. CHOI[1], Y. KIM[1], M. AHN[2], H. KIM[3], T. KO[1];* [1]YONSEI UNIVERSITY, [2]KUNSAN NATIONAL UNIVERSITY, [3]KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE. — AS SUPERCONDUCTING TECHNOLOGY IMPROVES, A NEED FOR A SUPERCONDUCTING CURRENT LEAD INCREASES DUE TO A CURRENT CAPACITY AND A HEAT LEAK OF THE CURRENT LEAD. THEREFORE SOME RESEARCHES ON HIGH TEMPERATURE SUPERCONDUCTING CURRENT LEAD (HTSCL) HAVE BEEN CONDUCTED WITH HTS BULK. HTS BULK DOES NOT ONLY HAVE AN ADVANTAGE OF THERMAL PROPERTY BUT ALSO A DISADVANTAGE OF MECHANICAL PROPERTY. ON THE OTHER HAND, THE PROPERTY OF 2G HTS WIRE, COATED CONDUCTOR (CC), CAN BE CHANGED BY ADJUSTING AN INTERNAL STRUCTURE OF THE TAPE. IN ORDER TO DESIGN AN HTSCL WITH CC TAPE, THERE ARE SOME ISSUES TO BE CONSIDERED; A HEAT LEAK, A PROTECTION, MECHANICAL STABILITY, AND CURRENT CAPACITY OF THE HTSCL. IN THIS WORK, WE STUDIED A STRUCTURE OF CC FOR 2 KA HTSCL BY NUMERICAL AND EXPERIMENTAL ANALYSIS. BASED ON THIS RESEARCH, 2 KA HTSCL WILL BE FABRICATED AS PROOF-OF-CONCEPT AND TESTED IN THE NEAR FUTURE.

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2MP2B-06

CHANGES IN THE THERMAL STABILITY OF 2G HTS WIRES BY LOCAL MODIFICATION OF THE STABILIZATION LAYER ***L. A. ANGUREL**[1], E. MARTÍNEZ[1], J. PELEGRÍN[1], R. LAHOZ[1], G. F. DE LA FUENTE[1], N. ANDRÉS[2], M. P. ARROYO[2], Y. Y. XIE[3], V. SELVAMANICKAM[4];* [1]ICMA (CSIC-UNIVERSITY OF ZARAGOZA), SPAIN, [2]I3A, UNIVERSITY OF ZARAGOZA, SPAIN, [3]SUPERPOWER, INC., 450 DUANE AVE., SCHENECTADY, NEW YORK 12304 USA, [4]SUPERPOWER, INC., 450 DUANE AVE., SCHENECTADY, NEW YORK 12304 USA, UNIVERSITY OF HOUSTON, 4800 CALHOUN ROAD, TEXAS 77004, USA. — RECENT STUDIES HAVE SHOWN THAT THE CHARACTERISTICS OF THE STABILIZING LAYER HAVE AN IMPORTANT INFLUENCE IN THE THERMAL STABILITY RESPONSE OF 2G HTS WIRE, NAMELY RE-123 COATED CONDUCTOR. IN ORDER TO VERIFY THIS RELATION, A CONTROLLED LOCAL MODIFICATION OF THE STABILIZING LAYER HAS BEEN INDUCED BY LASER ABLATION. BY MODIFYING THE LASER PROCESSING PARAMETERS, WE HAVE INDUCED LOCAL OR EXTENDED DEFECTS IN THE STABILIZING LAYER WITH DIFFERENT SHAPES AND GEOMETRIES.THERMAL STABILITY STUDIES WERE PERFORMED BY MEASURING THE SAMPLE RESPONSE TO OVERCURRENTS. IN THE EXPERIMENTS, THE THERMAL AND ELECTRIC FIELD PROFILES ALONG THE TAPES, COMBINED WITH DEFORMATION MAPS OBTAINED FROM INTERFEROMETRIC OPTICAL TECHNIQUES, WERE RECORDED. LASER EMISSION PARAMETERS HAVE BEEN EXPLORED IN ORDER TO DEFINE CONDITIONS FOR THE ABLATION PROCESS, WHICH DO NOT DETERIORATE THE SUPERCONDUCTING PROPERTIES OF THE COATED CONDUCTORS. SAMPLES HAVE BEEN CHARACTERIZED BEFORE AND AFTER SUCCESSIVE ABLATION PROCESSES IN ORDER TO UNDERSTAND THE INFLUENCE OF THE STABILIZING LAYER CHARACTERISTICS ON THE THERMAL STABILITY RESPONSE OF THESE MATERIALS.

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2MP2B-07

COATED CONDUCTOR RUTHERFORD CABLES (CCRC) FOR HIGH-CURRENT APPLICATIONS: CONCEPT AND PROPERTIES ***S. I. SCHLACHTER**, W. GOLDACKER, F. GRILLI, R. HELLER, A. KUDYMOW;* KARLSRUHE INSTITUTE OF TECHNOLOGY, INSTITUTE FOR TECHNICAL PHYSICS, KARLSRUHE, GERMANY. — IN THE PAST YEARS THE ROEBEL TECHNIQUE HAS BEEN ESTABLISHED AS A METHOD FOR CABLING OF COATED CONDUCTOR TAPES TO ACHIEVE HIGH CURRENT CARRYING CAPABILITIES FOR LOW AC-LOSS APPLICATIONS. WE HAVE SUCCESSFULLY DEVELOPED ROEBEL CABLES WITH UP TO 50 TAPES AND WITH CURRENT CARRYING CAPABILITIES UP TO 2.6 KA (77 K, SELF-FIELD). HOWEVER, FOR APPLICATIONS LIKE BUSBARS OR FUSION MAGNETS CURRENT CARRYING CAPABILITIES OF MORE THAN 10 KA ARE REQUIRED. SUCH HIGH CURRENTS CANNOT BE REACHED BY SIMPLE SCALE-UP WITH ADDITIONAL TAPES. WE PRESENT A CONCEPT FOR

COATED CONDUCTOR RUTHERFORD CABLES (CCRCS) FOR CURRENTS EXCEEDING 10 KA USING ROEBEL CABLES AS STRANDS. FIRST RESULTS FOR A SUBSIZE CCRC WITH 10 STRANDS OF 4 MM WIDE ROEBEL CABLES WILL BE SHOWN. IN ORDER TO DEFINE THE MINIMUM THICKNESS OF A CCRC THAT ALLOWS WINDING OF ROEBEL STRANDS WITHOUT DEGRADATION, COMBINED BENDING AND TORSION TESTS WERE PERFORMED FOR SINGLE TAPES AND ROEBEL CABLES. FOR CABLES APPLIED IN LOW BACKGROUND FIELDS (E.G. BUSBARS) SELF-FIELD EFFECTS STRONGLY INFLUENCE THE CURRENT CARRYING CAPABILITY, WHEREAS THEY PLAY A MINOR ROLE AT HIGHER FIELDS, E.G. IN MAGNETS. THE INFLUENCE OF SELF-FIELD ON NEIGHBORING STRANDS WAS MODELED BY FEM SIMULATIONS USING RESULTS OF $I_C(B)$ MEASUREMENTS AT DIFFERENT TEMPERATURES AND DIFFERENT ANGLES BETWEEN MAGNETIC FIELD AND TAPE. FEM SIMULATIONS WERE ALSO USED TO MODEL THE AC-LOSS BEHAVIOR OF THE CABLE.

2MP2B-08

INFLUENCE OF TURN-TO-TURN INSULATION ON QUENCH PROPAGATION IN MULTI-LAYER YBA2CU3OX CONDUCTORS AT 77 K AND 4.2 K ***M. PHILLIPS***[1]*, J. SCHWARTZ*[2]*;* [1]DEPARTMENT OF MECHANICAL ENGINEERING, FAMU-FSU COLLEGE OF ENGINEERING & NATIONAL HIGH MAGNETIC FIELD LABORATORY, [2]DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING, NORTH CAROLINA STATE UNIVERSITY. — FOR SUPERCONDUCTING MAGNETS USING YBA2CU3OX (YBCO) COATED CONDUCTORS TO BE SUCCESSFUL, IT IS NECESSARY TO DEVELOP EFFECTIVE APPROACHES TO QUENCH DETECTION AND PROTECTION. IT HAS BEEN CLEARLY SHOWN THAT QUENCH PROPAGATION IN YBCO CCS IS VERY SLOW, ONE APPROACH TO IMPROVED PROTECTION MAY BE TO ENHANCE TURN-TO-TURN PROPAGATION VIA THERMALLY CONDUCTING ELECTRICAL INSULATORS. IN THIS STUDY, THE EFFECT OF INSULATION PROPERTIES ON TWO-DIMENSIONAL QUENCH PROPAGATION IN MULTI-LAYER YBCO MAGNETS IS INVESTIGATED. COMSOL MULTI-PHYSICS, A FINITE ELEMENT ANALYSIS PROGRAM, IS USED TO EVALUATE THE QUENCH BEHAVIOR WITH SYSTEMATIC VARIATIONS IN THE MATERIAL PROPERTIES. AT PRESENT, SUPERCONDUCTING MAGNETS PRIMARILY USE INSULATORS THAT ARE ELECTRICALLY AND THERMALLY INSULATING, SUCH AS KAPTON. HERE, THE IMPACT OF ELECTRICALLY INSULATING, THERMALLY CONDUCTING INSULATORS ON QUENCH BEHAVIOR IS EVALUATED. IN PARTICULAR, THE EFFECTS ON MULTI-DIMENSIONAL PROPAGATION AND KEY QUENCH PROTECTION PARAMETERS SUCH AS PEAK VOLTAGE, PEAK TEMPERATURE AND PEAK TEMPERATURE GRADIENT ARE STUDIED. SIMULATIONS ARE PERFORMED AT 4.2 K AND 77 K USING MATERIAL PROPERTIES THAT REPRESENT KAPTON, ALUMINA AND BERYLLIA. SIGNIFICANT IMPACT ON THE DIMENSIONALITY OF QUENCH PROPAGATION, AND ALSO ON THE RATIO OF PEAK TEMPERATURE TO VOLTAGE, IS CLEARLY SHOWN.

DR. WAN-KAN CHAN

2MP2C-01

DEGRADATION OF YBCO COATED CONDUCTORS DUE TO OVER-CURRENT PULSE DRIVE ***M. ARAI***[1]*, H. MOMOTARI*[1]*, X. WANG*[1]*, H. UEDA*[1]*, A. ISHIYAMA*[1]*, T. SAITO*[2]*, Y. AOKI*[3]*, M. YAGI*[4]*, T. MACHI*[5]*, N. FUJIWARA*[5]*;* [1]WASEDA UNIVERSITY, [2]FUJIKURA,LTD., [3]SWCC SHOWA CABLE SYSTEMS CO.,LTD., [4]FURUKAWA ELECTRIC CO., LTD., [5]ISTEC. — YBCO COATED CONDUCTORS ARE EXPECTED TO BE USED IN FUTURE ELECTRIC POWER DEVICES, SUCH AS TRANSMISSION CABLES, TRANSFORMERS AND FAULT CURRENT LIMITERS. THEY ARE SUBJECTED TO SHORT-CIRCUIT FAULT CURRENTS GREATER THAN THE OPERATING CURRENT. THESE OVER-CURRENTS CAUSE HEAT GENERATION RESULTING IN DEGRADATION OF CHARACTERISTICS OF YBCO COATED CONDUCTOR. THEREFORE, IT IS NECESSARY TO KNOW THE TEMPERATURE LIMIT WITHOUT SUFFERING DEGRADATION. SO FAR, WE HAVE CARRIED OUT PRELIMINARY EXPERIMENTS ON DEGRADATION OF YBCO COATED CONDUCTORS DUE TO OVER-CURRENT PULSE DRIVE. AND WE FOCUSED ON THE RELATIONSHIP BETWEEN TEMPERATURE RISES AND I_C DEGRADATION. IN THIS STUDY, WE PREPARED YBCO COATED CONDUCTORS MADE BY THE TFA-MOD METHOD. WE ALSO CARRIED OUT OVER-CURRENT TESTS IN ORDER TO INVESTIGATE THE I_C DEGRADATION AND PERFORMED NUMERICAL SIMULATIONS ON THE THERMAL STRESS TO ESTIMATE THE STRESS AND STRAIN ACTING ON YBCO LAYER.

THIS WORK WAS SUPPORTED BY THE NEW ENERGY AND INDUSTRIAL TECHNOLOGY DEVELOPMENT ORGANIZATION (NEDO) AS THE PROJECT FOR DEVELOPMENT OF MATERIALS & POWER APPLICATION OF COATED CONDUCTORS, M-PACC.

2MP2C-02

THERMAL CYCLING EFFECT ON $YBA_2CU_3O_{7-\Delta}$ (YBCO) FILMS ***Y. XU****, Z. QIAN, Z. XU, R. BHATTACHARYA;* UES INC. — THERE HAVE BEEN GREAT ADVANCEMENTS IN RESEARCH AND DEVELOPMENT, PROCESSING AND APPLICATIONS WITH THE 2ND GENERATION (2G) HIGH TEMPERATURE SUPERCONDUCTORS (HTS) YBCO BASED HIGH TEMPERATURE SUPERCONDUCTOR WIRES TERMED COATED CONDUCTORS (CCS) ARE ON THE STAGE FOR LARGE-SCALE APPLICATIONS IN ADVANCE ELECTRICAL POWER AND OTHERS. NEVERTHELESS, ISSUES THAT ASSOCIATED WITH PRACTICAL APPLICATIONS HAVE NOT BEEN FULLY INVESTIGATED. IN THIS RESEARCH, THERMAL CYCLING EXPERIMENT UP TO 1100 TIMES BETWEEN ROOM TEMPERATURE AND LIQUID NITROGEN (77.3K) WITH AND WITHOUT A PROTECTION LAYER HAVE BEEN CARRIED OUT AND THE THERMAL CYCLING EFFECTS WERE STUDIED. EXPERIMENT RESULTS SHOW THAT YBCO FILMS DEGRADE AFTER LONG TIME STORAGE IN AMBIENT ENVIRONMENT AND DURING THERMAL CYCLING. NO DEGRADATION WAS OBSERVED FOR YBCO FILMS WITH A PROTECTION LAYER OF EITHER AN OXIDE OR A PLASTIC FILM AFTER 1100 THERMAL CYCLING. WHEREAS, AN IMPROVEMENT WAS OBSERVED FOR YBCO FILMS WITH A SILVER PROTECTIVE LAYER OF ABOUT 1 MM IN THICKNESS AFTER THERMAL CYCLING.

2MP2C-03

ESTIMATION OF COOLING PERFORMANCE IN CONTACTING BETWEEN BI2223 TAPE AND HIGH THERMAL CONDUCTION COMPOSITE IN CONDUCTION-COOLED SUPERCONDUCTING COIL ***T. TAKAO***[1]*, T. YUHARA*[1]*, D. HACHISUKA*[1]*, T. GOTO*[1]*, A. YAMANAKA*[2]*, A. NISHIMURA*[3]*;* [1]SOPHIA UNIVERSITY, [2]TOYOBO, [3]NIFS. — THE THERMAL CONNECTION BETWEEN A SUPERCONDUCTOR AND THE COLD HEAD OF A REFRIGERATOR IS IMPORTANT FOR THE THERMAL STABILITY OF A CONDUCTION-COOLED SUPERCONDUCTING COIL, BECAUSE THIS CONNECTION IS THE ONLY HEAT-FLOW PATHWAY FOR COOLING THE SUPERCONDUCTOR. THE CONNECTION MATERIAL MUST THEREFORE HAVE HIGH THERMAL CONDUCTIVITY. ALUMINUM NITRIDE (ALN) HAS A HIGH THERMAL CONDUCTIVITY BUT IS SO HARD AND BRITTLE THAT END USERS ALMOST ALWAYS HAVE TO ASK THE ALN MAKERS TO DO MINOR CUTTING AND DRILLING PROCESSES. THE THERMAL CONDUCTIVITY OF THE DYNEEMA FIBER REINFORCED PLASTIC (DFRP) IS NOT HIGHER THAN THAT OF ALN BUT IS SIMILAR AS THAT OF STAINLESS STEEL AT CRYOGENIC TEMPERATURES. AND DFRP HAS A REMARKABLE PROPERTY WHICH IS THERMALLY EXPANSION WITH COOL-DOWN. THE ADVANTAGE OF DFRP IS THAT IT CAN BE EASILY PROCESSED BY END USER-SIDE. WE MADE SOME SUPERCONDUCTING COILS WHOSE CONDUCTOR WAS BI2223 TAPE AND ITS BOBBIN MATERIAL WAS DFRP, AND MEASURED COIL VOLTAGE AND COIL CURRENT IN DC EXCITATION TESTS. ACCORDING TO THE EXPERIMENTAL DATA, THE COIL WAS THERMALLY STABLE BECAUSE THE HEATING IN THE TAPE WAS EFFECTIVELY COOLED TO THE CONTACTING BOBBIN. AND WE NUMERICALLY EVALUATED TEMPERATURE RISE OF THE TAPE IN THE SAME CONDITION AS THE EXPERIMENTAL CONDITION. THE EXPERIMENTAL RESULTS AND THE SIMULATION ARE ALSO COMPARED IN THE PAPER.

2MP2C-04

OVER-CURRENT TESTS ON GDBCO COATED CONDUCTORS WITH VARIOUS THICKNESSES OF SILVER STABILIZERS ***J. KIM***[1]*, J. LEE*[1]*, K. KIM*[1]*, D. YANG*[1]*, Y. KIM*[2]*, T. KO*[2]*, H. LEE*[1]*;* [1]KOREA UNIVERSITY, KOREA, [2]YONSEI UNIVERSITY, KOREA. — RECENTLY, 2G HTS TAPE IS BEING USED IN MANY SUPERCONDUCTING DEVICES SUCH AS MOTORS, CABLES AND SUPERCONDUCTING FAULT CURRENT LIMITERS (SFCL). AMONG THEM, ESPECIALLY, THE SFCL IS ONE OF THE MOST POWER TOOLS, USED TO FULFILL THE MODERN INDUSTRY'S GROWING ELECTRICAL POWER NEEDS. SINCE A STABILIZER OF THE 2G HTS TAPE PLAYS A SIGNIFICANT ROLE OF TRANSFERRING HEAT GENERATED IN MOMENT OF FAULT, IT IS CRITICAL TO DETERMINE THE DIMENSION OF THE STABILIZER FOR HIGH PERFORMANCES OF THE SFCL, REACTING IMMEDIATELY TO THE OCCURRENCE OF FAULT. IN THIS STUDY, WE ANALYZED THERMAL AND ELECTRICAL BEHAVIOR OF A GDBCO CC WITH RESPECT TO THE THICKNESS OF THE SILVER STABILIZER BY OVER-CURRENT TESTS. THE FINAL APPROACH TEMPERATURE AND ELECTRIC FIELD INTENSITY (E) OF THE GDBCO CCS WITH DIFFERENT STABILIZER THICKNESSES IN FAULT MODE WERE EVALUATED BY THEORY AND COMPARED WITH EXPERIMENTAL RESULTS.

THIS STUDY WAS SUPPORTED BY A KOSEF GRANT FUNDED BY THE KOREA GOVERNMENT (MEST 2009-0085369), AND BY A GRANT FROM THE CAST OF THE 21ST CENTURY FRONTIER R&D PROGRAM FUNDED BY THE MEST, KOREA.

2MP2C-05

OVER CURRENT CHARACTERISTICS IN YBCO COATED CONDUCTORS ***H. MOMOTARI***[1]*, M. ARAI*[1]*, X. WANG*[1]*, H. UEDA*[1]*, A. ISHIYAMA*[1]*, M. OHYA*[2]*, K. OHMATSU*[2]*, N. FUJIWARA*[3]*;* [1]WASEDA UNIVERSITY, [2]SUMITOMO ELECTRIC INDUSTRIES, LTD., [3]INTERNATIONAL SUPERCONDUCTIVITY TECHNOLOGY CENTER. — YBCO COATED CONDUCTORS ARE EXPECTED TO BE APPLIED TO POWER CABLE. IN PRACTICAL APPLICATIONS, HIGH TEMPERATURE SUPERCONDUCTING (HTS) CABLES MIGHT BE SUBJECTED TO SHORT-CIRCUIT FAULT CURRENT AND ARE ASSUMED TO OPERATE OVER 30 YEARS. THEREFORE, IN ORDER TO ENSURE THE CURRENT MARGIN OF YBCO COATED CONDUCTORS AGAINST FAULT CURRENT, WE HAVE CARRIED OUT PRELIMINARY EXPERIMENTS ON OVER CURRENT CHARACTERISTICS WITH HTS MODEL CABLE. CONCURRENTLY, WE HAVE PERFORMED NUMERICAL SIMULATIONS TO CLARIFY THE ELECTROMAGNETIC AND THERMAL BEHAVIORS IN THE HTS MODEL CABLE. IN THIS STUDY, WE NUMERICALLY SIMULATED THE FAULT CURRENT WAVEFORM IN EACH YBCO COATED CONDUCTOR WHICH MAKES UP A ENTIRE CABLE. AND THEN, WE CARRIED OUT EXPERIMENTS FOCUSING ON THE I-V CHARACTERISTICS AND THE CURRENT MARGIN WITHOUT SUFFERING IC-DEGRADATION AGAINST THE FAULT CURRENT BY VARYING AMPLITUDE OF THE WAVEFORM OBTAINED NUMERICALLY. FURTHERMORE, WE APPLIED THE FAULT CURRENT TO A YBCO COATED CONDUCTOR REPEATEDLY TO EXPERIMENTALLY INVESTIGATE THE IC DEGRADATION DUE TO ITERATION OF FAULT CURRENT.

THIS WORK WAS SUPPORTED BY THE NEW ENERGY AND INDUSTRIAL TECHNOLOGY DEVELOPMENT ORGANIZATION (NEDO) AS THE PROJECT FOR DEVELOPMENT OF MATERIALS & POWER APPLICATION OF COATED CONDUCTORS, M-PACC.

2MP2C-06

THE CHARACTERISTICS OF THE NORMAL ZONE PROPAGATION BEHAVIORS OF HTS COILS WITHOUT TURN-TO-TURN INSULATION ***T. KADOTA***[1]*, S. KIM*[1]*, H. SANO*[1]*, J. JOO*[1]*, Y. KWON*[2]*, H. KIM*[2]*, Y. JO*[2]*;* [1]OKAYAMA UNIVERSITY, [2]KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE. — HIGH TEMPERATURE SUPERCONDUCTING (HTS) COILS WOUND HTS WIRES HAVE VERY SLOW NORMAL ZONE PROPAGATION VELOCITY (NZPV) AND COMPLICATED QUENCH BEHAVIORS BECAUSE THE WIRES HAVE A HIGH THERMAL STABILITY AND LARGE SPECIFIC HEAT. ACCORDING TO THESE REASONS, IN CASE OF HTS COILS AND MAGNETS, IT IS DIFFICULT TO EXPECT THE SELF-PROTECTION LIKE LOW TEMPERATURE SUPERCONDUCTING (LTS) COILS, SO IT DEMANDED TO ADHERE HEATERS TO HTS COILS IN ORDER TO MAKE NORMAL ZONE PROPAGATE AS POSSIBLE AS QUICKLY. IN THIS PAPER, WE SUGGEST A METHOD WHICH REMOVES THE INSULATION AMONG TURN-TO-TURN IN THE COIL TO IMPROVE THE SELF-PROTECTION PROPERTY OF HTS COILS. BECAUSE THE

THERMAL AND ELECTRICAL CONTACTS BETWEEN THE WOUND WIRES ARE ENHANCED BY NO TURN-TO-TURN INSULATION, THE WHOLE THERMAL STABILITY OF HTS COILS BECOMES TO INCREASE. FURTHERMORE, ALTHOUGH A QUENCH OCCURS IN THE COIL, IT IS POSSIBLE TO REALIZE THE SELF-PROTECTION OF HTS COIL BECAUSE THE CURRENT PATH OF THE COIL IS MODIFIED IN ORDER TO AVOID QUENCHING. TO CONFIRM THE QUANTITATIVE EVALUATION FOR QUENCH BEHAVIOR OF THE SUGGESTED COIL, WE CARRIED OUT THE MEASUREMENTS WITH THE COILS DISPLACED TURN-TO-TURN INSULATION BY CU, NI ALLOY AND BRASS TAPES. THE EXPERIMENTAL RESULTS AND THE SELF-PROTECTION ABILITY ABOUT THE TESTED COILS WILL BE PRESENTED.

2MP2C-07

THERMAL CONDUCTIVITY OF YBCO COATED CONDUCTORS REINFORCED BY METAL TAPE *T. NAITO[1], **H. FUJISHIRO**[1], H. OKAMOTO[2], H. HAYASHI[2], Y. GOSHO[3], N. FUJIWARA[3], Y. SHIOHARA[3];* [1]IWATE UNIVERSITY, [2]KYUSHU ELECTRIC POWER CO., INC., [3]SRL-ISTEC. — YBCO COATED CONDUCTOR (YCC) CONSISTS OF THE SUBSTRATE (HASTELLOY), BUFFER LAYER, YBCO, AND AG LAYER. TO CLARIFY THE THERMAL TRANSPORT IN YCC, WE HAVE MEASURED THE THERMAL CONDUCTIVITY K(T) OF YCC. K(T) SLIGHTLY DECREASED WITH DECREASING TEMPERATURE AND SHOWED A MAXIMUM AROUND 20 K. K(T) INCREASES WITH INCREASING THICKNESS OF AG LAYER AND THE APPLIED HEAT MAINLY FLOWS THROUGH THE AG LAYER. WE ALSO MEASURED K(T) OF YCC REINFORCED BY CU OR CUNI. K(T) OF THE YCC-CU TAPE WAS ALMOST CONSTANT FROM 300 K DOWN TO 100 K, STARTS TO INCREASE BELOW 100 K, AND TAKES A MAXIMUM AROUND 20 K WHICH IS QUITE LARGER THAN THAT OF THE BARE YCC TAPE. ON THE OTHER HAND, K(T) OF THE YCC-CUNI WAS SMALL AND DECREASED MONOTONICALLY WITH DECREASING TEMPERATURE. THE THERMAL TRANSPORT IN THE LAMINATED YCC STRONGLY DEPENDS ON THE REINFORCING METAL TAPE.

THIS WORK WAS SUPPORTED BY THE NEW ENERGY AND INDUSTRIAL TECHNOLOGY DEVELOPMENT ORGANIZATION (NEDO).

2MP2C-08

NUMERICAL AND EXPERIMENTAL ANALYSIS OF QUENCH DEVELOPMENT AND PROPAGATION ON 2G HTS WIRE *J. **PELEGRÍN**[1], L. A. ANGUREL[1], E. MARTÍNEZ[1], Y. Y. XIE[2], V. SELVAMANICKAM[3];* [1]ICMA (CSIC-UNIVERSITY OF ZARAGOZA), SPAIN, [2]SUPERPOWER, INC., 450 DUANE AVE., SCHENECTADY, NEW YORK 12304 USA, [3]SUPERPOWER, INC., 450 DUANE AVE., SCHENECTADY, NEW YORK 12304 USA, UNIVERSITY OF HOUSTON, 4800 CALHOUN ROAD, TEXAS 77004, USA. — THE STUDY OF THE STABILITY PROCESS IN SECOND GENERATION HIGH TEMPERATURE SUPERCONDUCTORS (2G HTS WIRE) IS IMPORTANT TO DETERMINE THEIR OPTIMAL PERFORMANCE IN APPLICATIONS. IN THIS PAPER WE NUMERICALLY AND EXPERIMENTALLY ANALYZE THE QUENCH BEHAVIOR OF 2G HTS WIRE WITH ONLY SILVER OVERLAYER IN SELF-FIELD AND ADIABATIC CONDITIONS. THE THERMAL AND ELECTRIC FIELD PROFILES ALONG THE CONDUCTOR AFTER APPLYING AN ENERGY PULSE TO THE CONDUCTOR HAVE BEEN OBTAINED TOGETHER WITH THE PARAMETERS CHARACTERIZING THE QUENCH: MINIMUM QUENCH ENERGY (MQE) AND PROPAGATION VELOCITY (VP). THE ANALYSIS HAS BEEN PERFORMED AT DIFFERENT TEMPERATURES, T, BELLOW 77 K, AND AT DIFFERENT APPLIED CURRENTS, I/IC(T)<1, IC(T) BEING THE CRITICAL CURRENT. SPECIAL ATTENTION HAS BEEN PAID TO THE CONTRIBUTION TO THE EXPERIMENTAL MQE VALUES OF THE HEAT CAPACITY OF THE HEATER, WHICH HAS BEEN TAKEN INTO ACCOUNT FOR A BETTER COMPARISON WITH THE NUMERICAL RESULTS OBTAINED BY FINITE ELEMENT SIMULATION (FES).

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2MP2C-09

INVESTIGATION OF THE STABILITY BEHAVIOR OF COATED CONDUCTORS ***O. MÄDER**, M. NOE, A. KUDYMOW, W. GOLDACKER;* KIT, KARLSRUHE INSTITUTE FOR TECHNOLOGY. — SUPERCONDUCTING APPLICATIONS LIKE CABLES, CURRENT LEADS AND HIGH CURRENT POWER LINES MADE FROM YBCO COATED CONDUCTORS (CC) REQUIRE A PROTECTION OF THE CC AGAINST OVERHEATING WHEN A SITUATION OF OVER CURRENTS OCCURS. ONE POSSIBILITY TO PROTECT THE CCS IS THE APPLICATION OF A HIGHLY CONDUCTIVE STABILIZATION LAYER, AS ELECTROPLATED CU. THE DURATION OF OVER CURRENTS CAN VARY BETWEEN MICROSECONDS AND SEVERAL SECONDS DEPENDING ON THE APPLICATION CASE OF THE SUPERCONDUCTOR AND THE CHARACTERISTICS OF THE FAULT CURRENT. IF LN_2 IS USED AS COOLANT, THE TRANSIENT HEAT TRANSFER INTO THE COOLANT VARIES FROM ADIABATIC BEHAVIOR AT SHORT TERM OVER CURRENTS UP TO A NEARLY STATIC HEAT TRANSFER INTO THE COOLANT AT LONG TERM OVER CURRENTS. THE THERMAL BEHAVIOR OF CC COOLED BY LN_2 DURING OVER CURRENTS WAS INVESTIGATED EXPERIMENTALLY AND DESCRIBED WITH A MODEL. THE TIME TO REACH THE TRANSITION TEMPERATURE WAS CALCULATED AND MEASURED FOR DIFFERENT CURRENTS AND DIFFERENT AMOUNT OF STABILIZER ON THE CC. TO ALLOW AN EASY COMPARISON OF THE DIFFERENT CCS, A STABILITY NUMBER WAS INTRODUCED TO CHARACTERIZE THE MATERIAL PERFORMANCE. THE EXPERIMENTAL RESULTS ARE DISCUSSED WITH RESPECT TO TRADITIONAL STABILITY CRITERIA.

2MP2C-10

QUENCH PROPAGATION CHARACTERISTIC AND THERMAL STABILITY OF YBCO HTS TAPES ***L. REN**, Y. TANG, J. LI, J. SHI;* HUAZHONG UNIVERSITY OF SCIENCE AND TECHNOLOGY. — DURING OPERATING, AN YBCO HIGH TEMPERATURE SUPERCONDUCTING (HTS) MAGNET WILL SUFFER ELECTROMAGNETIC, THERMAL AND MECHANICAL DISTURBANCE WHICH COULD RESULT IN UNSTABLE OPERATION OF THE MAGNET. THEREFORE, IT IS NECESSARY TO STUDY THE QUENCH PROPAGATION CHARACTERISTIC AND THERMAL BEHAVIOR OF YBCO HTS TAPES. IN THIS RESEARCH, A SERIES OF EXPERIMENTS WERE CONDUCTED TO MEASURE

THE LONGITUDINAL QUENCH PROPAGATION VELOCITIES AND MINIMUM QUENCH CURRENTS OF YBCO HTS TAPES IN THE LIQUID NITROGEN TEMPERATURE. IN ADDITION, WHEN THE YBCO HTS TAPES WERE FED WITH DIFFERENT TRANSPORT CURRENT, THE THERMAL BEHAVIORS WERE OBSERVED. THE EXPERIMENTAL RESULTS GIVE THE QUENCH PROPAGATION VELOCITY, THE MINIMUM QUENCH CURRENT AND THE THERMAL STABILITY MARGIN FOR THE YBCO HTS TAPE MADE BY SUPERPOWER.

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2MP2D-01

PREFER ORIENTATION FESE CRYSTAL GROWTH BY BRIDGMAN METHOD *C. M. YANG[1], P. W. CHEN[1], J. C. KUO[1], P. DIKO[2],* ***I. G. CHEN[1]****, M. K. WU[3];* [1]DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING, NATIONAL CHENG KUNG UNIVERSITY, TAINAN, TAIWAN, [2]NATIONAL CHENG KUNG UNIVERSITY, TAINAN, TAIWAN, [3]INSTITUTE OF PHYSICS, ACADEMIA SINICA, TAIPEI, TAIWAN. — IRON-BASED SUPERCONDUCTOR FESE HAS BEEN STUDIED RECENTLY DUE TO ITS ARSENIC-FREE AND LESS TOXIC CHARACTERS, ALTHOUGH IT'S TC (~ 8 K) IS RELATIVE LOWER THAN OTHER IRON-BASED COMPOUND WITH ARSENIC DOPING. IN THIS REPORT, THE BRIDGMAN METHOD WITH VARIOUS DIRECTIONAL TEMPERATURE GRADIENTS WAS USED TO SYNTHESIZE LARGE GRAIN SIZE POLYCRYSTALLINE FESE SAMPLES WITH PREFERRED ORIENTATION. BY POLARIZED OPTICAL MICROSCOPE IMAGES AND XRD ANALYSIS, CRYSTAL SIZE UP TO 5MM WITH (101) PREFERRED ORIENTATION HAVE BEEN OBSERVED. SUPERCONDUCTING TRANSITION MEASURED BY SQUID MAGNETIC SUSCEPTIBILITY RESULTS SHOWN THAT TC WAS ~5 K AS-GROWN, BUT CAN BE RECOVERED TO ~7 K AFTER PROPER ANNEALING PROCESS. PRELIMINARY RESULTS INDICATE THAT CONTROLLED PRESSURE LESS THAN 10^{-1} TORR WILL RESULT IN SAMPLES WITH LOW POROSITY COMPARED WITH THAT GROWN IN AMBIENT ATMOSPHERE. DETAILED XRD AND SEM/EDX MICROSTRUCTURE STUDIES AS WELL AS THEIR CORRELATIONS WITH PHASE DIAGRAM WILL BE REPORTED.

THIS STUDY WAS SUPPORTED BY THE NATIONAL SCIENCE COUNCIL, TAIWAN, REPUBLIC OF CHINA, UNDER CONTRACT NSC 96-2112-M-006-012-MY3.

2MP2D-02

LIQUID PHASE EPITAXY OF BETA-PHASE FESE THICK FILMS *J. Y. WANG[1],* ***X. QI[1]****, J. C. KUO[1], I. G. CHEN[1], C. M. YANG[1], K. YATES[2], L. COHEN[2];* [1]DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING, NATIONAL CHENG KUNG UNIVERSITY, [2]DEPARTMENT OF PHYSICS, IMPERIAL COLLEGE, LONDON SW7 2BP, UK. — FESE HAS THE SIMPLEST COMPOSITION AND STRUCTURE, BUT YET POSSESSES ALL THE ELECTRONIC, MAGNETIC, AND STRUCTURAL EFFECTS RELEVANT TO THE SUPERCONDUCTIVITY IN THE COMPLEX IRON PNICTIDES. THEREFORE, IT WILL PLAY AN IMPORTANT ROLE IN THE UNDERSTANDING OF THE ORIGIN OF SUPERCONDUCTIVITY IN THESE IRON BASED COMPOUNDS. IN THIS STUDY, LIQUID PHASE EPITAXY (LPE), WHICH IS A PROCESS SIMILAR TO CRYSTAL GROWTH FROM HIGH-TEMPERATURE SOLUTION, HAS BEEN USED TO GROW FESE THICK FILMS ON THE $LAALO_3$ SUBSTRATES WITH SESN AS THE FLUX. THE OBTAINED FILMS WITH THE TYPICAL THICKNESS OF 2-5 MICROMETERS WERE CONFIRMED BY BOTH X-RAY DIFFRACTION AND ELECTRON BACK-SCATTERING DIFFRACTION (EBSD) TO HAVE THE TETRAGONAL BETA-PHASE, WITH A QUALITY CLOSE TO SINGLE CRYSTAL. THE SAMPLES SHOWED A SHARP SUPERCONDUCTING TRANSITION WITH THE ONSET TC OF 6.1 K DETERMINED BY THE MAGNETIC MEASUREMENTS. THE LOWER TC COMPARED TO THE SINTERED POWDER SAMPLES WAS SUSPECTED TO BE CAUSED BY THE SN INCLUSION FROM THE FLUX, BUT COMPOSITIONAL ANALYSIS, SUCH AS ENERGY DISPERSIVE X-RAY SPECTROSCOPY (EDX), WAS UNABLE TO FIND THE TRACE OF SN IN THE GROWN FILMS.

2MP2D-03

ND1-XFEXOF THIN FILMS DEPOSITED BY CHEMICAL VAPOR DEPOSITION AS PRECURSORS FOR THE SYNTHESIS OF NDFEASO1-YFY SUPERCONDUCTING FILMS. *I. R. CORRALES-MENDOZA,* ***A. CONDE-GALLARDO****;* DEPARTAMENTO DE FÍSICA, CENTRO DE INVESTIGACIÓN Y DE ESTUDIOS AVANZADOS DEL IPN, MÉXICO DF, 07300. — BY EMPLOYING NEODYMIUM-HEXAFLUORO-PENTANEDIONATE (NDHF) AND IRON-TRIFLUORO-PENTANEDIONATE (FETF) AS CHEMICAL PRECURSORS, WE ARE ABLE TO GROW ND1-XFEXOF THIN FILMS BY AEROSOL ASSISTED CHEMICAL VAPOR DEPOSITION (AA-CVD) WITH DIFFERENT X VALUES. THE X-RAY DIFFRACTION AND ENERGY DISPERSIVE EXPERIMENTS, INDICATE THAT FOR X IN THE 0<X<0.6 RANGE, THE FILMS CRYSTALLIZE IN THE TETRAGONAL PHASE OF THE NON-STOICHIOMETRY NDO1-YF1+2Y STRUCTURE (SPATIAL GROUP P4/NMM); WHILE FOR X>0.6 THE FILMS DEVELOP AN AMORPHOUS PHASE THAT FINALLY TURNS INTO THE CORUNDUM STRUCTURE OF THE HEMATITE (FE2O3) FOR X>0.8. A DETAILED DESCRIPTION ABOUT THE THERMODYNAMIC CONDITIONS AND NDHF/FETF INITIAL CONCENTRATIONS TO OBTAIN FILMS WITH DIFFERENT X VALUES IS GIVEN. THE ELECTRICAL AND MAGNETIC CHARACTERIZATION OF THOSE FILMS, INDICATE THAT MOST OF THEM ARE SEMICONDUCTOR FILMS WITH AN ANTIFERROMAGNETIC TRANSITION ABOUT 280OC. GIVEN THAT WE ARE ABLE TO GROW FILMS WITH X=0.5, THE ND1-XFEXOF FILMS WITH THIS PARTICULAR CONCENTRATION CAN BE EMPLOYED TO DEVELOP NDFEASO1-YFY SUPERCONDUCTING FILMS BY INTRODUCING ARSENIC INTO THESE PRECURSOR FILMS BY MEANS OF DIFFUSION PROCESS. THE PRELIMINARY RESULTS ON DIFFUSION EXPERIMENTS INDICATE THAT IT IS REALLY POSSIBLE TO SYNTHESIZE NDFEASO1-YFY SUPERCONDUCTING FILMS BY THIS METHOD.

2MP2D-04

$FE(SE_XTE_{1-X})$ SUPERCONDUCTING THIN FILMS: COMPOSTION DEPENDENCE AND TRANSPORT PROPERTIES ***J. LALOË****, S. HEEDT, H. S. BARNARD, J. S. MOODERA;* MIT. — PBO-TYPE B-FESE COMPOUND BECOMES SUPERCONDUCTING WITH A RESISTIVE TRANSITION TEMPERATURE AT 8.5 K IN THE BULK.

FILMS WITH A THICKNESS ABOVE 200 NM HAVE BEEN FOUND TO DISPLAY THE SUPERCONDUCTING STATE, THOUGH T_C IN THESE CASES IS FURTHER REDUCED. THE SUBSTITUTION OF SE BY TE IN THE LATTICE WAS FOUND TO SLIGHTLY INCREASE T_C TO THE 9-11 K RANGE AFTER A HIGH-PRESSURE ANNEAL. OUR OBJECTIVE WAS TO INVESTIGATE MBE GROWN THINNER FILMS OF VARIOUS COMPOSITIONS. WE HAVE DEPOSITED THIN FILMS (<120 NM) OF FE(SE_XTE_{1-X}) (FST) BY CO-EVAPORATION FROM THREE THREE SEPARATE SOURCES. WE CHARACTERIZED OUR FILMS BY RUTHERFORD BACK-SCATTERING (RBS) AND X-RAY DIFFRACTION (XRD) TO CONFIRM THE FILM COMPOSITION AND CRYSTAL STRUCTURE, RESPECTIVELY. *R VS. T* MEASUREMENTS REVEAL THAT OUR AS-GROWN FST FILMS DO NOT DISPLAY THE SUPERCONDUCTING TRANSITION, WHEREAS A MILD ANNEAL (300 °C) AT ATMOSPHERIC PRESSURE ENABLES SUPERCONDUCTIVITY TO OCCUR. T_C FOR OUR FILMS RANGE FROM 4.5 TO 11 K; 18 NM FILMS DISPLAYING THE SUPERCONDUCTING TRANSITION AT ~4.5 K. PRELIMINARY *I-V* AND *DI-DV* MEASUREMENTS OF AL/AL_2O_3/FST TUNNEL JUNCTIONS REVEAL THE SUPERCONDUCTING GAP OF $2\Delta_{FST}$ ~ 1.6 EV FOR FST.

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2MP2D-05

HOMO EPITAXIAL GROWTH OF FE(SETE) FAMILY FILMS ***M. MUKAIDA***[1]*, K. YUKI*[1]*, A. ICHINOSE*[2]*, M. INOUE*[1]*, K. MATSUMOTO*[3]*, Y. YOSHIDA*[4]*, T. KISS*[1]*, R. TERANISHI*[1]*, S. MUNETOH*[1]*;* [1]KYUSHU UNIVERSITY, [2]CRIEPI, [3]KIT, [4]NAGOYA UNIVERSITY. — FE(SETE) FILMS ARE GROWN ON FE(SETE) SINGLE CRYSTAL SUBSTRATES. FE(SETE) SINGLE CRYSTALS ARE GROWN BY A CONVENTIONAL FLUX METHOD. THE FLUX MATERIALS USED IN THIS EXPERIMENT ARE KCL + NACL. FE, SE AND TE POWDERS ARE MIXED AND CALCINATED AT 425^{O}C TO PRODUCE $FESE_{0.5}TE_{0.5}$ POWDERS. THEY ARE MIXED AGAIN AND CALCINATED AT 650^{O}C. THE OBTAINED POWDERS ARE MIXED WITH KCL AND NACL. THEY ARE HEATED UPTO 750^{O}C AND COOLED TO 650^{O}C WITH A COOLING RATE OF 1^{O}C/MIN.CRYSTALS WITH A RECTANGULAR SHAPE ARE OBTAINED. X-RAY DIFFRACTION MEASUREMENTS REVEALED THAT THE SINGLE CRYSTALS ARE TETRAGONAL PHASE WITH A PLATE LIKE FEATURE. FETE FILMS ARE GROWN BY A PULSED LASER DEPOSITION METHOD USING AN ARF EXCIMER LASER. DETAILS OF THE GROWN FILMS WILL BE DISCUSSED.

THE AUTHORS THANK TO PROF. HOSONO FOR HIS VALUABLE COMMENTS ON THIN FILM GROWTH. THIS WORK WAS DONE WITH THE SUPPORT OF JST-TRIP.

2MP2D-06

TOWARDS PRACTICAL PNICTIDES: COMBINING LOW PRESSURE SYNTHESIS AND SPARK PLASMA SINTERING OF **$NDFEASO_{1-X}F_X$** ***A. KURSUMOVIC***[1]*, B. MAIOROV*[2]*, J. H. DURRELL*[1]*, S. HARRINGTON*[1]*, J. L. DRISCOLL*[1]*;* [1]UNIVERSITY OF CAMBRIDGE, [2]LOS ALAMOS NATIONAL LABORATORY. — WE HAVE DEMONSTRATED A WELL-CONTROLLED AMBIENT PRESSURE SYNTHESIS (APS) AT ~1150°C OF OXYPNICTIDES SUCH AS $NDFEASO_{1-X}F_X$ THAT PRODUCES POLYCRYSTALLINE MATERIAL WITH A TRANSITION TEMPERATURE EVEN HIGHER (T_C~55 K) THAN EQUIVALENT SAMPLES MADE BY HIGH PRESSURE SYNTHESIS (HPS) AT A GPA PRESSURE RANGE. HOWEVER, SUCH OBTAINED OXYPNICTIDE MATERIAL (APS OR HPS) IS TOO POROUS OR IN TOO SMALL PIECES FOR PRACTICAL PURPOSES. WE APPLIED SPARK PLASMA SINTERING (SPS) ON APS MATERIAL TO INCREASE THE DENSITY, AND MAKE A USEFUL SHAPE AND SIZE. BEFORE PRESSING, COMMUTED APS SAMPLES WERE VACUUM-ENCAPSULATED INTO A FE-TUBE. MODERATE PRESSURES (UP TO 80 MPA) AND TEMPERATURES (~1000°C) WERE USED. HIGH PULSING CURRENT, A KEY FACTOR IN SPS PROCESS, WAS ABOUT 1 $KA{\cdot}CM^{-2}$ THROUGH THE CONDUCTING SAMPLE, BEING CAPABLE OF HEATING RATES IN THE RANGE OF 100 $K{\cdot}S^{-1}$. RESULTING TAPES/BARS, SHOW NEAR THE THEORETICAL DENSITY HAVING MUCH IMPROVED CONNECTIVITY, HENCE LESS CURRENT PERCOLATION, WITH NORMAL STATE RESISTIVITY COMPARABLE TO VALUES REPORTED IN SINGLE CRYSTAL SAMPLES. THE COMBINED APS+SPS METHOD DEVELOPED HERE IS IDEAL FOR THE FABRICATION OF SHORT (FOR NOW) TAPES RAPIDLY AND SAFELY. THE HIGH CRITICAL TEMPERATURE (T_C>50 K) AND THE UPPER CRITICAL FIELD (H_{C2}>200 T), OF THE $NDFEASO_{1-X}F_X$ MATERIAL, ARE EASILY PRESERVED OR EVEN IMPROVED (DEPENDING ON THE CONDITIONS). HIGH FIELDS H_{C2} MEASUREMENTS ARE REPORTED IN DETAILS.

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2MP2D-07

THE ROLE OF PB ADDITION ON THE MICROSTRUCTURE AND SUPERCONDUCTING PROPERTIES OF POLYCRYSTALLINE **$SR_{0.6}K_{0.4}FE_2AS_2$** *L. WANG, Y. QI, Z. ZHANG, D. WANG, X. ZHANG, Z. GAO,* ***Y. MA****;* INSTITUTE OF ELECTRICAL ENGINEERING, CHINESE ACADEMY OF SCIENCES. — THE EFFECT OF PB ADDITION (0-20 WT%) ON POLYCRYSTALLINE $SR_{0.6}K_{0.4}FE_2AS_2$ SUPERCONDUCTOR HAS BEEN INVESTIGATED. IT IS FOUND THAT NO CHEMICAL REACTION WAS OCCURRED BETWEEN THE PB AND THE FEAS-BASED SUPERCONDUCTOR. HOWEVER, THE PRESENCE OF THE PB CAN AFFECT THE MICROSTRUCTURE AND SUPERCONDUCTING PROPERTIES OF THE FINAL PRODUCTS. THE CRITICAL TRANSITION TEMPERATURE T_C INDICATES NO DEGRADATION UP TO 20 WT% PB ADDITION, AND DRAMATIC IMPROVEMENTS OF MAGNETIC J_C AND IRREVERSIBILITY FIELD H_{IRR} WERE OBSERVED FOR APPROPRIATE PB CONCENTRATION. TRANSPORT CRITICAL CURRENT PROPERTY OF PURE AND PB-ADDED $SR_{0.6}K_{0.4}FE_2AS_2$ TAPES WAS ALSO MEASURED BY A FOUR-PROBE TECHNIQUE, AND A REMARKABLE ENHANCEMENT OF J_C AT LOW FIELDS WAS DETECTED FOR THE PB ADDED TAPES.

2MP2D-08

PROPERTIES OF SMFEASO1-XFX TYPE OXIPNICTIDE BULKS AND WIRES MADE VIA SEVERAL ROUTES ***M. MAJOROS***[1]*, M.*

KANUCHOVA[2], M. D. SUMPTION[1], M. A. SUSNER[1], C. S. MYERS[1], S. D. BOHNENSTIEHL[1], E. W. COLLINGS[1]; [1]THE OHIO STATE UNIVERSITY, [2]TECHNICAL UNIVERSITY OF KOSICE. — SMFEASO1-XFX TYPE OXIPNICTIDE BULKS AND WIRES WERE MADE WITH SEVERAL ROUTES. USING A SINGLE STEP ROUTE, PELLETS AND ENCASED WIRES WITH LOW AMOUNTS OF TOTAL REDUCTION WERE MADE. POLYCRYSTALLINE BULK SAMPLES AND WIRES WITH NOMINAL COMPOSITION SMO1-XFXFEAS (X=0.35 AND 0.4) WERE SYNTHESIZED BY CONVENTIONAL SOLID STATE REACTION USING HIGH-PURITY AS (WE USED ALLOTROPE-GREY ARSENIC), SMF3, SM, FE AND FE2O3 POWDERS AS STARTING MATERIALS. THE WEIGHED POWDERS WERE THOROUGHLY GROUNDED BY HAND WITH A MORTAR AND PESTLE AND PRESSED INTO PELLETS IN AN ARGON-FILLED GLOVE BOX. THE PRESSED PELLETS WERE SEALED IN AN EVACUATED QUARTZ AMPOULE AND HT TO 1100 OC. SIMILAR COMPOSITIONS WERE USED IN SWAGED WIRES, CONSTRUCTED WITH MONEL OUTER CASINGS AND NB INNER BARRIERS. A TWO STEP METHOD WAS ALSO USED IN A SECOND SET OF SAMPLES, IN THIS CASE BASED ON FEAS AND SMAS PRECURSORS PREPARED IN OUR LABORATORY. MAGNETIC MEASUREMENTS WERE MADE USING A QUANTUM DESIGN PPMS SYSTEM EQUIPPED WITH 14 TESLA SUPERCONDUCTING MAGNET. ONSET TC WAS SEEN TO BE 55 K FOR SAMPLES FROM THE FIRST SET, AND 53 K FOR SAMPLES MADE WITH THE FEAS PRECURSORS. BIRR AND BC2 VALUES WERE MEASURED AT HIGHER FIELDS, AND MAGNETIC PROPERTIES WERE INVESTIGATED. TRANSPORT MEASUREMENTS WERE ALSO MADE AND THE RESULTS ARE REPORTED.

2MP2D-09

TRANSPORT PROPERTY OF IRON-BASED SUPERCONDUCTING WIRE USING $FESE_{1-X}TE_X$ ***T. OZAKI****, K. DEGUCHI, Y. MIZUGUCHI, H. KUMAKURA, Y. TAKANO;* NATIONAL INSTITUTE FOR MATERIALS SCIENCE (NIMS). — WE HAVE BEEN WORKING ON A CHALLENGING ISSUE TO FABRICATE THE ION-BASED SUPERCONDUCTING WIRE. COMPARE TO THE OTHER FEAS-BASED SUPERCONDUCTOR, FESE SERIES (11 SERIES) HAS GREAT ADVANTAGE FOR APPLICATION DUE TO BINARY COMPOUND AND LESS TOXIC. WE SUCCEEDED IN OBSERVING ZERO RESISTIVITY CURRENT ON THE CURRENT-VOLTAGE MEASUREMENT FOR THE ION-BASED SUPERCONDUCTING WIRE USING AN IN-SITU POWDER-IN-TUBE (PIT) METHOD WITH AN FE SHEATH.[1)] WE ALSO FABRICATED THE 11 SERIES SUPERCONDUCTING WIRE USING EX-SITU PIT METHOD. THE $FESE_{1-X}TE_X$ SUPERCONDUCTING POWDER WAS STUFF INTO THE FE SHEATH AND APPLIED HEAT TREATMENT. IN ADDITION, WE ATTEMPTED TO FABRICATE THE MULTIFILAMENTARY WIRE WITH 11 SERIES.1) Y. MIZUGUCHI ET AL. APPL. PHYS. EXPRESS 2 (2009) 083004.

2MP2E-01

PROBLEMS ON THE VALUATION OF THE CRITICAL CURRENT DENSITY ANISOTROPY IN SINGLE CRYSTALS OF THE IRON BASED SUPERCONDUCTOR $BA_{0.5}K_{0.5}FE_2AS_2$ ***M. R. CIMBERLE[1], C. FERDEGHINI[2], M. PUTTI[3], M. TROPEANO[3], A. PROVINO[4], M. PANI[4], P. MANFRINETTI[4];*** [1]NATIONAL RESEARCH COUNCIL OF ITALY-IMEM, [2]NATIONAL RESEARCH COUNCIL OF ITALY-SPIN, [3]NATIONAL RESEARCH COUNCIL OF ITALY-SPIN AND PHYSICS DEPARTMENT, [4]NATIONAL RESEARCH COUNCIL OF ITALY-SPIN AND CHEMISTRY DEPARTMENT. — AMONG THE VARIOUS FAMILIES OF THE RECENTLY DISCOVERED IRON BASED SUPERCONDUCTORS, THE 122 PHASE IS CONSIDERED THE MOST APPEALING FROM THE TECHNOLOGICAL POINT OF VIEW: IN FACT, IN ADDITION TO A RELATIVELY HIGH SUPERCONDUCTING CRITICAL TEMPERATURE, THE TRANSITION DOES NOT BROAD IN APPLIED MAGNETIC FIELD AND THE PHASE PRESENTS LOW ANISOTROPY, AS IT HAS BEEN OBSERVED BOTH IN H_{C1} AND H_{C2} CURVES. THEREFORE THE STUDY OF THE CRITICAL CURRENT DENSITY, ITS IMPROVEMENT AND ITS ANISOTROPY ARE IMPORTANT IN VIEW OF POSSIBLE APPLICATIONS.HERE WE PRESENT A STUDY PERFORMED BY MAGNETIC MEASUREMENTS IN SINGLE CRYSTALS OF THE PHASE $BA_{0.5}K_{0.5}FE_2AS_2$. FROM THE HYSTERESIS LOOPS MEASURED APPLYING THE FIELD PARALLEL AND PERPENDICULAR TO THE A-B PLANE, THE CRITICAL CURRENT DENSITIES ARE ESTIMATED, TAKING INTO ACCOUNT THE ANISOTROPIC PENETRATION AND THE DEMAGNETIZATION COEFFICIENT. AT LOW TEMPERATURE AND FIELD A ANISOTROPY FACTOR OF ABOUT 10 IS OBTAINED, THAT IS SIGNIFICANTLY HIGHER THAN THE VALUES USUALLY REPORTED IN LITERATURE. IN ADDITION WE OBSERVE THAT THE SUPER-CURRENT ALONG THE C AXIS IS AFFECTED BY GRANULARITY, THAT POSES SEVERE PROBLEMS ON THE POSSIBLE APPLICATIONS AND ON THE RELIABILITY OF THE ESTIMATIONS MADE BY MAGNETIC MEASUREMENTS.

2MP2E-03

CURRENT-VOLTAGE CHARACTERISTICS OF IRON-PNICTIDE 122 SINGLE CRYSTALS ***K. MULLER[1], S. LAM[1], X. WANG[2], S. DOU[2], G. SUN[3], D. SUN[3], C. LIN[3];*** [1]CSIRO, MATERIALS SCIENCE AND ENGINEERING, SYDNEY NSW 2070, AUSTRALIA, [2]INSTITUTE FOR SUPERCONDUCTING AND ELECTRONIC MATERIALS, UNIVERSITY OF WOLLONGONG, WOLLONGONG, NSW 2522, AUSTRALIA, [3]MAX PLANCK INSTITUTE FOR SOLID STATE RESEARCH, HEISENBERGSTRAßE 1, 70569 STUTTGART, GERMANY. — THE CURRENT-VOLTAGE CHARACTERISTICS OF A $BA_{0.72}K_{0.28}FE_2AS_2$ SINGLE CRYSTAL WERE MEASURED IN MAGNETIC FIELDS UP TO 7 T APPLIED ALONG THE C DIRECTION AT TEMPERATURES DOWN TO 5 K BELOW T_C = 33 K. THE TOP SURFACE OF THE CRYSTAL SHOWED TERRACES WHERE THE STEPS ASCENDED ALONG ONE DIRECTION AND THE FOUR-PROBE CURRENT AND VOLTAGE CONTACTS WERE APPLIED SUCH THAT THE CURRENT WAS FORCED TO FLOW ALONG THE C DIRECTION THROUGH A MESA-LIKE STRUCTURE. TO INTERPRET THE DATA WE HAVE APPLIED A PHASE-SLIPPAGE MODEL USING THE AMBEGAOKAR-HALPERIN EQUATIONS. IN THE MODEL WE ASSUMED THAT THE TRANSPORT CURRENT IS FLOWING ALONG NARROW SUPERCONDUCTING CHANNELS IN C DIRECTION, BETWEEN THE DENSELY PACKED PANCAKE VORTICES, WHERE INTER-PLANAR REGIONS ACT AS WEAK LINKS. THE SUPERCONDUCTING FLUCTUATIONS THAT OCCUR IN EACH SUPERCONDUCTING CHANNEL ARE ASSUMED TO BE UNCORRELATED TO NEIGHBORING CHANNELS. THE MODEL PREDICTS QUANTITATIVELY THE MEASURED CURRENT-

VOLTAGE CHARACTERISTICS FOR DIFFERENT MAGNETIC FIELDS AND TEMPERATURES. THE BROADENING OF THE RESISTIVE TRANSITION OBSERVED WITH INCREASING MAGNETIC FIELD AND CURRENT IS PROPERLY DESCRIBED BY THE MODEL. FURTHERMORE, AS A COMPARISON, WE APPLIED THE THERMALLY ACTIVATED FLUX-FLOW MODEL AS WELL AS THE VORTEX LIQUID-GLASS MODEL TO DESCRIBE OUR EXPERIMENTAL DATA.

2MP2E-04

ESTIMATIONS OF CRITICAL CURRENT DENSITIES AND SUPER-CURRENT PATH IN IRON-BASED PNICTIDE SUPERCONDUCTORS ***B. NI***[1]*, J. GE*[1]*, E. S. OTABE*[2]*, M. KIUCHI*[2]*, T. MATSUSHITA*[2]*, Z. GAO*[3]*, L. WANG*[3]*, Y. QI*[3]*, X. ZHANG*[3]*, Y. MA*[3]*;* [1]FUKUOKA INSTITUTE OF TECHNOLOGY, [2]KYUSHU INSTITUTE OF TECHNOLOGY, [3]CHINESE ACADEMY OF SCIENCES. — THE SUPERCONDUCTING $SMFEASO_{0.8}F_{0.2}$ (1111 TYPE) AND $(SR,K)FE_2AS_2$ (122 TYPE) POLYCRYSTALLINE IRON-BASED PNICTIDES WERE PREPARED BY A NORMAL PIT METHOD. THE MAGNETIC FIELD AND TEMPERATURE DEPENDENCES OF CRITICAL CURRENT DENSITIES WERE INVESTIGATED BY RESISTIVE AND AC INDUCTIVE (CAMPBELL'S) METHODS. IT WAS FOUND THAT A FAIRLY LARGE CRITICAL CURRENT DENSITY OVER 10^9 A/M^2 EVEN AT THE RELATIVELY HIGH TEMPERATURES FLOWS LOCALLY WITH THE PERIMETER SIZE SIMILAR TO THE AVERAGE GRAIN SIZE OF THE BULK SAMPLES, WHILE AN EXTREMELY LOW TRANSPORT CURRENT DENSITY OF 10^5 - 10^6 A/M^2 CORRESPONDING TO THE GLOBAL CRITICAL CURRENT DENSITY FLOWS THROUGH THE WHOLE SAMPLE. FURTHERMORE, A UNIQUE HISTORY DEPENDENCE OF GLOBAL CRITICAL CURRENT DENSITY WAS OBSERVED, I.E., IT SHOWS A SMALLER VALUE IN THE INCREASING-FIELD PROCESS THAN THAT IN THE DECREASING-FIELD PROCESS. BASING ON THE EXPERIMENTAL RESULTS OF THE PENETRATING AC MAGNETIC FLUX PROFILE AND THE CHARACTERISTIC OF AC MAGNETIC FIELD VS. PENETRATION DEPTH, THE SUPER-CURRENT PATH, THE ELECTRICAL CONNECTIVITY BETWEEN GRAINS AND THE WEAK-LINK PROPERTIES IN THESE MATERIALS WERE DISCUSSED.

2MP2E-05

AIR-EXPOSURE EFFECTS OF SUPERCONDUCTIVITY IN FE(TE, S) ***K. DEGUCHI***[1]*, Y. MIZUGUCHI*[1]*, S. TSUDA*[2]*, T. YAMAGUCHI*[2]*, Y. TAKANO*[1]*;* [1]NATIONAL INSTITUTE FOR MATERIALS SCIENCE, JST-TRIP, UNIVERSITY OF TSUKUBA, [2]NATIONAL INSTITUTE FOR MATERIALS SCIENCE, JST-TRIP. — FETE HAS THE SIMPLEST STRUCTURE AMONG THE IRON-BASED SUPERCONDUCTORS. PURE FETE TAKES PLACE ANTIFERROMAGNETIC ORDER AROUND 70 K AND DOES NOT SHOW SUPERCONDUCTIVITY. THE S SUBSTITUTION SUPPRESSED THE MAGNETIC ORDER AND ACHIEVED SUPERCONDUCTIVITY AROUND 10 K [1]. TO SYNTHESIZE THE HIGH QUALITY FE(TE, S) SAMPLES, WE USE THE SOLID-STATE REACTION METHOD. ALTHOUGH AS-GROWN SAMPLE DID NOT SHOW ZERO RESISTIVITY, THE SAMPLE WHICH WAS EXPOSED TO THE AIR FOR SEVERAL DAYS SHOWED ZERO RESISTIVITY WITH A SHARP SUPERCONDUCTING TRANSITION [2]. THE T_C AND THE SUPERCONDUCTING VOLUME FRACTION WERE ENHANCED UP TO 7.5 K AND 74.1 %, RESPECTIVELY, AFTER 200 DAYS. WE THINK THAT ONE OF THE FACTOR THAT INDUCED SUPERCONDUCTIVITY IN FE(TE,S) IS MOISTURE IN AIR [3].[1] Y. MIZUGUCHI, ET AL, APPL. PHYS. LETT. 94 (2009) 012503.[2] K. DEGUCHI ET AL., TO BE PUBLISHED IN PHYSICA C, DOI:10.1016/J.PHYSC.2009.10.124[3] Y. MIZUGUCHI, ET AL, ARXIV: 0912.2240.

JST-TRIP, GRANT-IN-AID FOR SCIENTIFIC RESEARCH (KAKENHI)

2MP2E-06

ANION HEIGHT DEPENDENCE OF TC FOR THE FE-BASED SUPERCONDUCTORS ***Y. MIZUGUCHI****, Y. TAKANO;* NATIONAL INSTITUTE FOR MATERIALS SCIENCE. — SINCE THE DISCOVERY OF SUPERCONDUCTIVITY IN LAFEASO1-XFX [1], SEVERAL TYPES OF FE-BASED SUPERCONDUCTORS WITH A STRUCTURE SIMILAR TO LAFEASO HAVE BEEN FOUND TO SHOW A COMPARABLY HIGH TRANSITION TEMPERATURE TC.ONE OF THE INTERESTING PROPERTIES OF THE FE-BASED SUPERCONDUCTORS IS A SENSITIVITY OF TC TO CHANGES IN THE CRYSTAL STRUCTURE.FOR EXAMPLE, FESE SHOWS A DRAMATIC PRESSURE EFFECT ON TC; THE ONSET OF TC INCREASES FROM 13 K (AT AMBIENT) UP TO 37 K (UNDER 4-6 GPA) [2,3].WE FOUND THAT THE PRESSURE DEPENDENCE OF TC WAS CORRELATED TO THE PRESSURE DEPENDENCE OF THE SE HEIGHT FROM THE FE-SQUARE LATTICE.BY COMBINING THE DATA OF BOTH TC AND ANION HEIGHT FOR THE TYPICAL FE-BASED SUPERCONDUCTORS, WE FOUND THAT THE ANION HEIGHT DEPENDENCE OF TC FOR THE FE-BASED SUPERCONDUCTORS EXHIBITED A SYMMETRIC CURVE WITH A PEAK AROUND 0.138 NM [4].WE WILL DISCUSS THE DETAILS OF THE ANION HEIGHT DEPENDENCE OF TC, AND ALSO FOCUS ON THE EFFECT OF A DISORDER AT THE ANION SITE.REFERENCE[1]Y. KAMIHARA ET AL., J. AM. CHEM. SOC. 130, 3296 (2008).[2]Y. MIZUGUCHI ET AL., APPL. PHYS. LETT. 93, 152505 (2008).[3]S. MARGADONNA ET AL., PHYS. REV. B 80, 064506 (2009).[4]Y. MIZUGUCHI ET AL., ARXIV: 1001.1801.

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2MP2E-07

CRITICAL PROPERTIES OF POLYCRYSTALLINE (BA,K)FE2AS2 SUPERCONDUCTORS PREPARED BY A COMBINED PROCESS OF HIGH TEMPERATURE HEAT TREATMENT AND DEFORMATION ***K. TOGANO****, A. MATSUMOTO, H. KUMAKURA;* NATIONAL INSTITUTE FOR MATERIALS SCIENCE. — BULK POLYCRYSTALLINE SUPERCONDUCTORS OF $(BA,K)FE_2AS_2$ WERE SYNTHESIZED BY A COMBINED PROCESS OF HIGH TEMPERATURE HEAT TREATMENT AND DEFORMATION. THE SAMPLES HAVE A DENSE STRUCTURE WITH FEWER IMPURITY PHASES COMPARED TO SAMPLES PREPARED BY CONVENTIONAL SINTERING PROCESS. MAGNETO-RESISTANCE AND MAGNETIZATION MEASUREMENTS WERE CARRIED OUT ON THE SAMPLES IN ORDER TO EVALUATE SUPERCONDUCTING CRITICAL PROPERTIES. $-DH_{C2}(T)/DT$ IS AS LARGE AS OF ~9T/K, WHICH CORRESPONDS TO THE VALUE OF

SINGLE CRYSTALS. $H_{IRR}(T)$ HAS ALSO A STEEP SLOPE AT ABOUT 10K BELOW $H_{C2}(T)$, SUGGESTING THAT $(BA,K)FE_2AS_2$ SUPERCONDUCTOR HAS A GOOD POTENTIAL FOR MAGNETIC APPLICATIONS. HOWEVER, THE GLOBAL J_C IN APPLIED MAGNETIC FIELDS ESTIMATED FROM THE MAGNETIZATION HYSTERESIS OR MEASURED BY A STANDARD FOUR PROBE METHOD IS ABOUT TWO ORDERS OF MAGNITUDE SMALLER THAN THE LOCAL J_C ESTIMATED FROM THE MAGNETIZATION HYSTERESIS OF POWDERED SAMPLE, WHICH IS THE ORDER OF $10^5 A/CM^2$ AT 5K AND $10^3 A/CM^2$ AT 20K. THOSE RESULTS INDICATE THAT THE CURRENT PATH IS STILL LARGELY LIMITED IN THE BULK SAMPLES DESPITE ITS HIGH DENSITY, AND A WEAK LINK AT THE GRAIN BOUNDARY IS THE MOST PLAUSIBLE ORIGIN OF THE CURRENT LIMITATION.

THIS WORK WAS PARTLY SUPPORTED BY A GRANT-IN AID FOR TRIP FROM JST, JAPAN.

2MP2E-08**EFFECTS OF NI AND CO DOPING ON THE PHYSICAL PROPERTIES OF TE SUBSTITUTED BETA FESE SUPERCONDUCTOR** ***S. RAI****;* JNCASR. — ISOELECTRONIC TELLURIUM (TE) SUBSTITUTION FOR SELENIUM (SE) IN THE TETRAGONAL PHASE OF FESE (BETA - FESE) INCREASES THE SUPERCONDUCTING TRANSITION TEMPERATURE (TC) BY APPLYING A NEGATIVE PRESSURE ON THE LATTICE. HOWEVER, THE NORMAL STATE RESISTIVITY INCREASES AND SHOWS SEMI-METALLIC BEHAVIOR FOR SAMPLES WITH HIGHER TE CONCENTRATION. WITH INCREASING TE CONCENTRATION, THE TC INCREASES AND REACHES A MAXIMUM FOR FESE0.5TE0.5 AND THEN DECREASES WITH FURTHER INCREASE OF TE. WE HAVE INVESTIGATED THE EFFECT OF COBALT (CO) AND NICKEL (NI) DOPING IN FESE0.5TE0.5 IN THE NOMINAL COMPOSITION RANGE FE1-XTMXSE0.5TE0.5 (TM = CO (X = 0.05, 0.1, 0.15, 0.2) AND NI (X = 0.05, 0.1)). BOTH CO AND NI DOPING SUPPRESS TC AND DRIVES THE SYSTEM TO METAL - INSULATOR TRANSITION. THE IN-PLANE ('A') AND OUT-OF-PLANE ('C') LATTICE CONSTANTS DECREASE WITH INCREASING DOPANT CONCENTRATION.

THE AUTHORS ARE THANKFUL TO JAPAN SCIENCE AND TECHNOLOGY (JST) FOR PROVIDING INTERNATIONAL JOINT GRADUATE SCHOOL (IJGS) FELLOWSHIP UNDER THE "NIMS-JNCASR JOINT GRADUATE SCHOOL PROGRAM".

2MP2E-09

STUDY OF UPPER CRITICAL FIELD, MAGNETIZATION HYSTERESIS LOOPS, REMANENT MAGNETIZATION AND THERMO ELECTRIC POWER IN POTASSIUM FLUORIDE DOPED LAOFEAS MULTIBAND SUPERCONDUCTOR ***S. J. SINGH****[1], S. PATNAIK[1], J. PRAKASH[2], A. K. GANGULI[2];* [1]SCHOOL OF PHYSICAL SCIENCES, JAWAHARLAL NEHRU UNIVERSITY, NEW DELHI, INDIA, [2]DEPARTMENT OF CHEMISTRY, INDIAN INSTITUTE OF TECHNOLOGY, NEW DELHI, INDIA. — WE REPORT A NEW METHODOLOGY OF SYNTHESIZING THE OXYPNICTIDE SUPERCONDUCTORS WITH THE COMMONLY AVAILABLE POTASSIUM FLUORIDE (KF) AS A SOURCE OF FLUORINE INSTEAD OF THE EXPENSIVE LAF_3 THAT LEADS TO SIMULTANEOUS DOPING OF POTASSIUM AT LANTHANUM SITES AND RESULTS IN THREE FOLD INCREASE IN THE UPPER CRITICAL FIELD. WE REPORT THE T_C (ONSET) OF 28.50 K BY F-DOPING AND HIGHEST UPPER CRITICAL FIELD (~122 T) AT AMBIENT PRESSURE IN THE FAMILY OF LA-BASED OXYPNICTIDES. TO STUDY THE CONTRIBUTION FROM INTER AND INTRA-GRANULAR CURRENT DENSITY, WE COMPARE A REMANENT MAGNETIZATION MEASUREMENT ON $LA_{1.03}O_{0.9}F_{0.2}FEAS$ AND $LA_{0.8}K_{0.2}O_{0.8}F_{0.2}FEAS$ SUPERCONDUCTORS THAT SHOWS ONE MAJOR PEAK INDICATING SUBSTANTIAL ELECTROMAGNETIC GRANULARITY. THE SEEBECK COEFFICIENT (S) WITH RESPECT TO TEMPERATURE HAS NEGATIVE SIGN AND EXHIBITS UNCONVENTIONAL TEMPERATURE DEPENDENCE. ANALYSIS OF RESISTIVITY TRANSITION BROADENING UNDER MAGNETIC FIELD REVEALS THE SIGNATURES OF THERMALLY ACTIVATED FLUX FLOW AND THE CALCUATED ACTIVATION ENERGY FOLLOWS POWER-LAW DEPENDENCE WITH RESPECT TO MAGNETIC FIELD. *AUTHOR FOR CORRESPONDENCE:EMAIL: SPATNAIK@MAIL.JNU.AC.IN, SHIVJEES@GMAIL.COM

2MP2E-10

MAGNETIC CHARACTERIZATION OF BA(FE1-XCOX)2AS2 ***S. GAUDIO****[1], G. DE MARZI[1], G. CELENTANO[1], A. AUGIERI[1], V. GALLUZZI[1], A. MANCINI[1], A. RUFOLONI[1], A. VANNOZZI[1], A. DELLA CORTE[1], U. GAMBARDELLA[2], J. J. JIANG[3], J. WEISS[3], E. HELLSTROM[3], D. LARBALESTIER[3];* [1]ENEA RESEARCH CENTRE, [2]CNR-SPIN, [3]NATIONAL HIGH MAGNETIC FIELD LABORATORIES. — TABLE OF CONTENTS

MAGNETIC CHARACTERIZATION OF BA(FE1-XCOX)2AS2

MAGNETIC CHARACTERIZATION OF $BA(FE_{1-X}CO_X)_2AS_2$S. GAUDIO[1], G. DE MARZI[1] , G. CELENTANO[1] , U. GAMBARDELLA[2], A. AUGIERI[1], V. GALLUZZI, A. MANCINI[1], A. RUFOLONI, A. VANNOZZI, A. DELLA CORTE[1], J. JIANG[3], J. D. WEISS, E. E. HELLSTROM AND D. C. LARBALESTIER[3]*[1]ENEA C. R. FRASCATI, VIA ENRICO FERMI 45, 00044 FRASCATI, ITALY[2]CNR-SPIN SALERNO,UNIVERSITY OF SALERNO, 84084 FISCIANO, ITALY[3]NATIONAL HIGH MAGNETIC FIELD LABORATORY, FLORIDA STATE UNIVERSITY, TALLAHASSEE,FL 32310, USAEMAIL:SERGIO.GAUDIO@ENEA.IT*WE PERFORMED AN EXTENSIVE CHARACTERIZATION OF COBALT DOPED POLYCRYSTALLINE 122 IRON PNICTIDE SAMPLES, $BA(FE_{1-X}CO_X)_2AS_2$ WITH X = 0.07,0.09,0.1,0.12, BY MEANS OF HIGH-FIELD MAGNETIZATION AND FROM THE AC FIRST AND THIRD HARMONIC SUSCEPTIBILITY RESPONSE.FROM THE THIRD HARMONIC RESPONSE OF THE AC SUSCEPTIBILITY AS A FUNCTION OF THE DC MAGNETIC FIELD UP TO 10 T, AT DIFFERENT TEMPERATURES, FOR VARIOUS FREQUENCIES AND AMPLITUDES OF THE AC FIELD, WE DETERMINE THE IRREVERSIBILITY LINE, USING THE ONSET CRITERION. ALSO, THE VOLUME PINNING FORCE WAS CALCULATED BY EXTRACTING THE CRITICAL CURRENT DENSITY (J_C) FROM MAGNETIC HYSTERESIS LOOPS. WE ALSO ESTIMATE THE VALUES OF H_{C1}.WE ESTIMATE THE INTERGRAIN CRITICAL CURRENT DENSITY AND THE GRAIN SIZE BY USING A GRANULAR MODEL DESCRIBING THE DYNAMICAL REGIMES AS A FUNCTION OF THE MAGNETIC FIELD.

2MX-01

(INVITED) **IMPROVEMENT ON BI2212 ROUND WIRE AND COIL PERFORMANCE** ***Y. HUANG****[1], H. MIAO[1], M. MEINESZ[1], S.*

HONG[2], T. HOLESINGER[3], J. PARRELL[1]; [1]OXFORD SUPERCONDUCTING TECHNOLOGY, [2]HJC ENTERPRISES, [3]LOS ALAMOS NATIONAL LAB.. — THE BI-2212 INSERT COIL PERFORMANCE HAS BEEN IMPROVED SIGNIFICANTLY DURING LAST FEW YEARS. MORE PROJECTS HAVE BEEN ADDED TO THIS FIELD BECAUSE OF THIS MATERIAL'S UNIQUE PROPERTIES AND ITS POTENTIAL FOR ULTRA HIGH-FIELD (25-30T) APPLICATIONS. IN ORDER TO MEET PERFORMANCE REQUIREMENT FOR THE ADVANCING APPLICATIONS, OUR RECENT STUDIES ON THIS MATERIAL HAVE FOCUSED ON ESTABLISHING BI-2212 POWDER PARAMETERS TO PROVIDE BETTER RESULTS MORE CONSISTENTLY, AND ON IMPROVING WIRE FABRICATION FOR HIGHER JE, LONGER PIECE LENGTH AND LESS LEAKAGE. THE IMPACT OF PRECURSOR POWDERS FROM DIFFERENT RESOURCES HAS BEEN STUDIED BASED ON THEIR COMPOSITION, PARTICLE SIZE, TAP DENSITY, ETC. NEW WIRE CONFIGURATIONS AND PROCESS CONDITIONS HAVE BEEN TESTED TO ENHANCE WIRE CRITICAL CURRENT DENSITY (JC AT 4.2K) UNDER HIGH APPLIED FIELD BY MEANS OF INCREASING AG/2212 INTERFACE AREA AND FILAMENT HOMOGENEITY. DEVELOPING LARGER INSERT COIL THROUGH THE WINDING-AND-REACTING (W&R) METHOD HAS ALSO BEEN PURSUED. THE LEAKAGE HAS ALMOST BEEN ELIMINATED BY ENHANCING SHEATH INTEGRITY AND COIL HEAT TREATMENT HOMOGENEITY. SEVERAL LARGE COILS WITH 30 CM IN HEIGHT HAVE BEEN MADE AND ARE UNDER CHARACTERIZATION. THE RESULTS ON NEW WIRES AND COILS WILL BE PRESENTED IN DETAIL.

2MX-02

LEAKAGE STUDIES IN 2212 ROUND WIRE AND RUTHERFORD CABLES ***E. HELLSTROM***[1]*, T. PATTEN*[1]*, J. JIANG*[1]*, U. TROCIEWITZ*[1]*, D. LARBALESTIER*[1]*, E. BARZI*[2]*, A. GODEKE*[3]*;* [1]APPLIED SUPERCONDUCTIVITY CENTER/NATIONAL HIGH MAGNETIC FIELD LABORATORY, [2]FERMI NATIONAL ACCELERATOR LABORATORY, [3]LAWRENCE BERKELEY NATIONAL LABORATORY. — ROUND BI-2212 WIRE IS BEING INVESTIGATED FOR USE IN VERY HIGH FIELD MAGNET APPLICATIONS. IN THE PAST COILS MADE WITH FLAT TAPE AND ROUND 2212 CONDUCTOR LEAKED DURING THE HEAT TREATMENT, WHICH DEGRADES J_C. WIRE MANUFACTURERS NOW MAKE GREEN WIRE WITH SIGNIFICANTLY DECREASED LEAKAGE BUT IT IS NOT ENTIRELY ELIMINATED. ADDITIONAL FACTORS CAN CAUSE LEAKAGE INCLUDING REACTIONS WITH INSULATION AND COIL FORMERS DURING THE HEAT TREATMENT AND THE MECHANICAL DEFORMATION USED TO FABRICATE 2212 RUTHERFORD CABLE. THE VERY HIGH FIELD SUPERCONDUCTING MAGNET COLLABORATION (VHFSMC) HAS PURCHASED SEVERAL 2212 ROUND WIRES WITH DIFFERENT BUNDLING ARCHITECTURES MADE FROM DIFFERENT POWDERS. THESE WIRES ARE BEING FORMED INTO RUTHERFORD CABLES AND WOUND INTO SINGLE-STRAND SOLENOID COILS AND RUTHERFORD-CABLE RACETRACK COILS AS PART OF THE VHFSMC. THIS PRESENTATION WILL PRESENT STUDIES OF LEAKAGE IN INDIVIDUAL STRANDS, SECTIONS OF RUTHERFORD CABLES, AND COILS. INITIAL STUDIES SHOW THE NEW WIRES HAVE FEW LEAKS AND CABLING LOW-LEAKAGE 2212 WIRE INTO RUTHERFORD CABLE DOES NOT CAUSE ADDITIONAL LEAKAGE. HOWEVER, BARE 2212 WIRE HEAT TREATED ON A ZRO_2-COATED INCONEL COIL FORMER LEAKED PROFUSELY.

THIS WORK WAS SUPPORTED BY NSF-DMR, DOE-HEP AND THE STATE OF FLORIDA.

2MX-03

COMPARATIVE STUDIES OF NINE NEW BI-2212 ROUND WIRES ***J. JIANG****, D. MYERS, T. SHEN, F. KAMETANI, U. P. TROCIEWITZ, E. E. HELLSTROM, D. C. LARBALESTIER;* NATIONAL HIGH MAGNETIC FIELD LABORATORY, FLORIDA STATE UNIVERSITY. — THE VERY HIGH FIELD SUPERCONDUCTING MAGNET COLLABORATION (VHFSMC) IS WORKING TO MAKE ROUND WIRE $BI_2SR_2CACU_2O_X$ (BI-2212) CONDUCTOR SUITABLE FOR HIGH-FIELD MAGNET APPLICATIONS IN THE 20-30 T RANGE. SIGNIFICANT IMPROVEMENT IN CRITICAL CURRENT DENSITY (JC) IN MULTIFILAMENTARY ROUND WIRE HAS BEEN ACHIEVED IN THE PAST SEVERAL YEARS. HOWEVER, THE REACTION TO DEVELOP HIGH JC IN BI-2212 ROUND WIRE IS SO COMPLEX THAT THE WAY THAT HIGH JC IS DEVELOPED REMAINS LARGELY EMPIRICAL. IN THIS WORK, WE COMPARE 9 DIFFERENT BI-2212 WIRES MADE BY 2 DIFFERENT COMPANIES USING 3 DIFFERENT PRECURSOR POWDERS AND 2 MANUFACTURING PROCESSES. THE 9 WIRES WERE REACTED UNDER THE SAME CONDITIONS USING A RANGE OF MAXIMUM PROCESSING TEMPERATURES. THE COMPARATIVE STUDIES INCLUDE THE ANALYSIS OF THEIR MICROSTRUCTURE, CRITICAL CURRENT DENSITY (JC), CONNECTIVITY AND FLUX PINNING, AND THE EFFECTS OF THE PRECURSOR POWDERS AND ARCHITECTURES. THESE RESULTS WILL AMPLIFY RECENT DECONSTRUCTIONS OF THE COMPLEX HEAT TREATMENT PROCESS USED TO DEVELOP HIGH J_C BY INTRODUCING A WIDE RANGE OF ARCHITECTURE, FABRICATION AND POWDER QUALITY ISSUES. WE WILL DISCUSS THE RESULTS IN THE CONTEXT OF THE BROAD GOALS OF VHFSMC TO DEVELOP A RELIABLE VERY HIGH FIELD WIRE AND MAGNET TECHNOLOGY.

THIS WORK IS SUPPORTED BY DOE VHFSMC PROGRAM, BY NSF/DMR, AND BY THE STATE OF FLORIDA.

2MX-04

PROGRESS IN HIGH IC, JC BI-2212 ROUND WIRE CONDUCTORS ***T. G. HOLESINGER***[1]*, F. J. BACA*[1]*, J. A. KENNISON*[1]*, J. Y. COULTER*[1]*, K. R. MARKEN*[1]*, H. MIAO*[2]*, M. MEINESZ*[2]*, Y. HUANG*[2]*, J. A. PARRELL*[2]*, S. CAMPBELL*[3]*, V. LOMBARDO*[4]*, E. BARZI*[4]*;* [1]LOS ALAMOS NATIONAL LABORATORY, [2]OXFORD SUPERCONDUCTING TECHNOLOGY, [3]SCI ENGINEERED MATERIALS, INC., [4]FERMI NATIONAL ACCELERATOR LABORATORY. — THE HIGH-TEMPERATURE SUPERCONDUCTOR (HTS) BI2SR2CACU2OY HAS RECENTLY REEMERGED AS A VIABLE CANDIDATE FOR LOW-TEMPERATURE, HIGH-FIELD (> 20 T) MAGNET APPLICATIONS DUE TO ITS HIGH IRREVERSIBILITY FIELD AND UNIQUE CHARACTERISTIC, AMONG THE CU-O BASED HTS, TO BE FORMED INTO A HIGH-CURRENT, ROUND MULTIFILAMENTARY WIRE. THIS WORK SUMMARIZES THE PROGRESS OF PROCESSING, COMPOSITION, AND SECOND PHASE ADDITIONS ON THE SUPERCONDUCTING PROPERTIES OF AND

MICROSTRUCTURAL DEVELOPMENT WITHIN THE ROUND WIRE CONDUCTORS. THE BEST, SHORT-LENGTH, ROUND WIRES WERE FOUND TO HAVE ENGINEERING CRITICAL CURRENT DENSITIES IN EXCESS OF 1300 AND 500 A/MM2 IN SELF AND 12 T APPLIED FIELDS AT 4.2 K, RESPECTIVELY. SCANNING AND TRANSMISSION ELECTRON MICROSCOPY (SEM, (S)TEM) WERE USED TO EXAMINE THE KEY MICROSTRUCTURAL FEATURES AND RELATE THEM TO THE SUPERCONDUCTING PROPERTIES.

FUNDING PROVIDED BY THE AMERICAN RECOVERY AND REINVESTMENT ACT (ARRA) THROUGH THE U.S. DEPTARTMENT OF ENERGY, HIGH ENERGY PHYSICS. THIS WORK IS PART OF THE VERY HIGH FIELD SUPERCONDUCTING MAGNET COLLABORATION (VHFSMC).

2MX-05

EFFECT OF COOLING RATE ON RESOLIDIFICATION IN PARTIAL MELT PROCESSED BI2212/AG WIRE ***W. T. NACHTRAB***[1]*, X. T. LIU*[2]*, T. WONG*[1]*, J. SCHWARTZ*[2]*;* [1]SUPERCON, INC., [2]NORTH CAROLINA STATE UNIVERSITY. — IT IS WELL KNOW THAT THE J_C OF BI2212 IS DEPENDENT ON THE PEAK TEMPERATURE REACHED DURING PARTIAL MELT PROCESSING. HOWEVER, COOLING CONDITIONS FROM THE PEAK TEMPERATURE MUST ALSO BE CONTROLLED TO MAXIMIZE J_C. THIS PAPER WILL DESCRIBE THE EFFECTS OF COOLING CONDITIONS FROM PEAK PARTIAL MELT PROCESSING TEMPERATURE ON THE MICROSTRUCTURE AND PHASE ASSEMBLAGE BASED ON QUENCHED SAMPLES AND SEM/EDS ANALYSIS. THE PHASE ASSEMBLAGE AND MICROSTRUCTURE WILL BE CORRELATED WITH J_C FOR THE VARIOUS COOLING CONDITION INVESTIGATED ON FULLY TREATED PARTIAL MELT PROCESSED BI2212/AG MULTIFILAMENT ROUND WIRE.

THIS WORK WAS SUPPORTED IN PART BY A DOE SBIR PHASE II GRANT NO. DE-FG02-07ER86328

2MX-06

CURRENT TRANSPORT PROPERTIES OF SINGLE FILAMENTS EXTRACTED FROM BI2212 ROUND WIRES ***F. KAMETANI***[1]*, T. SHEN*[1]*, J. JIANG*[1]*, E. HELLSTROM*[1]*, Y. HUANG*[2]*, D. LARBALESTIER*[1]*;* [1]NATIONAL HIGH MAGNETIC FIELD LABORATORY, [2]OXFORD SUPERCONDUCTING TECHNOLOGY. — ROUND WIRE BI2212 IS A VERY PROMISING MATERIAL FOR HIGH FIELD MAGNETS, EXTENDING THE FIELD RANGE OF SUPERCONDUCTING MAGNETS TO WELL OVER 30 T, AS THE PRESENT VERY HIGH FIELD SUPERCONDUCTING MAGNET COLLABORATION (VHFSMC) PROJECT IS EXPLORING. ONE KEY MYSTERY OF PRESENT 2212 WIRES IS HOW HIGH JC IS POSSIBLE IN MACROSCOPICALLY UNTEXTURED FILAMENTS, A PROPERTY NOT FOUND IN ANY OTHER CUPRATE CONDUCTOR. WE ARE STUDYING SINGLE FILAMENTS FROM A SPECIAL WIRE IN WHICH FILAMENT-TO-FILAMENT BRIDGES ARE ABSENT, ENABLING US TO PERFORM CURRENT TRANSPORT MEASUREMENTS ON SINGLE FILAMENTS WITH DIFFERENT DOPING LEVELS FOLLOWED BY LOCAL MICROSTRUCTURAL INVESTIGATIONS. COMPARING THE V-I CHARACTERISTICS OF FILAMENTS WITH DIFFERENT OXYGEN DOPING LEVELS, WE FOUND SIGNS FOR GB CONTROL OF JC. SO FAR HOWEVER, POLYCRYSTALLINE SAMPLES OF BOTH UNDER- AND OVER-DOPED FILAMENTS HAVE BEEN FOUND WITH CHARACTERISTICS OF GRAINS RATHER THAN GBS. ANGULAR MEASUREMENTS OF JC DO HOWEVER SHOW THAT SOME LOCAL TEXTURE IS PRESENT, A RESULT CONSISTENT WITH LOCAL MICROSTRUCTURAL OBSERVATION. WE ARE REFINING OUR STUDY TO OBTAIN GREATER UNDERSTANDING OF THE LOCAL NATURE OF CURRENT FLOW IN THE PERSPECTIVE OF DEVELOPING A FUNDAMENTAL UNDERSTANDING OF GB CURRENT FLOW IN POORLY TEXTURED CUPRATES

2MX-07

PROCESS OPTIMIZATION FOR ENHANCED J_C OF BI-2212 USING METHODS OF STATISTICALLY DESIGNED EXPERIMENTS ***F. BACA***[1]*, T. G. HOLESINGER*[1]*, J. A. KENNISON*[1]*, J. COULTER*[1]*, K. MARKEN*[1]*, V. LOMBARDO*[2]*, E. BARZI*[2]*;* [1]LOS ALAMOS NATIONAL LABORATORY, [2]FERMI NATIONAL ACCELERATOR LABORATORY. — THEIR HIGH TRANSITION TEMPERATURES AND IRREVERSIBILITY FIELDS (H_{IRR}) MAKE HIGH-TEMPERATURE SUPERCONDUCTORS (HTS) ATTRACTIVE FOR PRODUCING VERY HIGH MAGNETIC FIELDS (> 20 T). IN PARTICULAR, THE COMMERCIALLY PRODUCIBLE ROUND-WIRE GEOMETRY MAKES BI-2212 A FAVORABLE CHOICE FOR WINDINGS TO PRODUCE THESE HIGH MAGNETIC FIELDS. HOWEVER, THE CRITICAL CURRENT DENSITIES (J_C) THAT LIMIT THE PERFORMANCE OF BI-2212 WIRES ARE REDUCED BY SEVERAL FACTORS, INCLUDING INTER-FILAMENTARY CONNECTIVITY AND VORTEX PINNING. TO UNDERSTAND THE RELATIONSHIPS BETWEEN WIRE PROPERTIES, PROCESSING, AND THE CRITICAL CURRENT DENSITY, J_C, WE USE STATISTICAL DESIGN OF EXPERIMENTS (SDE) METHODS TO IDENTIFY AND OPTIMIZE SIGNIFICANT THERMAL PROCESSING PARAMETERS. THE RELATIONSHIPS BETWEEN MICROSTRUCTURE, PROCESSING, AND J_C ARE SHOWN BY SCANNING AND (SCANNING) TRANSMISSION ELECTRON MICROSCOPY (SEM, (S)TEM).

DEPARTMENT OF ENERGY, VERY HIGH FIELD SUPERCONDUCTING MAGNET COLLABORATION (VHFSMC)

2MY-01

CRITICAL CURRENT VERSUS MAGNETIC-FIELD ORIENTATION IN YBCO THIN FILMS WITH COLUMNAR PINS BY COMPUTER SIMULATIONS OF VORTEX DYNAMICS ***J. P. RODRIGUEZ;*** CALIFORNIA STATE UNIVERSITY AT LOS ANGELES. — WE PERFORM THREE-DIMENSIONAL (3D) NUMERICAL SIMULATIONS OF VORTEX DYNAMICS IN A THIN FILM OF SUPERCONDUCTING YBCO THAT IS THREADED BY COLUMNAR PINNING CENTERS SUCH AS DISLOCATION LINES OR NANO-ROD INCLUSIONS. MASSIVELY PARALLEL COMPUTERS ARE EXPLOITED FOR THIS PURPOSE. IN PARTICULAR, VORTEX DYNAMICS WITHIN EACH LAYER OF THE YBCO FILM IS COMPUTED IN PARALLEL ON SEPARATE CENTRAL PROCESSING UNITS (CPUS) ASSIGNED TO EACH LAYER. 3D VORTEX DYNAMICS IS ACHIEVED BY COMMUNICATING BETWEEN PAIRS OF CPUS THAT CORRESPOND TO ADJACENT LAYERS. THE DEPENDENCE OF THE CRITICAL CURRENT ON THE ORIENTATION OF THE APPLIED MAGENTIC FIELD SHOWS A PEAK ALONG THE C-AXIS. IT HAS A CUSP-LIKE FORM THAT IS

SIMILAR TO THE PREDICTED DEPENDENCE ON FIELD ORIENTATION OF THE TRANSITION TEMPERATURE OF THE VORTEX SOLID. WE SHOW THAT THE C-AXIS PEAK IN THE CRITICAL CURRENT IS DUE TO CORRELATIONS OF THE PINNING FORCES ALONG THE LENGTH OF THE PINNING LINES..

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2MY-02

THICKNESS DEPENDENCE AND INFLUENCE OF SELF AND EXTERNAL FIELDS ON THE CRITICAL-CURRENT DENSITY OF COATED CONDUCTORS ***A. SANCHEZ***[1]*, C. NAVAU*[1]*, N. DEL-VALLE*[1]*, D. CHEN*[2]*, J. R. CLEM*[3]*;* [1]UNIVERSITAT AUTONOMA DE BARCELONA, [2]ICREA AND UNIVERSITAT AUTONOMA DE BARCELONA, [3]IOWA STATE UNIVERSITY AND AMES LABORATORY. — INCREASING CRITICAL CURRENT IN COATED CONDUCTORS IS AN IMPORTANT DIRECTION OF RESEARCH REQUIRED FOR THEIR APPLICATION IN MANY TECHNOLOGIES. IN THIS WORK WE PRESENT A MODEL FRAMEWORK FOR ANALYZING THE CURRENT-DENSITY DISTRIBUTION IN COATED CONDUCTORS CARRYING A TRANSPORT CURRENT. WE SHOW HOW THE EFFECT OF SELF-FIELDS CAN INFLUENCE THE VALUE OF THE CRITICAL CURRENT AT ZERO APPLIED FIELD. THE THICKNESS-DEPENDENCE EFFECT IN COATED CONDUCTORS WIDELY EXPERIMENTALLY OBSERVED - CURRENT DENSITY DECREASING WITH CONDUCTOR THICKNESS - IS EXPLAINED IN THIS WAY, AS WE HAVE RECENTLY PRESENTED [APPL. PHYS. LETT. 96, 072510 (2010)]. WE NEXT SHOW SOME EXAMPLES OF HOW THE TOTAL TRANSPORT CURRENT IN THIN SUPERCONDUCTING FILMS CAN BE MODIFIED BY CHANGING THE SUPERCONDUCTOR GEOMETRY AND THE EXTERNAL MAGNETIC-FIELD DISTRIBUTION.

2MY-03

ELECTRICAL CHARACTERIZATION AND MODELLING OF TECHNICAL SUPERCONDUCTORS FOR USE IN APPLICATIONS WITH MODERATE MAGNETIC FIELDS AND LOWER TEMPERATURES ***A. KUHNERT****, M. P. OOMEN, J. RABBERS, T. ARNDT;* SIEMENS AG. — CHARACTERIZATION OF TECHNICAL SUPERCONDUCTORS IS AN IMPORTANT ISSUE CONCERNING THE DESIGN OF COILS FOR ROTATING MACHINES AND OTHER APPLICATIONS. PARTICULARLY THE CRITICAL CURRENT OF THE CONDUCTOR AS A FUNCTION OF MAGNETIC FIELD B, TEMPERATURE T AND FIELD ANGLE A IS OF INTEREST. THE GOAL OF THIS WORK IS TO UNDERSTAND THE IC(B,T,A)-CHARACTERISTICS OF TECHNICAL SUPERCONDUCTORS ENABLING US TO PREDICT THE PROPERTIES AT OPERATING CONDITIONS FROM A REDUCED NUMBER OF MEASUREMENTS, E.G. IN LN2. WITH OUR NEW AND UNIQUE EXPERIMENTAL SETUP, WHICH IS UNDER CONSTRUCTION, THE ELECTRICAL PERFORMANCE OF TECHNICAL SUPERCONDUCTORS WILL BE MEASURED AT TEMPERATURES DOWN TO 10 K AND IN MAGNETIC FIELDS UP TO 5 T. THE CURRENTS MAY REACH 3 KA. FURTHERMORE THE SAMPLES CAN BE CONSIDERABLY LONGER THAN IN EXISTING SETUPS. THIS ALLOWS US TO MEASURE CRITICAL CURRENTS AT CONDITIONS RELEVANT FOR APPLICATIONS, I.E. IN MODERATE MAGNETIC FIELDS AND LOWER TEMPERATURES. IN THIS CONTRIBUTION WE PRESENT IC(B,T,A)-MEASUREMENTS DONE WITH PRESENT SETUPS AND FIRST RESULTS OF THE NEW SETUP.

2MY-04

CRITICAL CURRENT DENSITY AND T_C VARIATIONS IN THE YBCO FILMS OF COATED CONDUCTORS ***P. BERNSTEIN****, C. MCLOUGHLIN, Y. THIMONT, J. NOUDEM, C. HARNOIS;* CNRS - CRISMAT ENSICAEN. — THE SURFACE CRITICAL CURRENT DENSITY, J_{CR} ,OF COATED CONDUCTORS MAINTAINS A CONSTANT VALUE ABOVE A CRITICAL YBCO FILM THICKNESS, WHILE THE CRITICAL CURRENT DENSITY, $J_{CR,}$ APPEARS TO DECREASE. WITH NO ACCORD ON THE CAUSE OF THIS PHENOMENON, WE PROPOSE THAT SUPERCONDUCTIVITY DOES NOT EXTEND TO THE WHOLE YBCO FILM IN SOME SAMPLES. FOR THIS PURPOSE WE FIRST POINT OUT THAT, MEASUREMENTS CARRIED OUT BY IJADUOLA ET AL.[PHYS.REV.B73, 134502 (2006)] RESULT IN A CONSTANT MAXIMUM $J_{CR,}$AT LOW TEMPERATURE (J_{CR}(5K) =29MA/CM^2) IN CCS WITH A VERY THIN YBCO FILM. THEN, WE REPORT J_{CR} (T) MEASUREMENTS ON RECENTLY MANUFACTURED CCS SHOWING THE POSSIBLE EXISTENCE OF A T_C GRADIENT ALONG THE C-DIRECTION IN THE YBCO FILMS. THE J_{CR}(T) OF SOME OF THE CCS MEASURED AT LOW TEMPERATURE AND THE YBCO FILM THICKNESS, YIELD THE IJADUOLA VALUE FOR J_{CR} EVEN THOUGH THE YBCO FILM THICKNESS IS OF THE ORDER OF 1 MICROMETER. THIS SUGGESTS THAT THE IJADUOLA VALUE IS UNIVERSAL FOR FULLY SUPERCONDUCTING CCS. FOR OTHER CCS, THE CALCULATION OF THEIR THICKNESS WITH THE IJADUOLA VALUE AND THE COMPARISON OF THEIR T_C PROFILE TO THAT OF THE FULLY SUPERCONDUCTING CCS, IMPLIES THAT THEY WERE NOT UNIFORMLY SUPERCONDUCTING THROUGH THE YBCO STRUCTURE. RELATING THE T_C GRADIENT TO A POSSIBLE GRADIENT IN THE OXYGEN CONTENT OF THE FILMS, WE BELIEVE THAT THE NON-SUPERCONDUCTING PART OF THEIR YBCO FILM IS UNDERDOPED.

THIS WORK WAS SUPPORTED BY DGA, CONTRACT N°0634008.

2MY-05

THE STRAIN DEPENDENCE OF THE CRITICAL CURRENT DENSITY OF $YBA_2CU_3O_{7-\Delta}$ COATED CONDUCTORS AS A FUNCTION OF MAGNETIC FIELD, ANGLE, AND TEMPERATURE ***J. S. HIGGINS****, D. HAMPSHIRE;* DURHAM UNIVERSITY. — FROM AN ENGINEERING STANDPOINT, THE MAGNETIC FIELD (B), TEMPERATURE (T), AND STRAIN DEPENDENCE (E) OF THE CRITICAL CURRENT IN PRACTICAL SUPERCONDUCTING WIRES/TAPES IS CRITICAL FOR OPTIMIZING DEVICE DESIGN USING SUPERCONDUCTING TECHNOLOGY. THE HIGHLY ANISOTROPIC AND BRITTLE NATURE OF $YBA_2CU_3O_{7-\Delta}$ COATED CONDUCTOR TAPES MEANS A DETAILED INVESTIGATION OF THE PARAMETERS THAT AFFECT THE CRITICAL CURRENT IS A CHALLENGING EXPERIMENTAL TASK TO ACHIEVE WITHIN A SINGLE STRAIN APPARATUS. HERE WE PRESENT STRAIN MEASUREMENTS ON YBCO COATED CONDUCTORS USING A BENDING APPARATUS DESIGNED FOR USE IN HORIZONTAL

SPLIT-PAIR MAGNET SYSTEMS WITH 40 MM DIAMETER ACCESS PORTS. THE DESIGN AND CONFIGURATION OF THE EXPERIMENTAL SETUP ALLOWS FOR A SMOOTH VARIATION IN APPLIED STRAIN BETWEEN -2% < $E_{APPLIED}$ < +1%. MAGNETIC FIELDS UP TO 0.5 T AT T = 77 AND 66 K, AND 15 T AT 4.2 K, WERE APPLIED AT VARIOUS ANGLES WITH RESPECT TO THE COATED CONDUCTOR SURFACE. AT 77 K IN ZERO FIELD, J_C CAN BE REVERSIBLY SUPPRESSED BY MORE THAN 80% BY APPLYING A ~1 % COMPRESSIVE STRAIN. WE WILL PRESENT OUR MOST RECENT MEASUREMENTS OF J_C WHICH MAKES IT POSSIBLE TO BEGIN AN INVESTIGATION INTO THE SCALING RELATION FOR $J_C(B, T, E, \Theta)$.

2MY-07

IMPROVEMENT OF CRITICAL CURRENT DENSITIES AND TRAPPED MAGNETIC FIELD IN SINGLE DOMAIN YBCO BY INSULATING INCLUSIONS: CONTROL OF THE PINNING CENTERS SIZE *N. MOUTALBI[1], J. NOUDEM[2],* ***A. M'CHIRGUI[1];*** [1]FACULTY OF SCIENCES, [2]CRISMAT/CNRS, UCBN/ENSICAEN. — BULK HIGH TEMPERATURE SUPERCONDUCTORS (HTS) HAVE SIGNIFICANT POTENTIAL FOR THE GENERATION OF CONSIDERABLY HIGHER MAGNETIC FIELDS THAN THOSE ACHIEVABLE WITH PERMANENT MAGNETS. THEIR FIELD GENERATING ABILITY FORMS THE BASIS OF NUMEROUS OF NOVEL AND PERMANENT MAGNET-LIKE ENGINEERING APPLICATIONS. THE TOP SEEDED MELT GROWTH METHOD HAS BEEN WIDELY USED TO FABRICATE LARGE SINGLE GRAIN YBCO SUPERCONDUCTORS THAT CAN TRAP HIGH MAGNETIC FIELDS. HOWEVER, ADDITIONAL IMPROVEMENT IN THE SUPERCONDUCTING PROPERTIES IS NEEDED. THE GENERATION OF EFFECTIVE ARTIFICIAL PINNING CENTERS IN A CONTROLLED WAY AND WITH OPTIMAL DIMENSIONS CAN CONTRIBUTE TO THE IMPROVEMENT OF PINNING CAPABILITY AND THE ENHANCEMENT OF THE TRAPPED MAGNETIC FIELD AND THUS THE PERFORMANCE OF THE CRITICAL CURRENT DENSITY UNDER HIGH MAGNETIC FIELDS. IN THIS WORK, WE STUDY THE EFFECT OF THE SIZE OF ARTIFICIAL PINNING CENTERS ON SUPERCONDUCTING PROPERTIES. TO THIS EFFECT, TWO ALUMINA NANO-PARTICLE DISPERSIONS WITH MEAN SIZE DIAMETER OF ABOUT D_1=20NM AND D_2= 130NM WERE SUCCESSFULLY INCORPORATED INTO MELT-TEXTURED YBCO. THE MICROSTRUCTURES AND THE SUPERCONDUCTING PROPERTIES WERE INVESTIGATED BY SCANNING ELECTRON MICROSCOPY, SCANNING HALL FLUX MAPPING AND SQUID. THE EXPERIMENTAL RESULTS HAVE SHOWN THAT DECREASING THE SIZE OF THE PINNING CENTERS LEADS TO FURTHER IMPROVEMENTS OF THE TRAPPED FIELD AND THE CRITICAL CURRENT DENSITIES.

2MY-08

INVESTIGATION OF DYNAMIC BEHAVIORS OF LOW-LEVEL DISSIPATION AT YBA2CU3O7-Δ GRAIN BOUNDARIES USING LOW-TEMPERATURE NEAR-FIELD SCANNING MICROWAVE MICROSCOPY ***J. WU[1]****, R. LU[1], C. CHRISTIANSON[1], J. DIZON[1], T. HAUGAN[2], P. BARNES[2], J. BACA[3];* [1]UNIV. OF KANSAS, [2]US AIR FORCE RESEARCH LAB, [3]LOS ALAMOS NATIONAL LAB. — NEAR-FIELD SCANNING MICROWAVE MICROSCOPY (NSMM) PROVIDES A UNIQUE NONDESTRUCTIVE APPROACH FOR DETECTION OF LOCAL DISSIPATION WITH HIGH SENSITIVITY AND HIGH SPATIAL RESOLUTION. WITH RECENTLY IMPROVED NSMM PROBES OF SPATIAL RESOLUTION OF 400 NM (~10^{-6} WAVELENGTH), DETECTION OF DISSIPATION WAS ACHIEVED ON YBCO MICROBRIDGES AT CURRENTS MORE THAN ***THREE ORDERS OF MAGNITUDE*** BELOW THE J_C(T). IN THIS WORK, WE REPORT CHARACTERIZATION OF THE DYNAMIC BEHAVIOR OF LOW-LEVEL DISSIPATION AT THE GRAIN BOUNDARY OF $YBA_2CU_3O_{7-\Delta}$ MICROBRIDGES AS FUNCTION OF TIME, TEMPERATURE AND APPLIED ELECTRICAL CURRENT. ON HIGHER-ANGLE GRAIN BOUNDARY, THE DISSIPATION DEVELOPS RAPIDLY WITH INCREASING CURRENT AND SHOWS APPROXIMATELY LINEAR DEPENDENCE ON CURRENT. ON LOWER-ANGLE GRAIN BOUNDARY, NONLINEAR FEATURES WERE OBSERVED AND ATTRIBUTED TO BI-MODAL PATTERN OF DISSIPATION EVOLUTION OF NUCLEATION OF ISOLATED HOT SPOTS AND THEIR EVOLUTION. COMPARISON WITH THE SIMILAR NSMM+IV MEASUREMENT MADE ON THE "BULK" PART OF THE SAME $YBA_2CU_3O_{7-\Delta}$ MICROBRIDGES ON A REDUCED TEMPERATURE SCALE SHOWS HIGHER DISSIPATION ON THE GRAIN BOUNDARY CAN BE MOSTLY ATTRIBUTED TO THE LOWER T_C VALUES ON GRAIN BOUNDARIES. THIS ARGUMENT IS SUPPORTED BY NSMM+IV MEASUREMENT REPEATED ON NANOPARTICLE-DOPED YBCO GRAIN BOUNDARIES WITH LOCALLY IMPROVED T_C VALUES.

3EA-01

(INVITED) **UNDERSTANDING AND MEASURING HEAT TRANSPORT AND HEAT STORAGE IN LOW-DIMENSIONAL STRUCTURES AT LOW TEMPERATURES** ***S. WITHINGTON****, D. J. GOLDIE;* UNIVERSITY OF CAMBRIDGE. — TRANSITION EDGE SENSORS (TESS) ARE THE DETECTORS OF CHOICE FOR MANY AREAS OF ASTRONOMY. THE PERFORMANCE OF A TES IS DETERMINED, LARGELY, BY THE THERMAL CONDUCTANCES AND HEAT CAPACITIES OF THE STRUCTURES THAT MAKE UP THE DEVICE. TO MANUFACTURE LARGE, UNIFORM, ULTRA-LOW-NOISE ARRAYS, A DETAILED UNDERSTANDING OF THE ELECTRO-THERMAL PHYSICS OF THE MATERIALS AND STRUCTURES THAT MAKE UP THE DEVICE ARE REQUIRED. WE WILL DISCUSS THE INTIMATE RELATIONSHIP BETWEEN THE ACOUSTIC PROPERTIES OF MATERIALS AND THEIR THERMAL BEHAVIOUR. WE WILL REVIEW VARIOUS CONCEPTS FOR UNDERSTANDING HEAT CONDUCTION AND STORAGE IN LOW-DIMENSIONAL, LOW TEMPERATURE STRUCTURES MADE FROM AMORPHOUS MATERIALS. FOR EXAMPLE, WE WILL CONSIDER HOW THE TEMPERATURE PROFILE ALONG A BAR CAN BE CALCULATED, INCLUDING THE TRANSITION TO THE QUANTUM-LIMIT. WE SHALL CONSIDER THE ROLE OF SCATTERING AND ROUGHNESS, AND ASSESS PROCESSES THAT MIGHT BE RESPONSIBLE FOR VARIATIONS SEEN IN THE BEHAVIOUR OF DEVICES FABRICATED BY DIFFERENT GROUPS. WE WILL REVIEW A NUMBER OF TECHNIQUES FOR MEASURING THE THERMAL BEHAVIOUR OF MATERIALS AND STRUCTURES; IN PARTICULAR DIFFERENTIAL RADIOMETRIC TES THERMOMETRY. WE WILL DESCRIBE HOW THE EFFECT OF HAVING SAY A SUPERCONDUCTING FILM ON A DIELECTRIC LEG CAN BE MEASURED PRECISELY. WE WILL SUGGEST A NUMBER OF STUDIES THAT MIGHT BE UNDERTAKEN TO REFINE OUR

UNDERSTANDING OF THE ELECTRO-THERMAL BEHAVIOUR OF TESS.

3EA-02

STUDY OF EXCESS HEAT CAPACITY AND SUPPRESSED KAPITZA CONDUCTANCE IN TES DEVICES *Y. ZHAO[1], **J. A. CHERVENAK**[2], W. B. DORIESE[3], S. T. STAGGS[4];* [1]CORNELL UNIVERSITY, [2]NASA GSFC, [3]NIST, BOULDER, [4]PRINCETON UNIVERSITY. — A NUMBER OF GROUPS HAVE PRODUCED TES DEVICES USING DIELECTRIC MEMBRANES FOR THERMAL ISOLATION IN WHICH EXCESS HEAT CAPACITY IS REPORTED. WE HAVE FABRICATED A SERIES OF TES DEVICES USING LARGE AREA MEMBRANES AND NARROW LEGS FOR THERMAL ISOLATION TO STUDY THE SCALING OF INTRINSIC PARAMETERS LIKE THE HEAT CAPACITY OF THE MEMBRANE. DEVICES ARE ARRANGED ON A SINGLE CHIP TO ENSURE SIMILARITY OF DEVICES PARAMETERS (I.E., FILM THICKNESSES) AND PROCESSING HISTORY. MEASUREMENTS OF THE CURRENT-VOLTAGE CHARACTERISTIC AND COMPLEX IMPEDANCE ARE MADE USING A MULTICHANNEL SQUID SETUP SO THAT DEVICES ARE READOUT UNDER SIMILAR CONDITIONS. WE HAVE DEVELOPED A MODEL FOR NONIDEAL TRANSITION EDGE SENSOR PERFORMANCE THAT ENABLES EXTRACTION OF HEAT CAPACITIES AND THERMAL CONDUCTANCES AS IDENTIFIED BY THE MODEL. WE REPORT ON THE MAGNITUDE OF EXCESS HEAT CAPACITY IN THE DIELECTRIC MEMBRANE AND THERMAL CONDUCTANCE OF THE METAL-TO-DIELECTRIC INTERFACE IN EACH OF THE DESIGNS.

3EA-03

ANOMALOUS THERMAL BEHAVIOR IN GAMMA-RAY MICROCALORIMETERS ***R. D. HORANSKY**, D. A. BENNET, J. A. BEALL, K. D. IRWIN, J. N. ULLOM;* NIST, BOULDER. — WE ARE DEVELOPING MICROCALORIMETER GAMMA-RAY DETECTORS FOR NUCLEAR MATERIALS ANALYSIS AND ASTROPHYSICS. THESE DETECTORS CONSIST OF A BULK ABSORBER ATTACHED TO A THERMALLY-ISOLATED THIN-FILM SUPERCONDUCTOR BIASED IN ITS TRANSITION. GAMMA-RAY MICROCALORIMETERS HAVE ACHIEVED AN ORDER OF MAGNITUDE IMPROVEMENT IN RESOLUTION OVER THE NEAREST COMPETING TECHNOLOGY, HIGH PURITY GERMANIUM. SUPERCONDUCTING TIN HAS BEEN THE BEST PERFORMING ABSORBER MATERIAL. HOWEVER, THE SENSORS RETURN TO THERMAL EQUILIBRIUM AFTER ABSORBING A GAMMA-RAY 10X MORE SLOWLY THAN PREDICTED BY THERMAL MODELS. THIS RESPONSE HAS LIMITED THE ACHIEVABLE COUNT RATE. ALSO, THE TIN IS ONLY 20% EFFICIENT FOR 100 KEV PHOTONS WHERE HIGHER Z MATERIALS WOULD DELIVER A MARKED IMPROVEMENT. HIGH Z MATERIALS HAVE SHOWN A LONGER RECOVERY TIME THAN TIN. WE DEMONSTRATE THAT PART OF THIS ANOMALOUS RESPONSE IS DUE TO THE ADHESIVE USED TO ATTACH THE ABSORBER. WE ALSO SHOW RESULTS FROM A SYSTEMATIC STUDY OF ADHESIVE VOLUME, ABSORBER GEOMETRY, AND ABSORBER MATERIAL DESIGNED TO DETERMINE WHETHER THE ANOMALOUS THERMAL BEHAVIOR IS DUE SOLELY TO THE ADHESIVE OR IF ADDITIONAL PHYSICS IN THE ABSORBER SUCH AS QUASIPARTICLE RECOMBINATION PLAYS A ROLE IN THE RECOVERY PROCESS. IF THE SOURCE OF THE ANOMALOUS BEHAVIOR CAN BE FOUND AND ELIMINATED, MICROCALORIMETERS ARRAYS WILL BE ABLE TO MEASURE AT 10X HIGHER COUNT RATE AND WITH NEAR UNITY EFFICIENCY AT 100 KEV.

THIS WORK SUPPORTED BY THE US DEPARTMENT OF HOMELAND SECURITY AND THE DEPARTMENT OF ENERGY THROUGH THE OFFICE OF NONPROLIFERATION RESEARCH AND DEVELOPMENT.

3EA-05

DEVICE CHARACTERIZATION AND READOUT FOR FAST TUNGSTEN OPTICAL TRANSITION EDGE SENSORS ***B. CALKINS**, A. E. LITA, N. TOMLIN, S. NAM;* NIST BOULDER. — HIGH EFFICIENCY SINGLE PHOTON DETECTORS WITH PHOTON NUMBER RESOLVING CAPABILITY ARE REQUIRED FOR A VARIETY OF EXPERIMENTS AND APPLICATIONS IN THE FIELDS OF QUANTUM OPTICS AND QUANTUM INFORMATION. IN ADDITION, FAST RECOVERY AND LOW ARRIVAL-TIME JITTER IS DESIRED. TUNGSTEN TRANSITION EDGE SENSOR MICROCALORIMETERS HAVE BEEN USED TO ACHIEVE THESE GOALS, UTILIZING A SELF-ABSORBER DESIGN THAT RELIES ON THE DECOUPLING OF THE ELECTRON AND PHONON SYSTEMS OF TUNGSTEN IN ITS TRANSITION TO PROVIDE THE WEAK THERMAL LINK NECESSARY FOR CALORIMETER OPERATION. THIS RESULTS IN FAST RECOVERY TIME (≤ 1 μS), WHILE STILL RETAINING THE NECESSARY ENERGY RESOLUTION TO RESOLVE INDIVIDUAL PHOTONS. IN THIS WORK WE REPORT ON THE CHARACTERIZATION OF THESE DEVICES AND THE ELECTRICAL READOUT TECHNIQUE THAT THEIR USE REQUIRES. CHARACTERISTIC DEVICE IMPEDANCE MEASUREMENTS AT FREQUENCIES EXTENDING ABOVE 1 MHZ SHOW GOOD AGREEMENT WITH A SINGLE-BODY THERMAL MODEL. IN ADDITION, WE DISCUSS POTENTIAL FUTURE IMPROVEMENTS IN DEVICE SPEED OF THE OPTICAL TES.

3EA-06

THERMAL PROPERTIES OF SILICON NITRIDE BEAMS BELOW ONE KELVIN ***G. WANG**[1], V. YEFREMENKO[1], A. DATESMAN[1], V. NOVOSAD[1], J. PEARSON[1], R. DIVAN[1], J. LEE[1], C. CHANG[2], L. BLEEM[2], A. CRITES[2], J. MEHL[2], S. MEYER[2], J. CARLSTROM[2], J. SAYER[3], J. RUHL[3], J. MCMAHON[4];* [1]ARGONNE NATIONAL LABORATORY, [2]UNIVERSITY OF CHICAGO, [3]CASE WESTERN RESERVE UNIVERSITY, [4]UNIVERSITY OF MICHIGAN. — LOW STRESS SILICON NITRIDE BEAMS HAVE BEEN WIDELY USED AS MECHANICAL SUPPORTS AND WEAK THERMAL LINKS IN CRYOGENIC DETECTORS. WE HAVE INVESTIGATED THE THERMAL TRANSPORT PROPERTIES OF ONE MICROMETER THICK SILICON NITRIDE BEAMS WITH WIDTHS FROM TEN MICROMETERS TO THIRTY MICROMETERS BELOW ONE KELVIN. WE MEASURED THE THERMAL CONDUCTANCE OF THE SILICON NITRIDE BEAMS BY SIMULTANEOUSLY EMPLOYING A SUPERCONDUCTING TRANSITION EDGE SENSOR (TES) AS BOTH A HEATER AND A SENSOR. BASED UPON THESE MEASUREMENTS, WE CALCULATE THE THERMAL PARAMETERS OF THE BEAMS. WE UTILIZE A BOUNDARY LIMITED PHONON SCATTERING MODEL AND ASSUME THE PHONON MEAN FREE

PATH TO BE TEMPERATURE INDEPENDENT IN THE CALCULATION. PHONON MEAN FREE PATH IN THE SILICON NITRIDE BEAM DEPENDS ON ITS WIDTH, SO IS THE THERMAL CONDUCTIVITY. THE PHONON MEAN FREE PATHS, SPECIFIC HEATS, AND THERMAL CONDUCTIVITIES ARE ESTIMATED USING THE MODEL AND TESTING DATA.

THE WORK AT ARGONNE NATIONAL LABORATORY, INCLUDING THE USE OF FACILITY AT THE CENTER FOR NANOSCALE MATERIALS, WAS SUPPORTED BY THE U.S. DEPARTMENT OF ENERGY, UNDER CONTRACT NO. DE-AC02-06CH11357.

3EA-07

TRANSITION EDGE SENSORS USING A LOW-G SPIDER-WEB-LIKE SIN SUPPORTING STRUCTURE ***P. KHOSROPANAH***[1]*, M. L. RIDDER*[1]*, M. P. BRUIJN*[1]*, M. PARRA-BORDERIAS*[2]*, B. P. F. DIRKS*[1]*, R. A. HIJMERING*[1]*, L. GOTTARDI*[1]*, J. VAN DER KUUR*[1]*, A. M. POPESCU*[1]*, P. A. J. DE KORTE*[1]*, H. F. C. HOEVERS*[1]*, J. R. GAO*[1]*;* [1]SRON NETHERLANDS INSTITUTE FOR SPACE RESEARCH, [2]INSTITUTO DE CIENCIA DE MATERIALES DE ARAGON, CSIC-UNIVERSIDAD DE ZARAGOZA. — TRANSITION EDGE SENSORS (TES) ARE A SERIOUS CANDIDATE FOR APPLICATION IN THE EUROPEAN SAFARI IMAGING SPECTROMETER (THE WAVELENGTH RANGE OF 30-210 MICROMETER) ON THE JAPANESE SPICA TELESCOPE. SINCE THE TELESCOPE MIRROR WILL BE OPERATED AT 4.5 K, THE REQUIRED NEP OF THE DETECTORS SHOULD BE 2X10^-19 W/HZ^0.5 AT A BASE TEMPERATURE OF AROUND 50 MK. APART FROM THIS CHALLENGING REQUIREMENT, THERE ARE ALSO CRITICAL DEMANDS ON THE PIXEL SIZE, WHICH SHOULD BE 480X480 UM^2 FOR THE SHORTEST WAVELENGTH BAND, AND ON THE TIME CONSTANT (<3.2 MS).WE ARE DEVELOPING TIAU TES BOLOMETERS ON A SI3N4 MEMBRANE, WHERE NARROW, 1 UM THICK SI3N4 MEMBRANE LEGS ACT AS THERMAL LINKS BETWEEN TES AND THE BATH. AFTER HAVING DEMONSTRATEDTES WITH 4 LONG (1.8 MM) STRAIGHT SUPPORTING LEGS, SHOWING A MEASURED THERMAL CONDUCTANCE (G) OF 3.2X10^-13 W/K AND AN ELECTRICAL NEP OF 3X10^-19 W/HZ^0.5 BASED ON THE MEASURED G (TAKING ONLY THE PHONON NOISE INTO ACCOUNT), WE NOW FOCUS ON A NEW TYPE OF SI3N4 SUPPORTING CONFIGURATION. THE NEW DEVICE IS ALSO BASED ON TIAU, BUT ON A SPIDER-WEB LIKE SI3N4 STRUCTURE. THIS DESIGN ALLOWS FOR A LOW-G TES TO HAVE A COMPACT PIXEL SIZE.THE PAPER REPORTS THE FIRST EXPERIMENT AND ANALYSIS THAT ARE PERFORMED USING A DEVICE WITH FEW SI3N4 RINGS IN THE SPIDER WEB STRUCTURE AND WITH A TC OF 155 MK. THE MEASURED G IS 2X10 ^-12 W/K, WHICH IS VERY CLOSE TO WHAT WE EXPECTED, AND THE NEP BASED ON PHONON NOISE IS 1X10^-18 W/HZ^0.5.

3EB-01

(INVITED) **ENERGY-EFFICIENT SINGLE FLUX QUANTUM TECHNOLOGY** ***O. A. MUKHANOV****;* HYPRES. — USING EFFICIENCY FIGURES OF MERIT CONNECTING PROCESSING CAPABILITIES WITH POWER DISSIPATED (OPS/WATT, JOULE/BIT, ETC.) BECAME DOMINATING IN CHOOSING TECHNOLOGIES FOR IMPLEMENTING THE NEXT GENERATION OF COMPUTING AND COMMUNICATION NETWORK SYSTEMS. SUPERCONDUCTIVITY IS VIEWED AS A TECHNOLOGY CAPABLE OF ACHIEVING HIGHER ENERGY EFFICIENCIES AS COMPARED TO ANY OTHER TECHNOLOGIES. STATIC POWER DISSIPATION OF STANDARD RSFQ LOGIC ASSOCIATED WITH DC BIAS RESISTORS IS RESPONSIBLE FOR THE DOMINANT PART OF CIRCUIT POWER DISSIPATION. WE WILL REVIEW AND COMPARE DIFFERENT SUPERCONDUCTOR DIGITAL TECHNOLOGY APPROACHES AND LOGIC FAMILIES ADDRESSING THIS PROBLEM. THESE WILL INCLUDE ENERGY-EFFICIENT DERIVATIVES OF RSFQ, RQL, AND NEWLY INVENTED ZERO-STATIC-POWER EFFICIENT ERSFQ AND ESFQ LOGIC FAMILIES. A COMPREHENSIVE INTRODUCTION OF ESFQ - NOVEL ENERGY-EFFICIENT SINGLE FLUX QUANTUM LOGIC FAMILY - WILL BE PRESENTED. WE WILL ALSO PRESENT NOVEL ENERGY-EFFICIENT APPROACHES FOR OUTPUT DATA INTERFACE AND OVERALL CRYOSYSTEM DESIGN. WE WILL ALSO DISCUSS HOW THE MAXIMIZATION OF ENERGY-EFFICIENCY AFFECTS ARCHITECTURE CHOICES, CIRCUIT COMPLEXITY, CLOCK SPEED, COMPUTATIONAL PERFORMANCE, POWER DELIVERY AND MANAGEMENT, CLOCK DISTRIBUTION, I/O DESIGN, AND CRYOGENIC PHYSICAL DESIGN.

3EB-02

(INVITED) **CARRY LOOK-AHEAD ADDER IN RECIPROCAL QUANTUM LOGIC** *A. Y. HERR,* ***Q. P. HERR****, A. G. IOANNIDIS, D. L. MILLER, O. T. OBERG, S. B. SHAUCK;* NORTHROP GRUMMAN CORPORATION. — RECIPROCAL QUANTUM LOGIC IS A NEW SUPERCONDUCTOR LOGIC FAMILY THAT COMBINES THE HIGH SPEED AND LOW POWER SIGNAL LEVELS OF SINGLE-FLUX-QUANTUM DATA ENCODING WITH THE DESIGN METHODOLOGY OF CMOS. THE COMBINATIONAL LOGIC GATES SUPPORT MULTIPLE LEVELS OF LOGIC PER PIPELINE STAGE USING STANDARD LOGIC SYNTHESIS TOOLS. AC POWER PROVIDES A STABLE CLOCK REFERENCE AT EACH GATE, WHICH REMOVES TIMING UNCERTAINTY. EFFECTIVE SERIES BIASING OF GATES USING TRANSFORMER COUPLING ENABLES LOW-CURRENT POWER SUPPLY, AND ZERO STATIC POWER DISSIPATION REMOVES THE POWER PENALTY FOR INACTIVE CIRCUITRY. ALL OF THIS HAS ENABLED THE DESIGN OF AN EIGHT-BIT CARRY LOOK-AHEAD ADDER THAT HAS 700 JOSEPHSON JUNCTIONS AND 1.5 CLOCK CYCLES OF LATENCY AT 20 GHZ IN 4500 A/CM^2 TECHNOLOGY. THE CIRCUIT IS EXPECTED TO DISSIPATE ONLY 5μW AT 4 KELVIN UNDER FULL UTILIZATION. WE PRESENT THE DESIGN OF THIS CIRCUIT FROM THE TOP LEVEL DOWN TO THE LOGIC GATES, INCLUDING MEASURED BIAS MARGINS OF ± 40%.

THIS WORK WAS SUPPORTED IN PART BY THE DEFENSE MICRO-ELECTRONICS AGENCY.

3EB-03

REDUCED POWER CONSUMPTION IN SUPERCONDUCTING ELECTRONICS ***T. ORTLEPP***[1]*, O. MIELKE*[2]*, S. ENGERT*[1]*, J. KUNERT*[2]*, H. TOEPFER*[1]*;* [1]ILMENAU UNIVERSITY OF TECHNOLOGY, [2]INSTITUTE FOR PHOTONIC TECHNOLOGY. — RAPID SINGLE FLUX QUANTUM (RSFQ) ELECTRONICS IS BASED ON THE JOSEPHSON JUNCTION AS ACTIVE SWITCHING

ELEMENT. IN STANDARD RSFQ CIRCUITS ITS SWITCHING ENERGY IS MUCH LOWER THAN THE STATIC POWER CONSUMPTION CAUSED BY THE RESISTIVE CURRENT DISTRIBUTION NETWORK. DUE TO THIS THERMAL HEATING OF THE CHIP, THE MAXIMUM NUMBER OF JUNCTIONS ON A SINGLE CHIP IS LIMITED TO ABOUT 1 MILLION. THE FREQUENCY-DEPENDENT CONTRIBUTION TO POWER DISSIPATION FROM JUNCTION SWITCHINGS IS ONLY ABOUT 2 PERCENT OF THE STATIC ONE. THIS FACT LIMITS THE DIRECT CONSTRUCTION OF VLSI SYSTEMS FOR HIGH-PERFORMANCE COMPUTING AS WELL AS SMALL-SCALE CIRCUIT APPLICATIONS IN THE VICINITY OF ULTRA-SENSITIVE DETECTORS OR EVEN QUANTUM CIRCUITS.WE PRESENT AN ASSESSMENT OF DIFFERENT APPROACHES FOR REDUCING THE STATIC POWER CONSUMPTION BY INVESTIGATING THE POTENTIAL OF INDUCTIVE BIAS DISTRIBUTION NETWORKS AS WELL AS REDUCED CRITICAL CURRENTS. WE DEMONSTRATE THE OPERATION STABILITY OF SIMPLE DIGITAL CIRCUITS WITH 5 TIMES SMALLER CRITICAL CURRENTS AT 4.2 KELVIN AND DISCUSS POSSIBLE APPLICATIONS. THE COMBINATION OF NEW DESIGN APPROACHES CAN PROVIDE DIGITAL SUPERCONDUCTIVE CIRCUITS IN WHICH STATIC AND DYNAMIC POWER CONSUMPTION HAVE A SIMILAR AMOUNT.

THE PROJECT WAS FUNDED BY THE EUROPEAN FRAMEWORK PROJECT S-PULSE.

3EB-04

NO STATIC POWER DISSIPATION BIASING OF RSFQ CIRCUITS *D. E. KIRICHENKO,* ***A. F. KIRICHENKO****, S. SARWANA;* HYPRES. — WE PRESENT NOVEL, RESISTOR-FREE APPROACH TO DC BIASING OF RSFQ CIRCUITS (ERSFQ). THIS BIASING SCHEME DOES NOT DISSIPATE ENERGY IN STATIC (NON-ACTIVE) MODE AND DISSIPATES ORDERS OF MAGNITUDE LESS POWER THAN TRADITIONAL RSFQ WHILE OPERATING. USING THIS APPROACH, WE HAVE DESIGNED, FABRICATED AND SUCCESSFULLY TESTED AT HIGH SPEED A NUMBER OF RSFQ CIRCUITS, INCLUDING A 20-BIT RIPPLE COUNTER. IN THIS PRESENTATION, WE WILL REVEAL THE METHOD, DEMONSTRATE EXPERIMENTAL RESULTS, AND DISCUSS FUTURE OF POWER-EFFICIENT RSFQ.

3EB-05

PROGRESS WITH PHYSICALLY AND LOGICALLY REVERSIBLE SUPERCONDUCTING DIGITAL CIRCUITS ***J. REN****, V. K. SEMENOV;* SUNY AT STONY BROOK. — THE SPEED OF LIGHT DESIGNATES THE LIMIT FOR CLOCK FREQUENCIES OF MODERN DIGITAL CIRCUITS. HOWEVER THE BEST DEMONSTRATED SPECIFIC ENERGY DISSIPATION (PER LOGIC OPERATION) IS STILL ABOUT 6 ORDERS OF MAGNITUDE ABOVE THE THERMODYNAMIC THRESHOLD KTLN2. LONG AGO IT WAS PROVEN THEORETICALLY THAT THE THRESHOLD CAN BE CROSSED AT REVERSIBLE LOGIC CIRCUITS. HOWEVER UNTIL RECENTLY, SUCH REVERSIBLE CIRCUITS HAVE BEEN THEORETICALLY ANALYZED USING A HIGHLY IMPRACTICAL MECHANICAL "BILLIARD BALL" MODEL. EIGHT YEARS AGO AT AN ASC CONFERENCE, WE SUGGESTED A MORE PRACTICAL REVERSIBLE COMPUTING MODEL BASED ON NSQUID GATES. SINCE THEN WE HAVE EXPERIMENTALLY DEMONSTRATED SEVERAL SIMPLE CIRCUITS (SHIFT REGISTERS) WITH SPECIFIC ENERGY DISSIPATION EXCEEDING THE THRESHOLD ONLY BY A SMALL (2 TO 4) NUMERICAL FACTOR. AT THE CONFERENCE WE WILL DISCUSS ARCHITECTURAL ISSUES AND SHOW NEW CIRCUITS SUPPORTING OUR "TIMING BELT" CLOCKING SCHEME AND 2/3 MAJORITY GATE. THE CIRCUITS ARE MEASURED AT 4 K TEMPERATURE, BUT DUE TO THE EXTREMELY LOW ENERGY DISSIPATION THEY COULD BE ADAPTED FOR OPERATION AT MILLI-KELVIN TEMPERATURES EITHER AS SUPPORT OR AS MULTI-QUBIT CIRCUITS.

THIS WORK WAS SUPPORTED IN PART BY THE NATIONAL SECURITY AGENCY (NSA) UNDER ARMY RESEARCH OFFICE (ARO) CONTRACT NUMBER W911NF-06-1-217.

3EB-06

ADIABATIC QUANTUM FLUX PARAMETRON AS AN ULTRA-LOW-POWER SUPERCONDUCTING LOGIC DEVICE ***N. YOSHIKAWA****, D. OZAWA;* YOKOHAMA NATIONAL UNIVERSITY. — ULTRA-LOW-POWER SUPERCONDUCTING LOGIC CIRCUITS BASED ON ADIABATIC (REVERSIBLE) OPERATION OF QUANTUM FLUX PARAMETRON (QFP) DEVICE WERE INVESTIGATED. ADIABATIC OPERATION IS A TECHNIQUE TO DECREASE THE ENERGY DISSIPATION OF THE CIRCUIT BY VARYING THE AMPLITUDE OF THE CLOCK SLOWLY. THE SINGLE-BIT ENERGY CONSUMPTION COMPARABLE TO THE ENERGY SCALE K_BT MAY BE POSSIBLE BY USING THIS TECHNIQUE. IN THIS STUDY WE EXAMINED CIRCUIT PARAMETER CONDITIONS OF QFP DEVICES FOR THE ADIABATIC OPERATION BY CALCULATING THE ENERGY OF THE SYSTEM. THE ENERGY DISSIPATION OF THE ADIABATIC QFP DEVICES WAS ALSO EVALUATED BY CIRCUIT SIMULATIONS. IT WAS SHOWN THAT THE SINGLE-BIT ENERGY DISSIPATION OF THE ADIABATIC QFP DEVICES CAN BE MUCH LOWER THAN I_C PHI_0, WHERE THE I_C AND PHI_0 ARE THE CRITICAL CURRENT OF THE JOSEPHSON JUNCTION AND A FLUX QUANTUM, RESPECTIVELY. THE PROPOSED ADIABATIC QFP DEVICES WERE IMPLEMENTED USING THE ISTEC NB STANDARD PROCESS (STP2) TO VERIFY THEIR BASIC OPERATION. THE TEST RESULTS WILL BE SHOWN AT THE CONFERENCE.

NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY PARTIALLY CONTRIBUTED TO THE CIRCUIT FABRICATION.

3EC-01

INVESTIGATION OF LOW-FREQUENCY EXCESS FLUX NOISE IN DC SQUIDS AT MK TEMPERATURES ***D. DRUNG****, J. BEYER, J. STORM, M. PETERS, T. SCHURIG;* PTB. — THERE IS AN INCREASING NUMBER OF SQUID APPLICATIONS WHERE THE DEVICE IS OPERATED AT MK TEMPERATURES, E.G., THE READOUT OF CRYOGENIC DETECTORS. LOW-FREQUENCY FLUX NOISE TENDS TO INCREASE AT ULTRA-LOW TEMPERATURES AND 1/F NOISE CAN BECOME SIGNIFICANT EVEN IN THE KHZ RANGE. TO ADDRESS THIS ISSUE, WE MEASURED A SERIES OF SQUIDS BOTH AT 4.2 K AND BELOW 0.3 K. WE PERFORMED A THOROUGH ANALYSIS OF THESE MEASUREMENTS TOGETHER

WITH RESULTS OBTAINED DURING THE PAST FOUR YEARS FROM VARIOUS EXPERIMENTS WITH DIFFERENT TYPES OF OUR SQUID SENSORS. CONSIDERING THE LARGE SPREAD IN THE LOW-FREQUENCY NOISE AT 4.2 K, THERE WAS NO SYSTEMATIC DEPENDENCE ON THE FABRICATION PARAMETERS. IN CONTRAST, BELOW A FEW K THE LOW-FREQUENCY NOISE REMAINED NEARLY CONSTANT OR INCREASED STRONGLY DEPENDING ON WHETHER THE BOTTOM NB OR THE INSULATION LAYER WAS FABRICATED IN OUR NEWER SPUTTER SYSTEM (FHR) INSTEAD OF THE OLDER ONE (ALCATEL). THE BEST UNCOUPLED ENERGY SENSITIVITY ACHIEVED SO FAR WITH A 50PH SQUID WAS OF 5 H-BAR (PLANCKS CONSTANT) AT 100 KHZ, INCREASING TO 15 H-BAR AT 1 KHZ AND 250 H-BAR AT 10 HZ. IN OUR LATEST SENSOR MASK SET, WE ADDED A SERIES OF SPECIAL TEST SQUIDS WHICH ALLOW US TO INVESTIGATE THE NOISE CONTRIBUTION OF THE DIFFERENT THIN-FILMS OF THE SQUID. USING THESE DEVICES, WE WILL INVESTIGATE IN MORE DETAIL THE DEPENDENCE OF THE EXCESS LOW-FREQUENCY NOISE ON THE DEPOSITION PARAMETERS AND THE INSULATION MATERIAL (SIOX VERSUS SIXNY).

THIS WORK WAS SUPPORTED IN PART BY THE EUROPEAN COMMISSION IN THE FRAMEWORK OF THE EUROPEAN MICROKELVIN COLLABORATION.

3EC-02

ULTRA-SENSITIVE SQUID MICROSUSCEPTOMETER FOR MAGNETIC MEASUREMENTS AT VERY LOW TEMPERATURES AND BROAD BANDWIDTH ***M. J. MARTÍNEZ-PÉREZ***[1]*, J. SESÉ*[2]*, F. LUIS*[1]*, R. CÓRDOBA*[2]*, D. DRUNG*[3]*, T. SCHURIG*[3]*, E. BELLIDO*[4]*, R. DE MIGUEL*[2]*, A. LOSTAO*[5]*, D. RUÍZ-MOLINA*[4]*, C. GÓMEZ-MORENO*[2]*;* [1]INSTITUTO DE CIENCIA DE MATERIALES DE ARAGÓN (ICMA), [2]INSTITUTO UNIVERSITARIO DE INVESTIGACIÓN EN NANOCIENCIA DE ARAGÓN (INA), [3]PHYSIKALISCH-TECHNISCHE BUNDESANSTALT (PTB), [4]CENTRO DE INVESTIGACIÓN EN NANOCIENCIA Y NANOTECNOLOGIA (CIN2, CSIC-ICN), [5]INSTITUTO UNIVERSITARIO DE INVESTIGACIÓN EN NANOCIENCIA DE ARAGÓN (INA) AND FUNDACIÓN ARAGÓN I+D (ARAID). — IN THIS WORK WE PRESENT ULTRA SENSITIVE SQUID SUSCEPTOMETERS CAPABLE OF OPERATION UNDER EXTREME CONDITIONS OF FREQUENCY (0.001 HZ - 1 MHZ) AND LOW TEMPERATURES (13 MK). INTEGRATED 2-STAGE SQUID CURRENT SENSORS HAVE BEEN USED AS STARTING POINT. REROUTING SOME CONNECTIONS OF THE SQUID'S INPUT CIRCUIT, AN INTEGRATED SUSCEPTOMETER WITH EXPERIMENTAL SPIN SENSITIVITY OF 10^4 BOHR MAGNETON/$HZ^{1/2}$ IS OBTAINED THE MODIFICATION OF THE CHIPS IS CARRIED OUT USING GALLIUM FOCUSED ION BEAM INDUCED DEPOSITION (FIBID) WITH $W(CO)_6$ AS PRECURSOR GAS. WE HAVE DEMONSTRATED THAT SUPERCONDUCTING CONNECTIONS BETWEEN W FIBID LINES AND NB FILMS CAN BE FABRICATED AND THAT THEY ARE OPERATIVE AT 4.2K, PROVIDING THEN A POWERFUL TECHNIQUE TO FIX ERRORS OF DESIGN IN DEVICES, REPAIR DAMAGED CIRCUITS, OR TO CARRY OUT MODIFICATIONS. THIS INSTRUMENT OFFERS NEW POSSIBILITIES IN THE STUDY OF NANOSIZED MAGNETS FOR DIFFERENT APPLICATIONS SUCH AS QUANTUM COMPUTING OR HIGH-DENSITY INFORMATION STORAGE, ALL OF THEM REQUIRING THIN FILMS OR MONOLAYER PARTICLE ARRANGEMENTS. AS AN ILLUSTRATION, WE REPORT EXPERIMENTAL RESULTS SHOWING MAGNETIC MEASUREMENTS PERFORMED OVER TWO-DIMENSIONAL ARRAYS OF ANTIFERROMAGNETIC 2 NANOMETER SIZED PARTICLES FABRICATED BY DIP-PEN NANOLITHOGRAPHY.

FUNDING FROM DGA PI091/08 NABISUP, MICINN MAT2006-13765 MOLBIT, MAT2009-13977 MOLCHIP AND INTEGRATED ACTION HA2006-0051 WITH GERMANY, AND “MOLECULAR NANOSCIENCE” CONSOLIDER 2010 IS ACKNOWLEDGED.

3EC-03

SQUIDS BASED ON SUBMICROMETER-SIZED JOSEPHSON TUNNEL JUNCTIONS FABRICATED IN THE CROSS-TYPE TECHNOLOGY ***M. SCHMELZ***[1]*, R. STOLZ*[1]*, V. ZAKOSARENKO*[1]*, S. ANDERS*[1]*, L. FRITZSCH*[1]*, M. MEYER*[2]*, H. MEYER*[1]*;* [1]IPHT JENA, [2]SUPRACON AG. — WE REPORT ON THE PROPERTIES OF SUBMICROMETER-SIZED NB/AL/ALOX/NB JOSEPHSON TUNNEL JUNCTIONS FABRICATED IN A CROSS-TYPE TECHNOLOGY. THE VERY LOW CAPACITANCE OF THESE JUNCTIONS IS SHOWN BY THE EVALUATION OF FISKE STEPS OF CROSS TYPE RECTANGULAR JUNCTIONS, MAKING THEM CAPABLE CANDIDATES FOR VERY LOW NOISE AND HIGH PERFORMANCE SQUIDS.AN IMPROVEMENT OF SQUID PARAMETERS, LIKE USABLE VOLTAGE SWING AND INTRINSIC FLUX NOISE IS DEMONSTRATED FOR DIFFERENT TYPES OF SQUID MAGNETOMETERS. AN INCREASED SENSITIVITY OF MORE THAN A FACTOR OF 2 COMPARED TO TODAY’S BEST SQUID MAGNETOMETERS WAS OBTAINED. THE REPORTED SENSORS EXHIBIT A VERY HIGH USABLE VOLTAGE SWING IN THE RANGE OF 150-200µV.BESIDE THESE IMPROVEMENTS A VERY HIGH STABILITY AGAINST EXTERNAL FIELDS OF UP TO SEVERAL MT DURING COOLING DOWN AND UNSHIELDED OPERATION IS SHOWN. THUS, THESE SQUIDS ARE SUITED FOR A WIDE FIELD OF APPLICATIONS, AS FOR EXAMPLE IN ULTRA-LOW-FIELD NMR, WHERE SO FAR A SPECIAL MEASUREMENT SETUP IS USED TO PREVENT FLUX TRAPPING IN SQUIDS.

3EC-05

MODELLING THE BEHAVIOR OF HTS TERAHERTZ RSQUIDS ***C. M. PEGRUM***[1]*, J. C. MACFARLANE*[2]*, J. DU*[3]*;* [1]FIELDSOLUTIONS AND UNIVERSITY OF STRATHCLYDE, [2]UNIVERSITY OF STRATHCLYDE AND CSIRO MATERIALS SCIENCE & ENGINEERING, [3]CSIRO MATERIALS SCIENCE & ENGINEERING. — IN PREVIOUS WORK [1, 2] WE LOOKED IN DETAIL AT SIMULATIONS OF OUR HTS RESISTIVE DC SQUIDS (RSQUIDS). USING A LUMPED-COMPONENT MODEL AND NEGLECTING STEP-EDGE JUNCTION CAPACITANCE, WE FOUND THAT THE INTERNALLY-GENERATED ALTERNATING CURRENTS MODIFIED THE CURRENT-VOLTAGE CURVES SIGNIFICANTLY AND COULD ALSO LEAD TO SUB-HARMONIC STEPS AND OTHER NOVEL FEATURES. THESE RSQUIDS CAN NOW BE MADE WITH JUNCTIONS WITH HIGH ICRN PRODUCTS AND CONSEQUENTLY THE JOSEPHSON FREQUENCY IS THEN ABOVE 1 THZ. THIS CALLS FOR A MORE REFINED MICROWAVE MODEL OF THE DEVICE, WHICH WE WILL PRESENT HERE. WE TREAT THE

RSQUID LOOP AS A CO-PLANAR STRIPLINE, RATHER THAN AS AN INDUCTOR. THE RSQUID SERIES RESISTOR IS ALSO REPRESENTED AS A DISTRIBUTED COMBINATION OF RESISTANCE AND INDUCTANCE, RATHER THAN SIMPLY A RESISTOR IN SERIES WITH ITS SELF INDUCTANCE. WE NOW INCLUDE JUNCTION CAPACITANCE, AS THE STEWART-MCCUMBER PARAMETER CAN BE CLOSE TO UNITY. WE WILL REPORT A WIDE RANGE OF SIMULATIONS AND DISCUSS THESE RESULTS IN RELATION TO POTENTIAL APPLICATIONS OF RSQUIDS AS ACTIVE MICROWAVE DEVICES. [1] C. M. PEGRUM, THE DYNAMICS OF HIGH-FREQUENCY DC RSQUID OSCILLATORS, SUPERCOND. SCI TECHNOL., VOL. 22, NO. 3, P. 064004, JUN. 2009; [2] C. M. PEGRUM AND J.C. MACFARLANE, SELF-INDUCED STRUCTURE IN THE CURRENT-VOLTAGE CHARACTERISTICS OF RSQUIDS, IEEE TRANS. APPL. SUPERCOND., VOL. 19, NO. 3, PP. 778-781, JUN. 2009.

3EC-06

VOLTAGE BIASED SQUID BOOTSTRAP CIRCUIT-CIRCUIT MODEL AND NUMERICAL SIMULATION *Y. WANG[1], H. WANG[1], **X. XIE**[1], H. DONG[1], M. JIANG[1], Y. ZHANG[2], H. KRAUSE[2], A. OFFENHÄUSSER[2], M. MÜCK[3];* [1]SHANGHAI INSTITUTE OF MICROSYSTEM AND INFORMATION TECHNOLOGY, CHINESE ACADEMY OF SCIENCES, [2]INSTITUTE OF BIO- AND NANOSYSTEM (IBN-2), RESEARCH CENTER JUELICH (FZJ), [3]INSTITUT FÜR ANGEWANDTE PHYSIK, JUSTUS-LIEBIG-UNIVERSITÄT GIEßEN. — A NEW SQUID DEVICE CALLED SBC (**S**QUID **B**OOTSTRAP **C**IRCUIT) DESIGNED FOR DIRECT READOUT UNDER VOLTAGE BIAS MODE WAS RECENTLY DEVELOPED BY THE PRESENT AUTHORS. CONSISTING OF TWO PARALLEL BRANCHES, THE SBC INCLUDES FOUR ELEMENTS: A CONVENTIONAL DC SQUID, A SHUNT RESISTOR R_S, AND TWO COILS WHICH ARE SEPARATELY COUPLED TO THE SQUID VIA MUTUAL INDUCTANCE M_1 AND M_2. IN THIS PAPER, WE HAVE ESTABLISHED AN EQUIVALENT CIRCUIT MODEL FOR SBC. BASED ON THIS MODEL, THE BASIC EQUATIONS OF THE DEVICE ARE DERIVED AND THE EXPRESSION OF EQUIVALENT FLUX NOISE FROM THE PREAMPLIFIER IS OBTAINED. THE EFFECTS OF THE THREE PARAMETERS ON THE CHARACTERISTICS OF SBC UNDER VOLTAGE BIAS, INCLUDING NOISE PERFORMANCES, ARE ANALYZED AND NUMERICALLY SIMULATED. IT IS SHOWN THAT BY SELECTING APPROPRIATE M_1, M_2 AND R_S, THE PREAMPLIFIER NOISE CAN BE EFFECTIVELY SUPPRESSED. COMPARISONS WITH THE EXPERIMENTAL RESULTS ARE PRESENTED. THESE SIMULATIONS ARE OF GREAT SIGNIFICANCE FOR UNDERSTANDING AND OPTIMIZING THE PERFORMANCE OF THE SBC.

3EC-07

NANOSCALE SQUID FOR THE DETECTION OF MAGNETIC NANOPARTICLE MACROSCOPIC-SPIN STATES ***S. K. H. LAM**, P. F. VOHRALIK;* CSIRO. — WE HAVE BEEN DEVELOPING SQUID-BASED TECHNIQUES FOR STUDYING MAGNETIC MATERIALS AT NANOSCALE DIMENSIONS. PREVIOUS PAPERS HAVE DISCUSSED THE FABRICATION AND NOISE PROPERTIES OF LOW-NOISE NB NANOSQUIDS [1] AND METHODS FOR ATTACHING ORGANIC NANOPARTICLES TO SUCH DEVICES [2]. HERE, WE SHOW THE ELECTRICAL CHARACTERISTICS OF A NEW NB NANOSQUID. THE DEVICE HAS A HOLE-SIZE OF 70-100 NM IN DIAMETER, FABRICATED IN A 250 NM WIDE NB TRACK, RESULTING IN AN EFFECTIVE AREA OF 0.040 MM^2. THE SQUID LAYOUT WAS CHOSEN TO MINIMIZE BACKGROUND NOISE AND REDUCE THE LIKELIHOOD THAT VORTICES WOULD REMAIN IN THE FILM AFTER BEING EXPOSED TO LARGE MAGNETIC FIELD [3]. THE NOISE OF THE DEVICE (MEASURED AT ZERO FIELD) DOES NOT CHANGE SIGNIFICANTLY AFTER BEING EXPOSED TO AN IN-PLANE FIELD OF UP TO 1 T. IN THE PRESENCE OF FERRITIN NANOPARTICLES ATTACHED TO THE SQUID SURFACE, AN EXTERNAL MAGNETIC FIELD WAS USED TO MANIPULATE THE ORIENTATION OF THE FERRITIN MAGNETIC MOMENT AND THE SQUID WAS USED TO IDENTIFY THE RESULTING ORIENTATION. PRELIMINARY RESULT INDICATES THAT THERE IS A CHANGE OF ~ 15 $M\Phi_O$ IN THE SQUID OUTPUT, CONSISTENT TO THE FLUX CHANGE COUPLED TO THE SQUID DUE TO THE FLIPPING OF THE FERRITIN'S TWO MACROSCOPIC-SPIN STATES.[1] S.K.H. LAM, SUST 19 (2006) 963.[2] S.K.H. LAM ET AL., NANOTECHNOLOGY 19 (2008) 285303.[3] P F VOHRALIK AND S.K.H. LAM, SUST 22 (2009) 064007.

3EC-08

THREE DIMENSIONAL ALUMINUM NANOBRIDGE JOSEPHSON JUNCTIONS AND SQUIDS ***E. M. LEVENSON-FALK**, R. VIJAY, I. SIDDIQI;* QNL, UC BERKELEY. — NANOSQUIDS, WHICH CONSIST OF A SUPERCONDUCTING LOOP INTERRUPTED BY TWO SUB-MICRON WEAK LINK JOSEPHSON JUNCTIONS, ARE COMMONLY USED FOR MEASURING NANOSCALE MAGNETS. THESE SQUIDS HAVE ENHANCED FLUX COUPLING ON ACCOUNT OF THE NARROW WEAK LINKS, BUT TYPICALLY HAVE LOWER FLUX SENSITIVITY THAN CONVENTIONAL TUNNEL JUNCTION BASED DEVICES, MAINLY ON ACCOUNT OF REDUCED NONLINEARITY IN THEIR CURRENT-PHASE RELATION. WE EXPLORE DIFFERENT WEAK LINK JUNCTION GEOMETRIES TO OPTIMIZE FLUX SENSITIVITY. IN PARTICULAR, WE HAVE FABRICATED 30 NM WIDE, 50-400 NM LONG ALUMINUM NANOBRIDGES CONTACTED WITH TWO AND THREE DIMENSIONAL BANKS. WE PRESENT I-V CHARACTERISTICS AND SQUID CRITICAL CURRENT MODULATION DATA. THE THREE DIMENSIONAL NANOSQUIDS SHOW ENHANCED FLUX MODULATION OF THE CRITICAL CURRENT. OUR RESULTS ARE IN GOOD QUANTITATIVE AGREEMENT WITH NUMERICAL SOLUTIONS OF THE USADEL EQUATIONS FOR BOTH GEOMETRIES. WHEN COMBINED WITH DISPERSIVE MEASUREMENT TECHNIQUES, THESE NANOSQUIDS CAN BE USED FOR HIGH SPEED, LOW BACKACTION MEASUREMENTS. WE ALSO DISCUSS QUBITS BASED ON NANOBRIDGE JUNCTIONS.

WE ACKNOWLEDGE FUNDING FROM DARPA, AFOSR, AND ONR

3EP3A-01

EXAMINATION FOR IMPROVEMENT OF POWER HANDLING CAPABILITY OF SUPERCONDUCTING FILTERS USING MULTI-LAYERED MICROSTRIP LINE RESONATORS ***Y. ENDO**, S. ONO, M. UNO, T. SAITO, A. SAITO, K. NAKAJIMA, S. OHSHIMA;* YAMAGATA UNIVERSITY. — WE INVESTIGATED THE POWER HANDLING CAPABILITY OF SUPERCONDUCTING FILTERS USING

MULTI-LAYERED MICROSTRIP LINE RESONATORS (MSLRS). A MULTI-LAYERED MSLR CONSISTS OF SUPERCONDUCTING/INSULATING/SUPERCONDUCTING MULTI-LAYERED FILM TO IMPROVE THE POWER HANDLING CAPABILITY OF SUPERCONDUCTING FILTER. THE CURRENT FLOWING ALONG THE BOTTOM EDGES OF THE MULTI-LAYERED MSLR WAS LESS CONCENTRATED THAN THAT IN THE CONVENTIONAL MSLR.A 3-POLE FILTER USING THE STRAIGHT-TYPE MSLR WAS DESIGNED BASED ON THE CHEBYSHEV FUNCTION TO HAVE THE CENTER FREQUENCY OF 5 GHZ AND BANDWIDTH OF 100 MHZ. THE SINGLE-LAYERED AND MULTI-LAYERED MSLR FILTERS WERE FABRICATED WITH THE SIMULATED FILTER DESIGN USING NBN SINGLE-SIDED 600-NM THICK FILM AND NBN/ALN/NBN SINGLE-SIDED 300/40/300-NM MULTI-LAYERED FILM ON MGO SUBSTRATES. BOTH FILTERS SHOWED GOOD FREQUENCY RESPONSES AT 6.8 K. THE INPUT-OUTPUT RELATIONS OF BOTH FILTERS AT 6.8 K WERE MEASURED. THE POWER HANDLING CAPABILITY OF MULTI-LAYERED MSLR FILTER WAS 1.9 DB LARGER THAN THAT OF THE SINGLE-LAYERED MSLR FILTER. THE MULTI-LAYERED MSLR COULD BE IMPROVED THE POWER HANDLING CAPABILITY OF SUPERCONDUCTING FILTERS.

THIS WORK WAS SUPPORTED BY GRANT-IN-AID FOR YOUNG SCIENTISTS (B) (21760246) AND TELE COMMUNICATIONS ADVANCEMENT FOUNDATION. A PART OF THIS WORK WAS CARRIED OUT IN THE CLEAN ROOM OF YAMAGATA UNIVERSITY.

3EP3A-02

DEVELOPMENT OF TRIMMING TECHNIQUE FOR SUPERCONDUCTING TUNABLE FILTERS ***T. SAITO**, S. ONO, M. UNO, Y. ENDO, A. SAITO, K. NAKAJIMA, S. OHSHIMA;* YAMAGATA UNIVERSITY. — WE DEVELOPED TRIMMING TECHNIQUES FOR SUPERCONDUCTING TUNABLE FILTERS WITH A DIELECTRIC TUNING PLATE AND DIELECTRIC TRIMMING RODS. THE TUNING PLATE HAS WINDOWS WHILE THE DIELECTRIC TRIMMING RODS ARE PASSED. WE DESIGNED A 5-POLE FILTER WITH 5 GHZ CENTER FREQUENCY AND 100 MHZ BANDWIDTH USING AN ELECTROMAGNETIC FIELD ANALYSIS SIMULATOR. WE PROPOSED TRIMMING TECHNIQUES USING A TRIMMING LIBRARY. THE TRIMMING LIBRARY MEANS ASSEMBLY OF CALCULATED DATA OF FREQUENCY RESPONSES FOR COMPARING TO EXPERIMENTAL DATA. WE MADE THE TRIMMING LIBRARY USING A CIRCUIT ANALYSIS SIMULATOR (S-NAP). FIRST, WE DESIGNED CONVENTIONAL Π-TYPE EQUIVALENT CIRCUIT WITH OPTIMAL BAND PASS FILTER CHARACTERISTIC. WE DETERMINED ALL C AND L TO MEET THE SPECIFICATIONS OF THE FILTER BY USING THE S-NAP. NEXT, WE CALCULATED THE FILTER CHARACTERISTICS BY CHANGING THE VALUES OF C OF EACH RESONATOR. THE CHANGES IN C WERE ASSUMED TO BE 1 OR 2%. THE FILTER CHARACTERISTICS OF 1 OR 2% REDUCTION IN C CHANGED GREATLY. WE COULD OBTAIN THE EFFECTIVE ADJUSTING POINTS FOR TRIMMING RODS USING THE TRIMMING LIBRARY CONSIST OF S11 PROPERTIES. THESE RESULTS INDICATE THAT OUR METHOD WILL BE USEFUL FOR THE NEXT GENERATION OF SDR SYSTEM.

THIS WORK WAS SUPPORTED BY GRANT - IN - AID FOR YOUNG SCIENTISTS (B) (21760246) AND TELECOMMUNICATIONS ADVANCEMENT FOUNDATION. A PART OF THIS WORK WAS CARRIED OUT IN THE CLEAN ROOM OF YAMAGATA UNIVERSITY.

3EP3A-03

RELIABILITY OF SUSPENDED BRIDGES ON SUPERCONDUCTING MICROSTRIP FILTERS USING MEMS SWITCHES ***J. VARGAS**[1], Y. HIJAZI[1], A. BOGOZI[2], J. NOEL[3], Y. VLASOV[3], G. LARKINS[3];* [1]UNIVERSIDAD DEL TURABO, [2]WRIGHT-PATTERSON AIR FORCE BASE, [3]FIU. — THIS WORK PROPOSES TO USE CAPACITIVE MICRO-ELECTRO-MECHANICAL SWITCHES (MEMS) BUILT ON A SUPERCONDUCTING MICROSTRIP HAIRPIN FILTER TO INVESTIGATE THE RELIABILITY OF MEMS FOR LONG TERM SURVIVABILITY. THIS DEVICE IS MADE OF A $YBA_2CU_3O_7$ THIN FILM DEPOSITED ON A 20 MM X 20 MM $LAALO_3$ SUBSTRATE BY RF MAGNETRON SPUTTERING, AS WELL AS $BATIO_3$, WHICH IS UTILIZED AS A DIELECTRIC INSULATION LAYER AT THE SWITCHING POINTS OF CONTACT. THE MAJOR CONCERN FOR CAPACITIVE MEMS IS STICTION BETWEEN THE GOLD SUSPENDED BRIDGE MEMBRANE (TOP LAYER) AND THE DIELECTRIC MATERIAL (BOTTOM LAYER). THE MAIN FAILURE MODE RESULTS FROM CHARGE BUILD-UP AT THE BOTTOM LAYER WHICH IN TURN DEPENDS ON THE ACTUATION VOLTAGE. THE ACTUATION VOLTAGE MEASURED AT ROOM AND CRYOGENIC TEMPERATURE IS USED TO DERIVE AND CALCULATE THE YOUNG'S MODULUS FORMULA WHICH TAKES INTO CONSIDERATION THE DEVICE GEOMETRY, RESIDUAL STRESS AND MECHANICAL PROPERTIES OF THE DEVICE. MODIFIED YOUNG'S MODULUS EQUATION WILL BE VALIDATED THROUGH RELIABILITY DATA OF MEMBRANE ACTUATION AND FAILURE MODE. THIS EQUATION WILL IN TURN BE USED IN MODELING OTHER RF MEMS DEVICES OPERATING AT CRYOGENIC TEMPERATURES.

3EP3A-04

NONLINEAR PHENOMENA IN SUPERCONDUCTING YBACUO MICROWAVE RESONATORS ***G. BACHAR**, O. SHTEMPLUCK, E. BUKS;* TECHNION - IIT. — WE STUDY SUPERCONDUCTING $YBACUO$ MICROWAVE RESONATORS, WITH AN INTEGRATED MICROBRIDGE, AND THEIR RESPONSE TO A MONOCHROMATIC INJECTED SIGNAL. IN A BOUND REGION IN THE INPUT POWER-INPUT FREQUENCY PLANE, AND CLOSE TO A RESONANCE FREQUENCY $\OMEGA_0$, A NONLINEAR PHENOMENON OF SELF-SUSTAINED MODULATION OF THE REFLECTED POWER OFF THE RESONATOR IS OBSERVE. WE ATTRIBUTE THIS BEHAVIOR TO THERMAL INSTABILITY IN THE MICROBRIDGE, WHICH ALTERNATELY OSCILLATES BETWEEN NORMAL- AND SUPER-CONDUCTIVE PHASES, AND SHIFTS $\OMEGA_0$ BACK AND FORTH. ADDITIONAL NON-LINEAR BEHAVIOR OF THE REFLECTED SIGNAL, SUCH AS PERIOD DOUBLING BIFURCATION AND JUMPING BETWEEN DIFFERENT SELF-MODULATION FREQUENCIES, IS ALSO DEMONSTRATED, AND IS ATTRIBUTED TO COUPLING OF SEVERAL CLOSELY LYING RESONANCE FREQUENCIES IN THE RESONATOR. WE GENERALIZE A THEORETICAL MODEL WHICH WE PREVIOUSLY PRESENTED, TO A MULTIMODE CASE. THE GENERALIZED MODEL CAN

ACCOUNT FOR THE VARIOUS PHENOMENA IN THE EXPERIMENTAL DATA, BOTH IN THE CASE OF SINGLE MODE SELF-MODULATION, AND IN THE CASE WHERE COUPLING BETWEEN SEVERAL MODES IS INVOLVED.

3EP3A-05

EIGHT-WAY MATCHED SUPERCONDUCTING AC POWER DISTRIBUTION ***O. T. OBERG;*** UNIVERSITY OF MARYLAND COLLEGE PARK. — WE HAVE DEVELOPED AN AC POWER DISTRIBUTION NETWORK FOR SUPERCONDUCTING LOGIC CIRCUITS. THE NETWORK IS BASED ON A MODIFIED WILKINSON POWER SPLITTER [OR: QUARTER-WAVE TAPERED LINE]. IT DISSIPATES ZERO POWER ON CHIP BY REMOVING ALL RESISTORS AND BY RECOMBINING THE OUTPUT POWER LINES. THE NETWORK INCLUDES 1:8 POWER DIVIDER AND AN 8:1 POWER COMBINER WITH 50 OHM INPUT AND OUTPUT IMPEDANCE AND 4 OHM INTERNAL IMPEDANCE CONSISTING OF EIGHT 32 OHM LINES IN PARALLEL. THE SPLITTER AND COMBINER ARE DESIGNED FOR A 17 GHZ CENTRAL FREQUENCY WITH REFLECTION LOSS LESS THAN 0.2 DB OVER A BANDWIDTH FROM 2-20 GHZ. THE DIVIDER CAN TOLERATE ELECTRICAL LENGTH MISMATCH BETWEEN THE INTERNAL LINES OF UP TO 5 PS KEEPING CURRENT AMPLITUDE SPREAD WITHIN 10%. IT IS DESIGNED FOR A NB PROCESS WITH A 5 UM WIRE PITCH AND HAS AN AREA OF ABOUT 1 MM^2. THE VALUES OF S11, S21, AND S31 CORRESPONDING TO TAPPING AN INTERNAL NODE INDICATE THAT THE DEVICE ACTS AS A TRUE POWER SPLITTER AS OPPOSED TO A CURRENT DIVIDER NETWORK OVER THE FREQUENCY RANGE.

3EP3A-06

AN L-BAND HTS DUPLEXER FOR COMMUNICATION APPLICATIONS ***Y. HE****, J. WANG, Q. ZHANG, Y. BIAN, C. LI, X. ZHANG, H. LI;* INSTITTUTE OF PHYSICS, CHINESE ACADEMY OF SCIEMCES. — AN L-BAND HTS DUPLEXER HAS BEEN DEVELOPED, WHICH IS COMPOSED OF A T-JUNCTION AND TWO CHANNELS. EACH CHANNEL HAS A 10-POLE QUASI-ELLIPTIC FUNCTION HTS FILTER. TO ACHIEVE A GOOD BALANCE BETWEEN SELECTIVITY AND FLAT GROUP DELAY, THE TWO PAIRS OF TRANSMISSION ZEROS OF EACH FILTER WERE ASSIGNED SUCH THAT ONE PAIR FOR HIGH SELECTIVITY AND THE OTHER FOR FLAT GROUP DELAY. TO REDUCE THE INFLUENCE OF THE PARASITICAL COUPLING, NOVEL COUPLING STRUCTURES WERE DEVELOPED. THE DUPLEXER WAS FORMED BY CONNECTING THE TWO FILTERS WITH A TWO BRANCH T-JUNCTION. THE LENGTH OF THE BRANCH LINKED TO ONE FILTER (CHANNEL A) IS ABOUT HALF OF THE GUIDED WAVELENGTH AT THE CENTRE FREQUENCY OF THE OTHER FILTER (CHANNEL B). THIS BRANCH FUNCTIONED AS AN “OPEN” STUB TO CHANNEL B AND STOPPED THE CHANNEL B SIGNAL PASSING THROUGH FILTER A. SO IS THE LENGTH OF THE BRANCH TO CHANNEL B. THE DUPLEXER WAS FABRICATED ON A 2-INCH-DIAMETER, 0.5-MM-THICK LAALO3 WAFER WITH DOUBLE-SIDED YBCO FILM. THE MEASURED RESULTS SHOWED A VERY HIGH PERFORMANCE: MIDBAND INSERTION LOSS BEING 0.2 DB, RETURN LOSS BETTER THAN -14 DB, BAND EDGE STEEPNESS BETTER THAN 20 DB/MHZ AT BOTH SIDES, OUT-OF-BAND REJECTION BETTER THAN 70 DB IN A WIDE FREQUENCY RANGE UP TO 3 GHZ AND EXCELLENT ISOLATION (HIGHER THAN 80 DB) BETWEEN THE TWO CHANNELS. IN ADDITION, THE FREQUENCY BAND OF 5-NS GROUP DELAY VARIATION IS OVER 10.5 MHZ (38.7% OF 1 DB BANDWIDTH).

THIS WORK WAS SUPPORTED IN PART BY THE EXTERNAL COOPERATION PROGRAM OF THE CHINESE ACADEMY OF SCIENCES (GRANT NO. GJHZ1007) AND THE CHINESE ACADEMY OF SCIENCES（GRANT NO. KJCX2-YW-W16）.

3EP3A-07

THE USE OF LOWPASS FILTERS AS IMPEDANCE INVERTERS FOR HIGHLY MINIATURIZED BANDSTOP FILTER DESIGNS ***P. D. LAFORGE****[1], R. R. MANSOUR[2], M. YU[3];* [1]UNIVERSITY OF REGINA, [2]UNIVERSITY OF WATERLOO, [3]COM DEV. — A HIGHLY MINIATURIZED LOW TEMPERATURE SUPERCONDUCTING 3-POLE LUMPED ELEMENT BANDSTOP FILTER IS DESIGNED AND TESTED. THE FILTER IS FABRICATED USING THE STANDARD NIOBIUM PROCESS OFFERED BY HYPRES, WHICH ALLOWS FOR THE USE OF LUMPED ELEMENTS IN MICROWAVE FILTER AND CIRCUIT DESIGNS. THE FABRICATED 3-POLE BANDSTOP FILTER HAS A CENTER FREQUENCY OF 2 GHZ, A BANDWIDTH OF 250 MHZ AND IS ONLY 4.65 MM IN LENGTH. TRADITIONAL BANDSTOP FILTERS MAKE USE OF 90° LENGTHS OF TRANSMISSION LINES AS IMPEDANCE INVERTERS BETWEEN RESONATORS. THE PROPOSED BANDSTOP FILTER DESIGN REPLACES THE 90° LENGTHS OF TRANSMISSION LINES WITH LOWPASS FILTERS, GENERATING A HUGE SAVINGS IN FILTER SIZE. ALL THREE RESONATORS ARE MADE UP OF A SERIES COMBINATION OF AN INDUCTOR AND A CAPACITOR FROM THE SIGNAL LINE TO THE GROUND LINE OF THE COPLANAR WAVEGUIDE (CPW) TRANSMISSION LINE. ON EITHER SIDE OF THE MIDDLE RESONATOR, A 5-POLE LUMPED ELEMENT LOWPASS FILTER IS USED TO ACHIEVE THE REQUIRED 90° PHASE SHIFT. THE CUTOFF FREQUENCY OF THIS LOWPASS FILTER IS 3.83 GHZ, AND HIGHER CUTOFF FREQUENCIES CAN BE ACHIEVED BY INCREASING THE ORDER OF THE LOWPASS FILTER, AS 7-POLE AND 9-POLE LOWPASS FILTERS WOULD HAVE CUTOFF FREQUENCIES OF 6.209 GHZ AND 8.684 GHZ, RESPECTIVELY, UNDER SIMILAR DESIGN CONSIDERATIONS. THE 5-POLE LOWPASS FILTER HAS A LENGTH OF 0.915 MM, WHICH IS APPROXIMATELY 1/16TH THE LENGTH OF A 15 MM, 90° LENGTH OF CPW TRANSMISSION LINE AT 2 GHZ.

3EP3A-08

A MINIATURIZED HTS MICROWAVE RECEIVER FRONT-END SUBSYSTEM FOR RADAR AND COMMUNICATION APPLICATIONS ***Y. HE****, Y. BIAN, J. GUO, C. LI, H. LI, Q. ZHANG, X. ZHANG;* INSTITTUTE OF PHYSICS, CHINESE ACADEMY OF SCIEMCES. — A MINIATURIZED HIGH PERFORMANCE HTS MICROWAVE RECEIVER FRONT-END SUBSYSTEM WAS CONSTRUCTED, WHICH USES A MINI STIRLING CRYOCOOLER TO COOL A HIGH SELECTIVE HTS FILTER AND A LOW NOISE AMPLIFIER (LNA). THE HTS FILTER WAS MINIATURIZED BY USING SPECIALLY DESIGNED COMPACT RESONATORS AND FABRICATING WITH DOUBLE-SIDED YBCO FILMS ON LAO SUBSTRATE WHICH HAS A RELATIVELY HIGH PERMITTIVITY. THE LNA WAS SPECIALLY DESIGNED TO WORK AT CRYOGENIC TEMPERATURE WITH NOISE FIGURE OF 0.27 DB AT 71 K. THE

MINI CRYOCOOLER, WHICH IS WIDELY USED IN INFRARED DETECTORS, HAS A SMALLER SIZE (60×80×100 MM) AND A LIGHTER WEIGHT (340 G) THAN THE STIRLING CRYOCOOLERS COMMONLY USED IN OTHER HTS FILTER SUBSYSTEMS, THE WHOLE FRONT-END SUBSYSTEM, INCLUDING A HTS FILTER, A LNA, A CRYOCOOLER AND THE VACUUM CHAMBER, HAS A SIZE OF ONLY Φ120×175 MM AND A WEIGHT OF ONLY 3.3 KG. THE MICROWAVE DEVICES INSIDE THE SUBSYSTEM ARE WORKING AT 71.8 K WITH A CONSUMED COOLING POWER OF 0.325 W. THE CENTER FREQUENCY OF THIS SUBSYSTEM IS 925.2 MHZ AND THE BANDWIDTH IS 2.7 MHZ (A FRACTIONAL BANDWIDTH OF 0.2%), WITH THE GAIN OF 20 DB AT CENTER FREQUENCY AND THE RETURN LOSS BETTER THAN -18 DB IN THE PASS BAND. THE STOP BAND REJECTION IS MORE THAN 60 DB AND THE SKIRT SLOPE IS EXCEEDING 120 DB/MHZ. THE NOISE FIGURE OF THIS SUBSYSTEM IS LESS THAN 0.8 DB. THIS FRONT-END SUBSYSTEM CAN BE USED IN RADARS AND COMMUNICATION SYSTEMS CONVENIENTLY DUE TO ITS COMPACT SIZE AND LIGHT WEIGHT.

THIS WORK WAS SUPPORTED IN PART BY THE EXTERNAL COOPERATION PROGRAM OF THE CHINESE ACADEMY OF SCIENCES (GRANT NO. GJHZ1007) AND THE CHINESE ACADEMY OF SCIENCES（GRANT NO. KJCX2-YW-W16）.

3EP3B-01

EXPERIMENTAL ANALYSIS OF THE BIAS CURRENT DEPENDENT GRAY ZONES OF QUASI-ONE-JUNCTION SQUIDS ***T. ORTLEPP***[1]*, S. MIYAJIMA*[2]*, A. BOZBEY*[3]*, A. FUJIMAKI*[2]*;* [1]ILMENAU UNIVERSITY OF TECHNOLOGY, [2]NAGOYA UNIVERSITY, [3]TOBB ECONOMY AND TECHNOLOGY UNIVERSITY ANKARA. — WE REPORT ON THE EXPERIMENTAL RESULTS OF THE GRAY ZONE MEASUREMENT OF QUASI-ONE-JUNCTION SQUID (QOJS) COMPARATORS. THE CIRCUITS WERE DESIGNED FOR THE ISTEC SRL 2.5 KA/CM² STANDARD PROCESS. THE GRAY ZONE WAS USED AS AN INDICATOR FOR THE CURRENT SENSITIVITY OF A COMPARATOR. DUE TO THE HIGH SENSITIVITY OF THE DESIGNED COMPARATORS, ENVIRONMENTAL AND SYSTEM NOISE CAN AFFECT THE GRAY ZONES. WE INVESTIGATED THE COMPARATOR BY USING TWO DIFFERENT SET-UPS AND ANALYZED THE BIAS CURRENT DEPENDENCE OF THE GRAY ZONE AT LOW SPEED. THE LOWEST GRAY ZONE VALUES FOR OPTIMIZED BIAS CURRENTS ARE IN THE RANGE OF 2.2 μA.WE OBSERVED TWO DISTINCT OPERATION MODES FOR THE TESTED CIRCUIT WITH DIFFERENT DESIGNS. IN ONE CASE, THE TRANSITION CURVES SHOW A CONVENTIONAL ERROR FUNCTION BEHAVIOR ON THE OTHER CASE, THE TRANSITION SHOW DOUBLE STEPS, WHICH CAN BE WELL FITTED WITH A DOUBLE ERROR FUNCTION. THE CONTRIBUTION INCLUDES A THOROUGH ASSESSMENT OF THE EXPERIMENTAL SET-UP AS WELL AS SIMULATION RESULTS FOR AN OPTIMIZED VERSION OF THE QOJS CIRCUIT.

3EP3B-02

GRAY ZONE MEASUREMENTS OF JOSEPHSON JUNCTIONS COMPARATOR CELLS WITH DIFFERENT TOPOLOGIES *B. EBERT*[1]*, O. MIELKE*[2]*, J. KUNERT*[2]*, R. STOTZ*[2]*,* ***T. ORTLEPP***[1]*;* [1]ILMENAU UNIVERSITY OF TECHNOLOGY, [2]INSTITUTE FOR PHOTONIC TECHNOLOGY. — A JOSEPHSON JUNCTION COMPARATOR IS A 1-BIT QUANTIZER DECIDING WHETHER A CERTAIN SIGNAL CURRENT IS ABOVE OR BELOW A GIVEN THRESHOLD. SUCH A DECISION MAKING ELEMENT IS THE KEY COMPONENT OF ANALOG-TO-DIGITAL CONVERTERS AS WELL AS A FUNDAMENTAL BUILDING BLOCK OF RAPID SINGLE FLUX QUANTUM (RSFQ) ELECTRONICS. THE COMPARATOR CONSISTS OF TWO JOSEPHSON JUNCTIONS CONNECTED IN SERIES WITH A SIGNAL CURRENT INPUT AT THE JOINING POINT OF THE TWO JUNCTIONS. THE APPLIED SIGNAL CURRENT DECIDES WHICH JUNCTION SWITCHES WHEN A PULSE ARRIVES AT THE CLOCK INPUT OF THE COMPARATOR. DUE TO THE PRESENCE OF THERMAL NOISE, A GRAY ZONE FOR THE SIGNAL CURRENT EMERGES IN WHICH A DECISION UNCERTAINTY EXITS. THE LARGER THE WIDTH OF THE GRAY ZONE, THE HIGHER IS THE PROBABILITY OF BIT ERRORS IN RSFQ ELECTRONICS. WE HAVE MEASURED AT LOW SPEED THE GRAY ZONE OF VARIOUS COMPARATORS WITH DIFFERENT TOPOLOGIES AND CIRCUIT PARAMETERS. SINCE THE SHUNT RESISTOR IS THE MAIN CONTRIBUTOR OF THERMAL NOISE, NEW SHUNTING SCHEMES WERE TESTED IN EXPERIMENTS. A MINIMUM GRAY ZONE WIDTH OF 3.2 μA WERE MEASURED AT 4.2 K. THE RESULTS SUGGEST A REVISION OF THE STANDARD COMPARTOR TOPOLOGY LEADING TO LOWER DECISION UNCERTAINTIES.

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3EP3B-03

CONCEPT OF SUPERCONDUCTING PIPE-LINE A/D CONVERTER ***J. NGANKIO NJILA***[1]*, P. FEBVRE*[2]*, D. CRETE*[1]*, J. MAGE*[1]*, B. MARCILHAC*[1]*;* [1]THALES-TRT FRANCE, [2]UNIVERSITÉ DE SAVOIE CHAMBÉRY-ANNECY. — SUPERCONDUCTIVE ANALOGUE TO DIGITAL CONVERTERS (ADC) GENERALLY HAVE SPEED AND POWER DISSIPATION ADVANTAGES WHICH SHOULD ENABLE THEIR APPLICATION IN TELECOMMUNICATION AND WHERE AN ANALOGUE SIGNAL (DELIVERED E.G. BY A SENSOR) NEEDS TO BE DIGITIZED FOR POST-PROCESSING.WE ARE DEVELOPING A NEW CONCEPT OF ANALOGUE TO DIGITAL CONVERTER USING HIGH CRITICAL TEMPERATURE (TC=90K) SUPERCONDUCTORS, BASED ON A PIPELINE ARCHITECTURE.THE PRINCIPLE IS TO PLACE A CASCADE OF N COMPARATORS ALONG A TRANSMISSION LINE ON WHICH PROPAGATES THE UP-CONVERTED ANALOGUE SIGNAL. THE CARRIER FREQUENCY IS USED IN THIS CASE AS A SAMPLING SIGNAL.EACH COMPARATOR, MADE WITH A SQUID LOOP, PRODUCES ONE BIT AT THE CARRIER FREQUENCY: IT CODES THE INPUT SIGNAL BY GENERATING OR NOT AN RSFQ PULSE (RESPECTIVELY "1" OR "0"), AND PASSES THE RESIDUE (ATTENUATED SIGNAL) IN THE FOLLOWING COMPARATOR.HERE, WE PRESENT STEPS FOR THE COMPARATOR OPTIMISATION AND MASK DESIGN.BESIDES SIMULATION RESULTS, WE PLAN TO PRESENT THE MEASUREMENTS AT 30GHZ CARRIER FREQUENCY.

3EP3B-04

SUPERCONDUCTING NEURAL NETWORK SOLVING A COMBINATORIAL OPTIMIZATION PROBLEM ***T. ONOMI****, Y. MAENAMI, K. NAKAJIMA;* RESEARCH INSTITUTE OF ELECTRICAL COMMUNICATION, TOHOKU UNIVERSITY. — COMBINATORIAL OPTIMIZATION PROBLEMS ARE GENERALLY NP-DIFFICULTY OR NP-COMPLETENESS. WHEN THE PROBLEM SIZE BECOMES LARGE, IT IS DIFFICULT FOR A VON NEUMANN TYPE COMPUTER TO CALCULATE A SOLUTION WITHIN REAL TIME. MANY RESEARCHES USING NEURAL NETWORKS HAVE BEEN PROPOSED AND INVESTIGATED FOR SOLVING THIS PROBLEM. SUCH NEURAL NETWORKS HAVE BEEN IMPLEMENTED WITH THE SEMICONDUCTOR CIRCUITS. COMPARED WITH A SEMICONDUCTOR CIRCUIT, A SUPERCONDUCTING CIRCUIT HAS THE FEATURE OF LOW POWER CONSUMPTION AND HIGH-SPEED PROCESSING. AN ANALOG TYPE OF SUPERCONDUCTING NEURAL DEVICE USING A COUPLED-SQUID HAS BEEN ALREADY PROPOSED.IN THIS RESEARCH, WE CONSTRUCT A NEURAL NETWORK USING COUPLED-SQUIDS TO SOLVE N-QUEEN PROBLEM THAT IS ONE OF THE COMBINATORIAL OPTIMIZATION PROBLEMS. THE N-QUEEN PROBLEM IS TO PLACE N QUEENS WITH NO COLLISIONS ON AN N X N CHESS BOARD. WE SHOW THE NETWORK CONSTRUCTED BY THE COMBINATION OF COUPLED-SQUIDS CAN REACH TO THE SOLUTION IN THE NUMERICAL SIMULATION. HOWEVER, THE CONDITION OF THE NETWORK MAY BE TRAPPED IN INCORRECT ANSWERS DUE TO THE EXISTENCE OF LOCAL MINIMA ON THE ENERGY FUNCTION OF THE NETWORK. JOSEPHSON VOLTAGE OSCILLATION IS EFFECTIVE FOR ESCAPING FROM SUCH CONDITIONS ON LOCAL MINIMA. WE INVESTIGATE THE DYNAMICS OF THE NETWORK AND DISCUSS THE PERFORMANCE BASED ON PARAMETERS OF NB INTEGRATION CIRCUIT.

3EP3B-05

ANALYSIS OF SUPERCONDUCTING ANALOG-TO-DIGITAL CONVERTERS FOR IMPROVED RESOLUTION AND LARGE DYNAMIC RANGE ***P. FEBVRE****;* UNIVERSITY OF SAVOIE. — ANALOG-TO-DIGITAL CONVERTERS (ADCS) ARE KEY COMPONENTS OF MOST DIGITAL SYSTEMS, AS THE NECESSARY INTERFACE BETWEEN THE ANALOGUE WORLD TO SEND AND RECEIVE SIGNALS. SUPERCONDUCTOR ELECTRONIC ADCS RELY ON THE MAGNETIC FLUX QUANTIZATION AND DO NOT SUFFER FROM THE LINEARITY ISSUES. MOREOVER, THE RAPID-SINGLE-FLUX QUANTUM (RSFQ) TECHNIQUE [1] ALLOWS THE SAMPLING OF SIGNALS FAR IN THE MICROWAVE RANGE WITH STATE-OF-THE-ART LOW CRITICAL TEMPERATURE NIOBIUM-BASED TECHNOLOGY.TWO MAIN APPLICATIONS REQUIRE THE USE OF FAST AND HIGH DYNAMIC RANGE SUPERCONDUCTING ADCS: FUTURE GROUND- OR SPACE-BASED TELECOMMUNICATION SYSTEMS FOR SOFTWARE DEFINED RADIO (SDR) AND ALL SYSTEMS REQUIRING VERY HIGH DYNAMIC RANGE IN THE 120-180 DB RANGE.WE WILL DESCRIBE AN ANALYSIS OF PERFORMANCES OF TWO DIFFERENT KINDS OF ADCS, RESPECTIVELY FOR SPACE AND GEOPHYSICS APPLICATIONS. NEW DESIGNS WITH THEIR ELECTRICAL CIRCUITS WILL BE DESCRIBED FOR OPERATION IN THE MICROWAVE FREQUENCY BAND WITH A SIGMA-DELTA ARCHITECTURE, AND FOR IMPROVED DYNAMIC RANGE WITH A DELTA DESIGN. THE PERFORMANCE IN TERMS OF NUMBER OF BITS OR DYNAMIC RANGE, FREQUENCY BANDWIDTH AND ULTIMATE SAMPLING SPEED WILL BE COMPARED WITH THE ONES OF EXISTING ADCS. CONSIDERATIONS ABOUT THE LAYOUT DUE TO TECHNOLOGICAL CONSIDERATIONS ARE TAKEN INTO ACCOUNT IN THE DESIGN.[1] K. LIKHAREV AND V. SEMENOV, IEEE TRANS. APPL. SUPERCOND. 1, 3 (1991).

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3EP3B-06

LINEARITY OF A DIGITAL SQUID MAGNETOMETER ***I. HAVERKAMP****[1], T. ORTLEPP[1], O. MIELKE[2], J. KUNERT[2], R. STOLZ[2], H. G. MEYER[2], H. TOEPFER[1];* [1]ILMENAU UNIVERSITY OF TECHNOLOGY, [2]INSTITUTE OF PHOTONIC TECHNOLOGY. — A DIGITAL SQUID MAGNETOMETER MEASURES MAGNETIC FIELDS BY COUNTING INTEGER MAGNETIC FLUX QUANTA WITHIN ITS SUPERCONDUCTING INPUT LOOP. ALTHOUGH RESOLUTION IS LIMITED IN COMPARISON TO ANALOG SQUID SYSTEMS, THE DIGITAL SQUID IS ABLE TO OUTRANGE ITS ANALOG COUNTERPART WITH REGARD TO PARAMETERS SUCH AS SLEW RATE AND DYNAMIC RANGE.IN THIS WORK WE EVALUATE THE PERFORMANCE OF A DIGITAL SQUID BASED ON A THREE-LEVEL LOGIC. DUE TO THIS BASIC PRINCIPLE, WE FACE A COMBINATION OF TWO COMPARATOR GRAYZONES LEADING TO HYSTERETIC BEHAVIOR OF THE SENSOR THAT PRODUCES A "DEAD ZONE" IN THE SIGNAL REVERSAL POINT. THE DEPENDENCE OF THE COMPARATOR THRESHOLD ON DESIGN PARAMETERS IS INVESTIGATED BY SIMULATION STUDIES AND RECONFIRMED BY EXPERIMENTAL RESULTS. FURTHERMORE, THE INFLUENCE OF THE SHIFTED THRESHOLD ON THE TOTAL HARMONIC DISTORTION OF THE SENSOR IS ANALYZED.WITH THE CURRENT DIGITAL SQUID DESIGN, WE WERE ABLE TO REACH A TOTAL DYNAMIC RANGE OF MORE THAN 53000 FLUX QUANTA (ABOUT 16 BIT) WITH A LINEARITY ERROR OF ABOUT 5 BIT DUE TO THE MENTIONED HYSTERETIC BEHAVIOR. WE DISCUSS THE RESULTS OF OUR INVESTIGATIONS AND PROVIDE GUIDELINES TO EXTEND DYNAMIC RANGE AND LINEARITY FOR FUTURE SENSOR DESIGNS.

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3EP3B-07

PERFORMANCE ANALYSIS OF A SUPERCONDUCTING ANALOG-TO-DIGITAL CONVERTER BASED ON HIGH LEVEL CIRCUIT DESCRIPTION *T. HADDAD, T. ORTLEPP,* ***H. TOEPFER****;* ILMENAU UNIVERSITY OF TECHNOLOGY. — JOSEPHSON JUNCTION COMPARATORS ARE ONE OF THE FUNDAMENTAL BUILDING BLOCKS IN RSFQ ELECTRONICS. THEY ARE USED TO BUILD VERY FAST ANALOG-TO-DIGITAL CONVERTERS AND SAMPLER CIRCUITS FOR LOW INPUT POWER AND HIGH-BANDWIDTH SIGNALS.WE INVESTIGATED THE DECISION TIME AND THE GREY ZONE OF A JOSEPHSON COMPARATOR AND A QUASI ONE JUNCTION SQUID (QOJS). THE DYNAMICS OF A JOSEPHSON COMPARATOR REMAINS INDEPENDENT ON CLOCK

SPEED ONLY UP TO A CHARACTERISTIC FREQUENCY. WE DERIVED THESE FREQUENCIES FOR DIFFERENT FABRICATION TECHNOLOGIES AND USED THE RESULTS TO CREATE A BEHAVIORAL MODEL OF THE DECISION ELEMENT.THE AIM OF OUR CONTRIBUTION IS THE EVALUATION OF OUR HIGH LEVEL MODELING AGAINST THE CLASSICAL ANALOG CIRCUIT SIMULATION. WE USE A STANDARD FIRST ORDER SIGMA-DELTA CONVERTER FOR OUR SIMULATIONS. TYPICAL CHARACTERISTICS OF ANALOG-TO-DIGITAL CONVERTERS ARE UTILIZED AS A MEASURE FOR THE PERFORMANCE COMPARISON. WE WILL DESCRIBE THE WAY OF MODELING THE ANALOG AND THE DIGITAL COMPONENTS AND COMPARE THE COMPUTATIONAL EFFORTS. THE CONFIDENCE IN OUR HIGH-LEVEL MODELSALLOW US A QUICK ANALYSIS OF DIFFERENT ARCHITECTURE AS WELL AS FAST PARAMETRICCIRCUIT OPTIMIZATION.

3EP3B-08

PHYSICAL SENSITIVITY OF SUPERCONDUCTOR ADCS ***V. K. SEMENOV****;* STONY BROOK UNIVERSITY. — SUPERCONDUCTOR ADCS ARE FAMOUS BY THEIR UNIQUE SAMPLING RATES AND DYNAMIC RANGES. HOWEVER, THE DEMONSTRATED PHYSICAL SENSITIVITY THAT COULD BE CHARACTERIZED, SAY, BY AN EFFECTIVE NOISE TEMPERATURE, IS MUCH WORSE THAT HAS BEEN ACHIEVED BY ANALOG SUPERCONDUCTOR SENSORS SUCH AS SQUIDS, RECEIVERS, MIXERS AND BOLOMETERS. TWO MAIN REASONS FOR THIS DRAWBACK ARE WELL KNOWN. THE FIRST ONE IS A VERY HIGH INHERENT BANDWIDTH OF SUPERCONDUCTOR MODULATORS THAT COULD BE ON ORDERS OF MAGNITUDE WIDER THAN THE REQUESTED SIGNAL BANDWIDTH. AS A RESULT, THE MODULATORS COLLECT A LOT OF OFF-BAND NOISE. THE SECOND REASON IS SERIOUS DIFFICULTIES WITH MATCHING OF IMPEDANCE OF MODULATORS AND PROSPECTIVE SIGNAL SOURCES. AT THE CONFERENCE WE WILL DISCUSS THESE AND OTHER DRAWBACKS AND WILL TRY TO SUGGEST HOW TO REDUCE THEIR HIGHLY UNDESIRABLE IMPACTS ON THE EFFECTIVE NOISE TEMPERATURES OF SUPERCONDUCTOR ADCS.

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3EP3C-01

NOISE PERFORMANCE OF NIOBIUM NANO-SQUIDS IN APPLIED MAGNETIC FIELDS ***E. J. ROMANS****[1], S. ROZHKO[1], L. YOUNG[1], L. HAO[2], D. C. COX[2], J. C. GALLOP[2];* [1]UNIVERSITY COLLEGE LONDON, [2]NATIONAL PHYSICAL LABORATORY. — NEW MEASUREMENT REQUIREMENTS IN QUANTUM COMMUNICATION, QUANTUM COMPUTING AND BASIC METROLOGY HAVE LED TO MUCH RECENT WORK ON FABRICATING NANO-SCALE SUPERCONDUCTING QUANTUM INTERFERENCE DEVICES (SQUIDS) USING SUPERCONDUCTING NANOBRIDGES AS THE ACTIVE JOSEPHSON ELEMENT. THESE ARE ULTRASENSITIVE MAGNETIC FLUX SENSORS THAT CAN BE POTENTIALLY USED TO MEASURE SMALL MAGNETIC CLUSTERS, MAGNETIC MOLECULES, THE DISPLACEMENT OF NANO-SCALE MECHANICAL RESONATORS AND AS FLUX QUBIT-READOUTS. IN PRINCIPLE AS THE DIMENSIONS (AND THUS THE GEOMETRIC INDUCTANCE) OF THE SQUID ARE REDUCED, THE SENSITIVITY SHOULD APPROACH THAT REQUIRED TO DETECT THE FLIP OF A SINGLE ELECTRON SPIN.HOWEVER IN ORDER TO EXPLOIT NANO-SQUIDS THEY NEED TO BE OPERATED IN LARGE BACKGROUND MAGNETIC FIELDS AND THEIR KINETIC INDUCTANCE SHOULD NOT BECOME TOO LARGE. IN THE PRESENT WORK WE HAVE FABRICATED A RANGE OF NIOBIUM DC NANO-SQUIDS USING FOCUSSED ION BEAM (FIB) LITHOGRAPHY WITH LOOPS AND TRACK WIDTHS OF VARIOUS DIMENSIONS DOWN TO 70 NM. WE REPORT ON THE VOLTAGE-FLUX AND NOISE PERFORMANCE OF THE DEVICES IN ZERO FIELD AND IN MAGNETIC FIELDS OF UP TO 1 T, APPLIED EITHER IN-PLANE OR PERPENDICULAR TO THE PLANE, AT TEMPERATURES BETWEEN 4.2 K AND 9 K. WE COMPARE THE MEASUREMENTS WITH MODELLED ESTIMATES OF THE INDUCTANCE OF THE STRUCTURES AND THE CONVENTIONAL THEORY OF NOISE IN DC SQUIDS.

3EP3C-02

READOUT OF NANOSQUID SENSORS USING A SQUID AMPLIFIER ***F. RUEDE****[1], C. AßMANN[1], J. BEYER[1], D. DRUNG[1], J. GALLOP[2], L. HAO[2], O. KAZAKOVA[2], T. SCHURIG[1];* [1]PTB CRYOSENSORS, BERLIN, GERMANY, [2]NATIONAL PHYSICAL LABORATORY, TEDDINGTON, UK. — NANOSQUID SENSORS ARE REGARDED AS A USEFUL TOOL FOR SENSITIVE MAGNETIC MEASUREMENTS AT THE NANOSCALE, E.G. DETECTION OF INDIVIDUAL MAGNETIC NANOPARTICLES, AND HAVE ACHIEVED A LOW NOISE LEVEL WHICH COULD POTENTIALLY LEAD TO DETECTION OF A SINGLE ELECTRON SPIN.IN CONTRAST TO COMMON SQUID SENSORS, THE FABRICATION AND READ-OUT OF NANOSQUIDS IS QUITE CHALLENGING. THE TECHNOLOGICAL OBSTACLES FOR THE PREPARATION OF JUNCTIONS AND SHUNT RESISTORS WITH NM-DIMENSIONS MAKE THE SELF-SHUNTED NANOBRIDGE JUNCTIONS ATTRACTIVE. HOWEVER, SELF-SHUNTED NANOBRIDGE JUNCTIONS HAVE SHOWN HYSTERETIC CHARACTERISTICS AT 4.2K. AN APPROACH IS TO INCREASE THE OPERATIONAL TEMPERATURE IN ORDER TO REDUCE THE CRITICAL CURRENT OF THE DEVICE. THE NANOSQUIDS (LOOP SIZE 250 ~ 800 NM) ARE PROCESSED BY PHOTOLITHOGRAPHY AND FOCUSED ION BEAM PATTERNING OF A SIMPLE BILAYER.THE SMALL SENSING AREA OF NANOSQUIDS AND ITS CORRESPONDINGLY LOW SENSITIVITY TO EXTERNAL MAGNETIC FIELDS HAMPER THE APPLICATION OF COMMON FEEDBACK SCHEMES. FOR DETECTION OF A MAGNETIC NANOPARTICLE ATTACHED TO THE SQUID, AN ADDITIONAL MAGNETIC FIELD FOR ALIGNING THE MAGNETIC MOMENT OF THE PARTICLE IS REQUIRED.WE REPORT THE DESIGN AND CONSTRUCTION OF AN EVACUATED LIQUID HELIUM COOLED PROBESTICK WITH RF-SHIELD, COIL SYSTEM, AND SQUID PRE-AMPLIFIER TO READ OUT THE VOLTAGE-BIASED NANOSQUID. SOME INITIAL EXPERIMENTAL RESULTS WILL BE PRESENTED.

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3EP3C-03

A CRYO-COOLED SCANNING SQUID MICROSCOPE FOR IMAGING HIGH-FREQUENCY MAGNETIC FIELDS ***C. P. VLAHACOS***[1]*, J. MATTHEWS*[2]*, F. C. WELLSTOOD*[3]*;* [1]NASA GODDARD SPACE FLIGHT CENTER, CRYOGENICS AND FLUIDS BRANCH, CODE 552, GREENBELT, MD 20771, [2]PHYSICAL OPTICS CORPORATION, 20600 GRAMERCY PLACE, TORRANCE, CA 90501-1821, [3]CENTER FOR NANOPHYSICS AND ADVANCED MATERIALS, DEPARTMENT OF PHYSICS, UNIVERSITY OF MARYLAND, COLLEGE PARK, MD 20742. — ONE IMPORTANT APPLICATION OF SCANNING SQUID MICROSCOPES IS FAULT DETECTION IN INTEGRATED CIRCUITS AND MULTI-CHIP MODULES. HOWEVER, THE PRESENT GENERATION OF COMPUTER PROCESSORS OPERATE AT OVER 1 GHZ, WELL ABOVE THE BANDWIDTH OF THE PRESENT GENERATION OF SQUID MICROSCOPES. TOWARDS THIS END, WE PRESENT RESULTS ON A CRYO-COOLED 4.2 K SCANNING SQUID MICROSCOPE WITH A BANDWIDTH OF DC TO 2 GHZ AND A SENSITIVITY OF ABOUT 50 NT PER SAMPLE. WE USE A THIN-FILM HYSTERETIC NB DC-SQUID AND A PULSED SAMPLING TECHNIQUE, RATHER THAN A NON-HYSTERETIC SQUID AND A FLUX-LOCKED LOOP, TO OVERCOME THE BANDWIDTH LIMITATION OF EXISTING SCANNING SQUID MICROSCOPES. THE MICROSCOPE ALLOWS FOR NON-CONTACT IMAGES OF TIME-VARYING MAGNETIC FIELD TO BE TAKEN OF ROOM-TEMPERATURE SAMPLES WITH TIME STEPS DOWN TO 50 PS AND SPATIAL RESOLUTION ULTIMATELY LIMITED BY THE SIZE OF THE SQUID TO ABOUT 10 MM. WE PRESENT TIME-VARYING MAGNETIC FIELD IMAGES OBTAINED WITH THIS SCANNING SQUID MICROSCOPE AND DISCUSS THE ADVANTAGES AND LIMITATIONS OF THIS METHOD.

LABORATORY FOR PHYSICAL SCIENCES, COLLEGE PARK, MD 20740 AND CENTER FOR NANOPHYSICS AND ADVANCED MATERIALS, DEPARTMENT OF PHYSICS, UNIVERSITY OF MARYLAND, COLLEGE PARK, MD 20742

3EP3C-04

OBSERVATION OF POLYCRYSTALLINE SOLAR CELL USING A LASER-SQUID MICROSCOPE ***Y. NAKATANI***[1]*, K. OTANI*[1]*, X. Y. KONG*[1]*, T. MAKI*[1]*, T. HAYASHI*[2]*, H. ITOZAKI*[1]*;* [1]OSAKA UNIVERSITY, [2]SENDAI NATIONAL COLLEGE OF TECHNOLOGY. — A LASER-SQUID MICROSCOPE IS A TOOL FOR THE NONDESTRUCTIVE INSPECTION OF THE ELECTRICAL PROPERTIES OF SEMICONDUCTORS. IN A LASER-SQUID MICROSCOPE, A PHOTOCURRENT IS INDUCED BY A LASER WHICH HAS ENERGY LARGER THAN THE BAND GAP OF THE SEMICONDUCTOR SAMPLE. THE MAGNETIC FIELD INDUCED BY THIS PHOTOCURRENT IS THEN DETECTED BY A SQUID. IN OUR EXPERIMENT THE LASER WAS FOCUSED ON THE SURFACE OF THE SAMPLE, AND AN HTS-SQUID WAS POSITIONED BEHIND THE SAMPLE TO DETECT THE MAGNETIC FIELD FROM THE PHOTOCURRENT. WE USED A MAGNETIC FLUX GUIDE BETWEEN THE SAMPLE AND SQUID IN ORDER TO DETECT THE MAGNETIC FIELD NEAR THE SAMPLE EFFECTIVELY. THE SAMPLE WAS SCANNED IN X AND Y DIRECTIONS WHILE THE RELATIVE POSITION OF THE SQUID AND LASER SPOT WAS FIXED. THE SAMPLE USED WAS A COMMERCIALLY AVAILABLE POLYCRYSTALLINE SILICON SOLAR CELL CONTAINING A P-N JUNCTION. IT HAD SEVERAL LINE ELECTRODES ON THE SURFACE, AND THE REVERSE SIDE WAS COVERED WITH A METAL ELECTRODE. WE OBSERVED A PIECE OF THIS POLYCRYSTALLINE SOLAR CELL USING 1065 NM AND 780 NM LASERS. ALTHOUGH BOTH LASER-SQUID MICROSCOPE IMAGES WERE SIMILAR, THERE WAS A GRAIN THAT COULD ONLY BE SEEN BY THE 1065 NM LASER. THE MAGNETIC FIELD STRENGTH INSIDE THIS GRAIN WAS REDUCED AND HAD A UNIFORM MAGNITUDE WHEN THE 1065 NM LASER WAS USED. THIS SHOWED THAT AMONG THE GRAINS IN THE SOLAR CELL, ONLY THIS PARTICULAR GRAIN HAS WAVELENGTH DEPENDENT ELECTRICAL OR OPTICAL PROPERTIES.

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3EP3C-05

EVALUATION OF A STM-SQUID PROBE MICROSCOPE ***N. WATANABE***[1]*, T. HAYASHI*[2]*, M. TACHIKI*[1]*, D. HE*[1]*, H. ITOZAKI*[3]*;* [1]NATIONAL INSTITUTE FOR MATERIALS SCIENCE, [2]SENDAI NATIONAL COLLEGE OF TECHNOLOGY, [3]OSAKA UNIVERSITY. — WE HAVE DEVELOPED A STM-SQUID PROBE MICROSCOPE THAT COMBINES A SQUID PROBE MICROSCOPE AND A SCANNING TUNNELING MICROSCOPE (STM). OUR AIM WAS TO OBTAIN HIGH-RESOLUTION MAGNETIC FIELD MEASUREMENT OF MAGNETIC MATERIALS. WE IMPROVED THE SPATIAL RESOLUTION OF THE SQUID PROBE MICROSCOPE BY LOCALLY FOCUSING A MAGNETIC FIELD AND TRANSMITTING THE MAGNETIC FIELD TO SQUID BY USE OF A HIGH PERMEABILITY PERMALLOY PROBE. WE ARE ABLE TO MEASURE TOPOGRAPHY OF THE SAMPLE SURFACE AND THE MAGNETIC FIELD OF THE SAMPLE AT THE SAME TIME USING THE PERMALLOY PROBE AS THE STM PROBE. WE HAVE ALREADY ACHIEVED A GREAT IMPROVEMENT IN THE SPATIAL RESOLUTION USING THE STM-SQUID PROBE MICROSCOPE, AND WE CAN NOW OBSERVE SUBMICRON MAGNETIC IMAGES. IN THE PRESENT STUDY, WE HAVE MEASURED THE MAGNETIC FIELD DISTRIBUTION GENERATED BY A MEANDER LINE WHOSE LINE AND SPACING WERE 500 NM. THE MEANDER LINE IS USEFUL FOR ESTIMATING THE PERFORMANCE OF STM-SQUID PROBE MICROSCOPE BECAUSE WE CAN QUANTIFY THE MAGNETIC FIELD OF A MEANDER LINE TO WHICH A CURRENT IS APPLIED. WHEN WE CHANGED THE CURRENT APPLIED TO THE MEANDER LINE, WE WERE ABLE TO OBSERVE CHANGES IN THE MAGNETIC FIELD ON THE SAMPLE SURFACE WITH THE STM-SQUID PROBE MICROSCOPE. WE ALSO MEASURED THE MAGNETIC FIELD ON THE SAMPLE SURFACE BY MAGNETIC FORCE MICROSCOPY (MFM) AND COMPARED THESE MEASUREMENTS TO THOSE OBTAINED WITH THE STM-SQUID PROBE MICROSCOPE.

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3EP3D-01

ANALYSIS OF POSSIBLE QUANTUM METASTABLE STATES IN BALLISTIC GRAPHENE-BASED JOSEPHSON JUNCTIONS ***J. G. LAMBERT****, S. CARABELLO, Z. THRAILKILL, R. C. RAMOS;* DREXEL UNIVERSITY. — GRAPHENE IS A RELATIVELY NEW MATERIAL (2004) MADE OF ATOMIC LAYERS OF CARBON ARRANGED IN A HONEYCOMB LATTICE. JOSEPHSON JUNCTION DEVICES ARE MADE FROM GRAPHENE BY DEPOSITING TWO PARALLEL SUPERCONDUCTING LEADS ON A GRAPHENE FLAKE. THESE DEVICES HAVE HYSTERETIC CURRENT-VOLTAGE CHARACTERISTICS WITH A SUPERCURRENT BRANCH AND SHAPIRO STEPS APPEAR WHEN IRRADIATED WITH MICROWAVES. THESE PROPERTIES MOTIVATE US TO INVESTIGATE THE PRESENCE OF QUANTUM METASTABLE STATES SIMILAR TO THOSE FOUND IN CONVENTIONAL CURRENT-BIASED JOSEPHSON JUNCTIONS. WE PRESENT WORK INVESTIGATING THE NATURE OF THESE METASTABLE STATES FOR BALLISTIC GRAPHENE JOSEPHSON JUNCTIONS. WE MODEL THE EFFECTIVE WASHBOARD POTENTIAL FOR THESE DEVICES AND ESTIMATE PARAMETERS, SUCH AS ENERGY LEVEL SPACING AND CRITICAL CURRENTS, TO DEDUCE THE DESIGN NEEDED TO OBSERVE METASTABLE STATES. WE PROPOSE DEVICES CONSISTING OF A PARALLEL ON-CHIP CAPACITOR AND SUSPENDED GRAPHENE. THE CAPACITOR IS NEEDED TO LOWER THE ENERGY LEVEL SPACING DOWN TO THE EXPERIMENTALLY ACCESSIBLE RANGE OF 1-20 GHZ. THE SUSPENDED GRAPHENE HELPS REDUCE THE NOISE THAT MAY OTHERWISE COME FROM TWO-LEVEL STATES IN THE INSULATING OXIDE LAYER. MOREOVER, BACKGATE VOLTAGE CONTROL OF ITS CRITICAL CURRENT INTRODUCES ANOTHER KNOB FOR QUANTUM CONTROL. WE WILL ALSO REPORT ON CURRENT EXPERIMENTAL PROGRESS IN THE AREA OF FABRICATION OF THIS PROPOSED DEVICE.

3EP3D-02

PROPERTIES INVESTIGATION OF GRAPHENE-BASED JOSEPHSON JUNCTIONS ***C. PORTESI****, E. MONTICONE, M. BRUNA, S. BORINI, E. TARALLI, M. RAJTERI;* INRIM. — GRAPHENE-BASED ELECTRONIC DEVICES HAVE ATTRACTED GREAT INTEREST BECAUSE OF THE OUTSTANDING PROPERTIES OF GRAPHENE, SUCH AS HIGH CARRIER MOBILITY AND CHEMICAL INERTNESS. A NUMBER OF EXPECTATIONS HAS ARISEN WITH TWO RECENT ACHIEVEMENTS: THE FABRICATION OF SUPERCONDUCTOR- GRAPHENE-SUPERCONDUCTOR (SGS) JOSEPHSON JUNCTIONS, BY EXPLOITING THE TECHNOLOGY OF MECHANICAL EXFOLIATION OF GRAPHITE, AND THE NEW PERSPECTIVES OPEN BY THE OBSERVATION OF SPONTANEOUS FORMATION OF AN INSULATING OXIDE LAYER AT THE INTERFACE BETWEEN GRAPHENE AND AN AL SUPERCONDUCTING LAYER. HERE, WE REPORT ON FABRICATION OF SUPERCONDUCTOR-INSULATOR-GRAPHENE- INSULATOR- SUPERCONDUCTOR (SIGIS) JUNCTIONS BASED ON AN AL/ALO_X/GRAPHENE/ALO_X/AL STRUCTURE. MULTILAYER GRAPHENE FLAKES ARE PREPARED BY A MICROMECHANICAL EXFOLIATION OF NATURAL GRAPHITE AND ARE THEN SELECTED OF APPROPRIATE THICKNESS THROUGH OPTICAL INVESTIGATION. THEN, THE AL LEADS ARE FABRICATED USING BOTH ELECTRON BEAM AND OPTICAL LITHOGRAPHY AND LIFT OFF. DISTANCE BETWEEN THE LEADS ARE IN THE RANGE OF 200-400 NM AND THE WIDTH OF THE JUNCTION IS 4 MM. THE RESULTS OF ELECTRICAL CHARACTERIZATION CARRIED OUT IN AN ^{3}HE REFRIGERATOR DOWN TO 300 MK, USING A FOUR-LEAD TECHNIQUE, WILL BE PRESENTED AND DISCUSSED.

3EP3D-03

RESONANCE EFFECTS ON COHERENT FLUX-FLOW OF BI-2212 INTRINSIC JOSEPHSON JUNCTIONS ***K. NAKAJIMA****, M. ISOBE, T. CHIBA, H. YAMADA;* YAMAGATA UNIVERSITY. — WE FOUND RESONANCE FEATURES ON THE FLUX-FLOW PROPERTIES OF BI-2212 INTRINSIC JOSEPHSON JUNCTIONS (IJJ) CAUSED BY INTRA-JUNCTION AND EXTERNAL MICROSTRIP LINE RESONANCES. FLUX-FLOW EXPERIMENTS WERE CARRIED OUT ON QUASI-ONE-DIMENSIONALLY LONG BI-2212 IJJ INTEGRATED WITH A STRIP LINE RESONATOR FABRICATED BY A STANDARD PHOTO LITHOGRAPHY FOR THE JUNCTION FOLLOWED BY A FOCUSED ION ETCHING FOR THE RESONATOR. THE MICROSTRIP LINE RESONATOR ATTACHED TO THE BI-2212 IJJ DEVELOPED REMARKABLE CHANGES ON THE CURRENT-VOLTAGE PROPERTIES THAT MAY REFLECT RESONANCE EFFECTS ON THE FLUXON DYNAMICS. PEDERSEN ET AL. [1] HAVE PROPOSED THZ GENERATION FROM BI-2212 IJJ IN THE COHERENT STATE ASSISTED BY AN EXTERNAL CAVITY RESONANCE. IN ADDITION TO THE EXTERNAL RESONANCE, THE COLLECTIVE FLUX-FLOW SHOWING VELOCITY MATCHING TO THE COHERENT ELECTROMAGNETIC MODE VELOCITY WAS ACHIEVED BY EXTERNAL MAGNETIC FIELD AS LOW AS 0.02 TESLA. THE HIGH SPEED FLUX-FLOW IN LOW MAGNETIC FIELDS HAS BEEN INTERPRETED BY TAKING INTO ACCOUNT OF THE EFFECT OF INTRA-JUNCTION RESONANCE, SUCH AS THE FISKE MODE. WE HAVE BEEN PURSUING THE FLUX-FLOW RF EMISSION FROM BI-2212 IJJ IN BOTH EXTERNAL AND INTRA-JUNCTION RESONANCE STATES.[1]N.F PEDERSEN, S. MADSEN, “THZ GENERATION USING FLUXON DYNAMICS IN HIGH TEMPERATURE SUPERCONDUCTORS”, IEEE TRANS. APPL. SUPERCOND., 19, 726(2009).

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3EP3D-04

CONTROL OF CRITICAL CURRENT OF INTRINSIC JOSEPHSON JUNCTIONS DUE TO SPIN INJECTION ***A. IRIE****, N. ARAKAWA, G. OYA;* UTSUNOMIYA UNIVERSITY. — WE HAVE INVESTIGATED THE INFLUENCE OF THE FERROMAGNET MAGNETIZATION ON THE CRITICAL CURRENT I_C OF THE INTRINSIC JOSEPHSON JUNCTIONS (IJJS) IN CO/AU/$BI_2SR_2CACU_2O_Y$ (BSCCO) MESA STRUCTURES UNDER APPLIED MAGNETIC FIELDS PARALLEL TO THE LAYER. THE MESA STRUCTURE WITH DIMENSIONS OF 5 X 5 UM^2 WERE FABRICATED BY USING ELECTRON BEAM LITHOGRAPHY, PHOTOLITHOGRAPHY AND AR ION MILLING. BEFORE AN APPLICATION OF MAGNETIC FIELD B, THE CURRENT-VOLTAGE CHARACTERISTICS OF THE MESA SHOWED THE TYPICAL MULTIPLE RESISTIVE BRANCHES WITH

HYSTERESIS SIMILAR TO THOSE OF CONVENTIONAL IJJS. HOWEVER, BY APPLYING B THE I_C WAS CONSIDERABLY SUPPRESSED AND THE I_C-B CURVE SHOWED HYSTERESIS IN CONTRAST TO CONVENTIONAL IJJS SUCH BEHAVIOR WAS OBSERVED IN A WIDE TEMPERATURE RANGE BETWEEN 4.2 K AND T_C. FURTHERMORE, THE SUPPRESSION OF I_C WAS FOUND TO BE MINIMIZED AT THE COERCIVE FILED OF THE CO LAYER. THIS IMPLIES THAT THE I_C IS SIGNIFICANTLY AFFECTED BY THE DOMAIN STRUCTURE OF THE CO FORMED ON IJJS. FROM THESE RESULTS WE FOUND THAT THE IC OF IJJS IN THE CO/AU/BSCCO MESA CAN BE CONTROL BY SMALL MAGNETIC FIELD AND THE HYBRID STRUCTURE OF FEROMAGNET AND IJJS MIGHT BE APPLICABLE FOR A SWITCHING DEVICE AND OTHER SPINTRONICS DEVICES.

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3EP3D-05

RAMP-TYPE JUNCTIONS OF UNDERDOPED AND OVERDOPED LA_{2-X}SR_{X}CUO_{4} ***G. -. KOREN****, T. KIRZHNER;* TECHNION - ISRAEL INSTITUTE OF TECHNOLOGY. — IN RAMP-TYPE SNS JUNCTIONS MADE OF YBA2CU3OY (YBCO) ONE CAN NOT HAVE DIFFERENT DOPING LEVELS OF THE BASE AND COVER ELECTRODES, SINCE BOTH ARE DETERMINED BY THE LAST OXYGEN ANNEALING PROCESS OF THE DEVICE. IN CONTRAST, RAMP JUNCTIONS MADE WITH LA2-XSRXCUO4 (LSCO-X) ELECTRODES DO NOT HAVE THIS LIMITATION, AS THE DOPING LEVELS ARE DETERMINED BY THE SR CONTENT ONLY, PROVIDED THE SAME OXYGEN ANNEALING PROCESS IS USED. HERE WE REPORT ON SN AND SNS JUNCTIONS OF THE LSCO SYSTEM MADE OF UNDERDOPED AND OVERDOPED ELECTRODES. THIS ALLOWS FOR AN ALMOST PERFECT MATCHING OF THE LATTICE CONSTANTS OF THE TWO ELECTRODES, ELIMINATES MOST OF THE INTERFACE RESISTANCE AND YIELDS JUNCTIONS WITH VERY HIGH TRANSPARENCY (0<Z<0.3). AS A RESULT THESE JUNCTIONS HAVE A TYPICAL ANDREEV CONDUCTANCE PEAK WITH A CLEAR ENERGY GAP. WE FIND THAT IN LSCO-10/LSCO-35 JUNCTIONS AT 2 K THERE IS A SINGLE PROMINENT ENERGY GAP AT WHICH IS ABOUT TWICE AS LARGE AS THE TUNNELING GAP. THIS OBSERVATION AGREES QUITE WELL WITH THE ARPES RESULTS, BUT IS FOUND IN CONTRADICTION WITH PREVIOUS POINT CONTACT RESULTS IN AU/YBCO WHERE THE OBSERVED ANDREEV GAP WAS MUCH SMALLER THAN THE TUNNELING GAP.

3EP3D-06

ENHANCED PROPERTIES OF INTRINSICALLY SHUNTED NB/AL-ALO$_X$-NB JOSEPHSON JUNCTIONS ***V. LACQUANITI****, N. DE LEO, M. FRETTO, A. SOSSO, D. ANDREONE, M. BELOGOLOVSKII;* INRIM. — OVERDAMPED JOSEPHSON JUNCTIONS WITH NON-HYSTERETIC CURRENT-VOLTAGE CHARACTERISTICS FORM THE BASIS OF MOST SUPERCONDUCTING ELECTRONIC CIRCUITS INCLUDING RSFQ LOGIC AND PROGRAMMABLE JOSEPHSON VOLTAGE STANDARDS. WE HAVE FOUND THAT AN ADDITIONAL NORMAL AL INTERLAYER OF SOME TENS OF NM THICKNESS IS CAPABLE OF PROVIDING AT $T \geq 4.2$ K THE NECESSARY DAMPING CONDITION IN NB/AL-ALO$_X$-NB **(**SNIS) JUNCTIONS AND REASONABLY HIGH PRODUCTS I_CR_N. IN THIS CONTRIBUTION, WE PROVIDE EXPERIMENTAL AND THEORETICAL ARGUMENTS PROVING THAT THIS FINDING IS CONDITIONED BY A PROXIMITY-INDUCED ENERGY GAP IN THE AL INTERLAYER AS WELL AS BY MULTIPLE ANDREEV REFLECTIONS WITHIN THE SNIS JUNCTION. THE ENHANCED TEMPERATURE BEHAVIOR OF THIS TYPE OF JOSEPHSON DEVICES COMPARED TO IDEAL SIS AND SNS JUNCTIONS, DUE TO THE THICK AL LAYER, IS CONFIRMED BY THE OBSERVATION OF WIDE SHAPIRO STEPS AT V = 1V AT TEMPERATURES AS HIGH AS 6-7 K.

3EP3D-07

JOSEPHSON JUNCTIONS WITHOUT PAIRS? ***A. M. KADIN****;* HYPRES, INC.. — IT IS WELL ESTABLISHED THAT SUPERCONDUCTIVITY IS BASED ON A COHERENT QUANTUM STATE OF COOPER PAIRS WITH CHARGE 2E, AND THIS IS EQUALLY TRUE OF THE JOSEPHSON EFFECT. NEVERTHELESS, A NOVEL REAL-SPACE PICTURE OF SUPERCONDUCTIVITY WAS RECENTLY PRESENTED [1], WHICH DOES NOT INVOLVE BOSE CONDENSATION OF BOUND PAIRS. INSTEAD, EACH ELECTRON IN THE CONDENSED PHASE IS A LOCALIZED STANDING WAVE, ON THE SCALE OF THE COHERENCE LENGTH, COUPLED TO A DYNAMIC CHARGE (OR SPIN) DENSITY WAVE, AND A SUPERCURRENT CORRESPONDS TO COLLECTIVE MOTION OF A DENSE ARRAY OF SUCH ELECTRONS. THE PRESENT PAPER EXTENDS THIS PICTURE TO TWO WEAKLY COUPLED SUPERCONDUCTORS, AND SHOWS HOW THE JOSEPHSON EFFECT (INCLUDING THE UBIQUITOUS FACTOR OF H/2E) MAY BE OBTAINED FOR VARIOUS MODELS OF JOSEPHSON JUNCTIONS, INCLUDING SIS, SNS, AND WEAK LINKS. HOWEVER, THIS PICTURE ALSO PREDICTS DEVIATIONS FROM THE STANDARD SINUSOIDAL JOSEPHSON RELATION IN SEVERAL LIMITS, SUCH AS NANOSCALE JUNCTIONS MUCH SMALLER THAN THE COHERENCE LENGTH. FINALLY, THE IMPLICATIONS FOR SUPERCONDUCTING QUANTUM COMPUTING WITHOUT A TRUE PAIR WAVEFUNCTION WILL BE DISCUSSED.[1] A.M. KADIN, "SUPERCONDUCTIVITY WITHOUT PAIRING?", HTTP://ARXIV.ORG/ABS/0909.2901

3EP3D-08

PI JOSEPHSON JUNCTIONS WITH MAGNETIC MULTILAYER BARRIERS ***J. W. A. ROBINSON****[1], G. B. HALÁSZ[1], A. I. BUZDIN[2], M. G. BLAMIRE[1];* [1]DEPARTMENT OF MATERIAL SCIENCE, UNIVERSITY OF CAMBRIDGE, PEMBROKE STREET, CAMBRIDGE CB2 3QZ, UK, [2]INSTITUT UNIVERSITAIRE DE FRANCE, PARIS AND CPMOH, UMR 5798, UNIVERSITY BORDEAUX I, 33405 TALENCE, FRANCE. — RAPID PROGRESS IN THE DEVELOPMENT OF PI JOSEPHSON JUNCTIONS USING MAGNETIC BARRIERS[1] HAS STIMULATED THEORETICAL INVESTIGATIONS OF MORE EXOTIC SYSTEMS IN WHICH THE MAGNETISM MAY BE NONHOMOGENEOUS[2]. SUCH SYSTEMS MAY BE REALISED BY USING EITHER MULTILAYER BARRIERS, OR BARRIERS CONTAINING INTRINSIC NON-LINEARITIES[3] OR DOMAIN WALLS[4].THIS PAPER FOCUSES ON THE FABRICATION AND TRANSPORT PROPERTIES OF PI JOSEPHSON JUNCTIONS IN

WHICH THE BARRIER CONSISTS OF A MAGNETIC MULTILAYER. IN PARTICULAR, WE SHOW USING A TRILAYER FE-CR-FE BARRIER IN WHICH THE CR-THICKNESS DETERMINES THE ALIGNMENT OF THE FERROMAGNETIC LAYERS THAT THE CRITICAL CURRENT IS MUCH LARGER IN THE ANTIPARALLEL CONFIGURATION. THE RESULT AGREES WITH PREDICTIONS OF A STRONGLY ENHANCED PROXIMITY EFFECT IN FERROMAGNETIC SYSTEMS WITH INHOMOGENEOUS MAGNETISM AND DEMONSTRATES THE POTENTIAL FOR SUPERCONDUCTOR / SPINTRONIC DEVICES IN WHICH THE PHASE-SHIFT MAY BE SWITCHED BETWEEN ZERO AND PI.1 A. I. BUZDIN, REV. MOD. PHYS. **77**, 935 (2005).2 F. S. BERGERET, A. F. VOLKOV, AND K. B. EFETOV, REV. MOD. PHYS. **77**, 1321 (2005).3 G. B. HALASZ, J. W. A. ROBINSON, J. F. ANNETT, ET AL., PHYS. REV. B **79** (2009).4 Y. V. FOMINOV, A. F. VOLKOV, AND K. B. EFETOV, PHYSICAL REVIEW B **75** (2007).

3EP3E-01

METASTABLE SUPERCONDUCTING QUBIT ***A. J. KERMAN****;* MIT LINCOLN LABORATORY. — ONE OF THE DISTINGUISHING FEATURES OF JOSEPHSON-JUNCTION-BASED QUBITS IS THEIR STRONG COUPLING TO ELECTROMAGNETIC (EM) FIELDS, WHICH PERMITS FAST GATE OPERATIONS (~10-100NS). HOWEVER, IT MAY ALSO BE RESPONSIBLE FOR THEIR SHORT EXCITED-STATE LIFETIMES (~4US): IF THE DECAY IS ELECTROMAGNETIC, ITS RATE DEPENDS ON THE SAME MATRIX ELEMENT WHICH GOVERNS MANIPULATIONS BY EXTERNAL FIELDS. UNFORTUNATELY, UNDERSTANDING SPONTANEOUS DECAY OF THESE CIRCUITS HAS SO FAR PROVED DIFFICULT, BECAUSE IT ALSO DEPENDS ON THEIR EM ENVIRONMENT AT GHZ FREQUENCIES, WHICH IS INFLUENCED BY MICROSCOPIC DEGREES OF FREEDOM IN THE SUBSTRATE, SURFACE OXIDES, OR JJ BARRIER DIELECTRICS. CONSEQUENTLY, A GREAT DEAL OF WORK IS ONGOING TO STUDY THESE DEGREES OF FREEDOM, AND TO REDUCE THEIR NUMBER THROUGH IMPROVED MATERIALS AND FABRICATION. IN THIS PRESENTATION, I WILL DISCUSS A DIFFERENT APPROACH: A QUBIT WHICH IS INSENSITIVE TO HIGH FREQUENCY EM FLUCTUATIONS *BY DESIGN*. THIS IS A DEPARTURE FROM CIRCUIT QED, IN WHICH STRONG TRANSVERSE COUPLING TO EM FIELDS IS BOTH A PREREQUISITE AND A FIGURE OF MERIT. AFTER DESCRIBING THE DETAILS OF THIS NEW QUBIT DESIGN, I WILL DISCUSS THE CONSEQUENCES OF WEAK EM COUPLING, THE FIRST AND FOREMOST OF WHICH IS A (POTENTIALLY) MUCH LONGER EXCITED-STATE LIFETIME. I WILL ALSO DESCRIBE HOW THESE METASTABLE QUBITS CAN BE MANIPULATED AND COUPLED TO EACH OTHER, AS WELL AS READ OUT AND INITIALIZED.

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3EP3E-02

EVOLUTION OF TWO-LEVEL QUANTUM SYSTEM UNDER DETERMINED EXPOSURE ***N. V. KLENOV****,* *A. V. SHARAFIEV, S. V. BAKURSKY, V. K. KORNEV, N. G. PUGACH;* MOSCOW STATE UNIVERSITY. — TWO-LEVEL QUANTUM SYSTEM BEHAVIOR CAUSED BY DETERMINED EXTERNAL EXPOSURE IS CONSIDERED. EVOLUTION OF DENSITY MATRIX OF THE SYSTEM HAS BEEN ANALYZED ANALYTICALLY AND NUMERICALLY IN THE FRAME OF LINDBLAD EQUATION. DECAY OF COHERENT STATE HAS BEEN ANALYZED AT DIFFERENT RIGIDNESS FACTORS OF THE TIME-DEPENDENT EXTERNAL FORCE. THE RESEARCH RESULTS ARE DISCUSSED FROM VIEWPOINT OF ACCOMPLISHMENT OF BALLISTIC READOUT AND LOGIC OPERATIONS WITH THREE- AND TWO-JUNCTION SUPERCONDUCTING QUBITS. ADDITIONAL ADVANTAGES COMING FROM IMPLEMENTATION OF THE FERROMAGNET-BASED JOSEPHSON JUNCTIONS ARE CONSIDERED AS WELL.

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3EP3E-03

DEUTERATED ALUMINUM OXIDE FOR SUPERCONDUCTING CIRCUITS ***K. OSBORN****[1], M. KHALIL[1], M. STOUTIMORE[1], S. GLADCHENKO[1], G. RUBLOFF[2], C. MUSGRAVE[3], F. WELLSTOOD[2], C. LOBB[2];* [1]LABORATORY FOR PHYSICAL SCIENCES, [2]UNIVERSITY OF MARYLAND, COLLEGE PARK, [3]UNIVERISTY OF COLORADO, BOULDER. — AMORPHOUS ALUMINUM OXIDE IS THE PREVALENT JUNCTION BARRIER IN SUPERCONDUCTING CIRCUITS, INCLUDING SUPERCONDUCTING QUBITS. LOSS ORIGINATING IN THIS BARRIER LEADS TO QUBIT RELAXATION AND DECOHERENCE. THE DEFECT IS CONVENTIONALLY DESCRIBED BY A TUNNELING TWO-LEVEL SYSTEM, WHERE THE TUNNELING MASS INCLUDES HYDROGEN. TO INVESTIGATE THIS BARRIER WE EMPLOY ATOMIC LAYER DEPOSITION, KNOWN FOR ITS CONFORMAL GROWTH OF NANOSCALE ALUMINUM OXIDE LAYERS. WE WILL STUDY SUPERCONDUCTING ALUMINUM RESONATORS WHERE THE QUALITY FACTOR OF THE RESONATOR IS DOMINATED BY THICK LAYERS OF ALD-GROWN ALUMINUM OXIDE. IN ORDER TO INVESTIGATE THE MASS DEPENDENCE ON THE DEFECT TUNNELING STATES, THE ALUMINUM OXIDE FILMS CONTAIN EITHER HYDROGEN (ALOX:H) OR DEUTERIUM (ALOX:D) IMPURITIES. THE RESULTS ARE COMPARED TO ALUMINUM RESONATORS WITH AMORPHOUS ALUMINUM OXIDE ONLY PRESENT AS A NATIVE OXIDE. PROGRESS TOWARDS MEASURING THE QUALITY OF ALD-GROWN TUNNELING BARRIERS IN A JOSEPHSON JUNCTION RESONATOR WILL ALSO BE PRESENTED.

M.S., G.R., C.M., AND C.L. ACKNOWLEDGE IARPA FOR FUNDING THIS WORK.

3EP3E-04

BARRIER DEFECT ANALYSIS USING JOSEPHSON JUNCTION RESONATORS ***M. STOUTIMORE****[1], M. KHALIL[1], C. LOBB[1], F. WELLSTOOD[1], K. OSBORN[2];* [1]UNIVERSITY OF MARYLAND, COLLEGE PARK, [2]LABORATORY FOR PHYSICAL SCIENCES. — SIMILAR TO PHASE QUBITS, JOSEPHSON JUNCTION (JJ) RESONATORS COUPLE TO DEFECTS IN THE JUNCTION BARRIER. THIS CAUSES SPLITTINGS IN THE SPECTROSCOPY OF THE

RESONATOR WHEN IT IS EXCITED NEAR SINGLE-PHOTON ENERGIES. WE HAVE DESIGNED JJ RESONATORS BY ADDING AN AL/ALOX/AL JOSEPHSON JUNCTION IN PARALLEL WITH A COPLANAR LOW-LOSS CAPACITOR AND AN INDUCTOR SO THAT THE TOTAL LOSS IS DOMINATED BY THE JUNCTION BARRIER. MEASUREMENTS ARE PERFORMED IN A DILUTION REFRIGERATOR AT 30MK WITH A DRIVE FREQUENCY OF APPROXIMATELY 7GHZ. BY APPLYING A DC FLUX BIAS, WE CAN TUNE THE RESONANCE FREQUENCY BY MORE THAN 1GHZ. ANALYSIS OF THE FREQUENCY OF SPLITTINGS AS A FUNCTION OF JUNCTION AREA AND BARRIER GROWTH PROCESS PROVIDES A METHOD FOR DETERMINING THE SOURCE OF THE DEFECTS. TOWARD THIS END, WE WILL PRESENT OUR WORK ON AMORPHOUS ALUMINUM OXIDE BARRIERS AND OUR PROGRESS IN STUDYING NOVEL BARRIER DIELECTRICS.

3EP3E-05

FIRST ORDER PHASE TRANSITION AND CIRCUIT QUANTUM ELECTRODYNAMICS OF A QUANTUM ISING MODEL IN A SUPERCONDUCTING CIRCUIT ***L. TIAN;*** UNIVERSITY OF CALIFORNIA, MERCED. — CIRCUIT QUANTUM ELECTRODYNAMICS HAS BEEN INTENSIVELY EXPLORED IN THE PAST FEW YEARS, WHERE VARIOUS QUANTUM OPTICAL EFFECTS SUCH AS THE LAMB SHIFT, SINGLE PHOTON BEHAVIOR, AND LASING HAVE BEEN OBSERVED. THE SUPERCONDUCTING RESONATORS PROVIDE A POWERFUL TOOL TO STUDY NOVEL PHENOMENA INVOLVING MICROWAVE PHOTONS. IN THIS WORK, WE WILL STUDY THE NONLINEAR BEHAVIOR OF A SUPERCONDUCTING RESONATOR COUPLING WITH A QUANTUM MANY-BODY SYSTEM CONSTRUCTED BY SUPERCONDUCTING QUBITS. THE QUANTUM MANY-BODY SYSTEM BEING CONSIDERED IS THE QUANTUM ISING MODEL FOR A QUBIT CHAIN. USING A SEMICLASSICAL APPROACH, WE SHOW THAT FIRST ORDER PHASE TRANSITION CAN BE OBSERVED IN THE QUBIT CHAIN WHEN INCREASING THE DRIVING POWER ON THE RESONATOR INSTEAD OF THE SECOND ORDER PHASE TRANSITION IN A SIMPLE QUANTUM ISING MODEL. OUR STUDY ALSO SHOWS THAT A BISTABLE REGIME FOR THE QUBIT CHAIN EXISTS, WHERE THE SYSTEM CAN BE IN EITHER THE PARAMAGNETIC PHASE OR THE FERROMAGNETIC PHASE. THE SUPERCONDUCTING CIRCUIT THAT IMPLEMENTS THIS MODEL IS STUDIED IN DETAIL WHERE THE COUPLING BETWEEN THE QUBIT AND THE RESONATOR IS ACHIEVED BY MODULATING THE INDUCTANCE OF THE SUPERCONDUCTING RESONATOR USING THE QUBITS. A FULL QUANTUM SIMULATION ON A TWO-QUBIT TOY MODEL COUPLING WITH THE RESONATOR IS CONDUCTED, WHICH SHOWS THE EFFECT OF THE QUANTUM FLUCTUATIONS ON THE PREDICTED NONLINEAR BEHAVIOR.

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3EP3E-06

LOCALIZATION OF METAL-INDUCED GAP STATES AT THE METAL-INSULATOR INTERFACE: ORIGIN OF FLUX NOISE IN SQUIDS AND SUPERCONDUCTING QUBITS ***S. CHOI****, D. LEE, J. CLARKE, S. G. LOUIE;*** THE UNIVERSITY OF CALIFORNIA. — THE ORIGIN OF MAGNETIC FLUX NOISE IN DC SUPERCONDUCTING QUANTUM INTERFERENCE DEVICES (SQUIDS) WITH A POWER SPECTRUM SCALING AS $1/f$ (f IS FREQUENCY) HAS BEEN A PUZZLE FOR OVER 25 YEARS. THIS NOISE LIMITS BOTH THE LOW FREQUENCY PERFORMANCE OF SQUIDS AND THE DECOHERENCE TIME OF FLUX-SENSITIVE SUPERCONDUCTING QUBITS, MAKING SCALING-UP FOR QUANTUM COMPUTING PROBLEMATIC. RECENT CALCULATIONS AND EXPERIMENTS INDICATE THAT THE NOISE IS GENERATED BY ELECTRONS THAT RANDOMLY REVERSE THEIR SPIN DIRECTIONS. THEIR AREAL DENSITY OF ~ 5×10^{17} M^2 IS RELATIVELY INSENSITIVE TO THE NATURE OF THE SUPERCONDUCTOR AND SUBSTRATE. HERE, WE PROPOSE THAT THE LOCAL MAGNETIC MOMENTS ORIGINATE IN METAL-INDUCED GAP STATES (MIGSS) LOCALIZED BY POTENTIAL DISORDER AT THE METAL-INSULATOR INTERFACE. MIGSS ARE PARTICULARLY SENSITIVE TO SUCH DISORDER, SO THAT THE LOCALIZED STATES HAVE A COULOMB REPULSION SUFFICIENTLY LARGE TO MAKE THEM SINGLY OCCUPIED. OUR NUMERICAL SIMULATIONS, INCLUDING LONG-RANGE COULOMB AND POSSIBLE KONDO RESONANCE EFFECTS, DEMONSTRATE THAT A MODEST LEVEL OF DISORDER GENERATES THE REQUIRED AREAL DENSITY OF LOCALIZED MOMENTS. THIS RESULT SUGGESTS THAT THE MAGNITUDE OF FLUX NOISE COULD BE REDUCED BY FABRICATING SUPERCONDUCTOR-INSULATOR INTERFACES WITH LESS DISORDER.

US DOE DE-AC02-05CH11231, SAMSUNG FOUNDATION, TERAGRID, NERSC.

3EP3E-07

MICROWAVE DISPERSION AND RESONANT INTERACTION IN A TRAVELING-WAVE JOSEPHSON PARAMETRIC AMPLIFIER ***H. R. MOHEBBI****, A. H. MAJEDI;*** UNIVERSITY OF WATERLOO, INSTITUTE FOR QUANTUM COMPUTING. — A NOVEL NONLINEAR TRANSMISSION LINE (TL) WHICH IS PERIODICALLY LOADED BY JOSEPHSON JUNCTIONS (JJ) IS PROPOSED AS A PLATFORM TO INVESTIGATE THE ASPECTS OF TRAVELING-WAVE PARAMETRIC AMPLIFICATION. THE INFLUENCE OF DISPERSION TO SUSTAIN THREE NON-DEGENERATE PHASED-LOCKED WAVES THROUGH THE TL IS HIGHLIGHTED. HAVING WEAK NONLINEARITY AND SLOW VARYING ASSUMPTIONS, WE EXPLOIT THE PERTURBATION THEORY WITH THE MULTIPLE SCALE TECHNIQUE TO DERIVE THE THREE COUPLED AMPLITUDE EQUATIONS TO DESCRIBE THE WAVE INTERACTION. BOTH CASES OF PERFECT PHASE-MATCHING AND SLIGHT MISMATCHING ARE ADDRESSED IN THIS WORK. THE NUMERICAL ANALYSIS BASED ON THE SPECTRAL METHOD IN SPACE AND FINITE DIFFERENCE IN TIME DOMAIN ARE USED TO MONITOR THE UNILATERAL GAIN, STABILITY AND BANDWIDTH OF THIS STRUCTURE. THESE PROPERTIES MAKE THIS STRUCTURE DESIRABLE FOR APPLICATIONS RANGING FROM SUPERCONDUCTING OPTOELECTRONICS TO DISPERSIVE READOUT OF SUPERCONDUCTING QUBITS.

3EP3F-01

TWO CHANNEL HTS SQUID GRADIOMETER SYSTEM FOR DETECTION OF METALLIC CONTAMINANTS IN A LITHIUM ION

BATTERY ***S. TANAKA***[1]*, T. AKAI*[1]*, M. TAKAMOTO*[1]*, Y. KITAMURA*[1]*, Y. HATSUKADE*[1]*, T. OHTANI*[2]*, S. SUZUKI*[1]*;* [1]TOYOHASHI UNIVERSITY OF TECHNOLOGY, [2]ADVANCE FOOD TECHNOLOGY CO., LTD.. — TWO CHANNEL HIGH-TC SQUID GRADIOMETER SYSTEM FOR DETECTION OF MAGNETIC FOREIGN MATTERS IN A LITHIUM ION BATTERY WAS DEVELOPED. FINDING ULTRA-SMALL METALLIC FOREIGN MATTERS IS A BIG ISSUE FOR A MANUFACTURER, WHICH PRODUCES COMMERCIAL PRODUCTS SUCH AS A LITHIUM ION BATTERY. IF IT HAPPENS, THE MANUFACTURE OF THE PRODUCT SUFFERS A LARGE AMOUNT OF LOSS TO RECALL FOR THE PRODUCTS. OUTER DIMENSION OF METALLIC PARTICLES LESS THAN 100 MICRON CAN NOT BE DETECTED BY A CONVENTIONAL X-RAY IMAGING. THEREFORE A HIGH SENSITIVE DETECTION SYSTEM FOR SMALL FOREIGN MATTERS IS REQUIRED. HOWEVER MOST OF THE CASE, THE MATRIX OF AN ACTIVE MATERIAL COATED SHEET ELECTRODE IS MAGNETIZED AND THE MAGNETIC SIGNAL FROM THE MATRIX IS LARGE ENOUGH TO MASK THE SIGNAL FROM CONTAMINANTS. THUS WE HAVE DEVELOPED A DETECTION SYSTEM BASED ON A SINGLE CHANNEL SQUID GRADIOMETER AND A HORIZONTAL MAGNETIZATION TO DATE. FOR PRACTICAL USE, WE SHOULD INCREASE THE DETECTION WIDTH OF THE SYSTEM BY EMPLOYING MULTIPLE SENSORS. IN THIS PAPER, WE PRESENT THE TWO CHANNEL HIGH-TC SQUID GRADIOMETER SYSTEM FOR INSPECTION OF AN ACTIVE MATERIAL COATED SHEET ELECTRODE OF A LITHIUM ION BATTERY. TWO SQUID GRADIOMETERS WERE MOUNTED IN PARALLEL WITH SEPARATION OF 12 MM. AS A RESULT, SMALL IRON PARTICLES OF LESS THAN 100 MICRON IN WIDTH OF 22 MM WERE SUCCESSFULLY MEASURED. THIS IS THE FIRST PRACTICAL SYSTEM FOR THE DETECTION OF THE CONTAMINANTS IN A LITHIUM ION BATTERY.

3EP3F-02

NON-DESTRUCTIVE EVALUATION OF DEEP-LYING DEFECTS IN MULTILAYER CONDUCTORS USING HTS SQUID GRADIOMETER ***J. KAWANO****, T. HATO, S. ADACHI, Y. OSHIKUBO, A. TSUKAMOTO, K. TANABE;* INTERNATIONAL SUPERCONDUCTIVITY TECHNOLOGY CENTER. — NON-DESTRUCTIVE EVALUATION (NDE) BASED ON EDDY CURRENT TECHNIQUE WITH A SQUID GENERALLY HAS AN ADVANTAGE OVER THE CONVENTIONAL EDDY CURRENT NDE SUCH AS APPLICABILITY TO DETECTION OF DEEP-LYING DEFECTS IN CONDUCTING MATERIALS. IN THE PRESENT STUDY, WITH THE AIM OF APPLYING A SQUID NDE TECHNIQUE TO SUPERCONDUCTING POWER DEVICES WITH MULTILAYER CONDUCTOR STRUCTURES AS WELL AS THICK METAL PLATES, WE HAVE EXAMINED THE ABILITY OF DETECTING DEFECTS IN MULTILAYER CONDUCTORS CONSISTING OF ALUMINUM OR INCONEL-600 PLATES BY USING AN HTS SQUID GRADIOMETER. PLANAR HTS SQUID GRADIOMETER WITH 1-3 MM SQUARE PICKUP LOOPS AND THE BASELINE OF 1-3 MM WERE FABRICATED BY USING HTS MULTILAYER AND RAMP-EDGE JUNCTION TECHNOLOGIES. IT WAS COOLED BY THERMAL CONDUCTION FROM A LN2 CRYOSTAT. A DOUBLE-D TYPE INDUCTION COIL WAS USED. WE CONFIRMED THAT DEFECTS SUCH AS 30 MM LONG AND 0.3 MM WIDE SLOTS WITH 2 MM DEPTH LOCATED AT THE BOTTOM OF MULTILAYER PLATES WITH THE TOTAL THICKNESS OF 20 MM OR LARGER CAN BE CLEARLY DETECTED. THE DIFFERENCE IN THE FREQUENCY DEPENDENCE OF THE DETECTED SIGNAL AMPLITUDE FOR THE ALUMINUM AND INCONEL-600 SAMPLES WAS WELL EXPLAINED BY THE DIFFERENCE IN THEIR ELECTRICAL CONDUCTIVITY.

THIS WORK WAS SUPPORTED BY THE NEW ENERGY AND INDUSTRIAL TECHNOLOGY DEVELOPMENT ORGANIZATION (NEDO).

3EP3F-03

HTS-RF-SQUID MICROSCOPE FOR METALLIC CONTAMINANT DETECTION ***M. TAKEMOTO****, T. AKAI, Y. KITAMURA, Y. HATSUKADE, S. TANAKA;* TOYOHASHI UNIVERSITY OF TECHNOLOGY. — RECENTLY, FINE METALLIC CONTAMINANTS MIXED IN INDUSTRIAL PRODUCTS CAUSE THE SERIOUS PROBLEMS. THEREFORE, WE HAVE DEVELOPED THE HTS-RF-SQUID DETECTORS FOR THE CONTAMINANT OF LESS THAN 0.1 MM IN THE INDUSTRIAL PRODUCTS. IN THE DETECTORS, WE HAVE USED HTS-RF-SQUID WITH THE SUBSTRATE RESONATOR AND THE FLUX FOCUSER. HOWEVER, SINCE THE HTS-RF-SQUID IS PLACED FACE TO FACE WITH THE FLUX FOCUSER ON THE RESONATOR, THE DISTANCE BETWEEN THE SQUID AND A SAMPLE CAN NOT BE SHORTENED TO LESS THAN THE THICKNESS OF THE RESONATOR. THIS CONFIGURATION IS THE DISADVANTAGE AS TO THE SENSITIVITY. THEREFORE, WE DESIGNED AND FABRICATED THE INTEGRATED HTS-RF-SQUID BASED ON A SINGLE $SRTIO_3$ BICRYSTAL SUBSTRATE RESONATOR, COMBINING THE HTS-RF-SQUID, FLUX FOCUSER, AND RESONATOR INTO A SINGLE CHIP. WE TESTED DIFFERENT SIZES OF THE SQUID HOLE WITH VARIOUS INDUCTANCES TO OPTIMIZE THE SENSITIVITY. THE FIELD SENSITIVITY OF 120 $FT/HZ^{1/2}$ IN THE WHITE REGION WAS OBTAINED WITH THE SQUID HOLE SIZE OF 50 MM X 800 MM. THEN, WE INTRODUCED THE SQUID TO THE CONTAMINANT DETECTOR UTILIZING THE SQUID MICROSCOPIC TECHNOLOGY, TO PERFORM THE DETECTION OF A FINE FERROMAGNETIC CONTAMINANT WITH DIAMETER OF 100 MM. AS THE RESULT, WE COULD MEASURE THE SIGNAL FROM THE CONTAMINANT WITH LIFTOFF OF 1.5 MM, WHICH WAS 6 TIMES LARGER THAN THAT WITH LIFTOFF OF 3 MM.

3EP3F-04

MODEL BASED INVERSE SOLUTION OF SQUID NDE USING A NEW NUMERICAL MODEL FOR THE EXTRACTION OF FLAW-INDUCED CURRENT INTERACTIONS *F. SARRESHTEDARI, S. RAZMKHAH, N. HOSSEINI, K. MEHRANY, H. KOKABI, J. SCHUBERT, M. BANZET,* ***M. FARDMANESH****;* SHARIF UNIVERSITY OF TECHNOLOGY. — INCORPORATING AN ANALYTICAL APPROACH TO SIMULATE THE INTERACTION OF A SERIES OF LONG CRACKS AND THE INDUCED CURRENT OF A DOUBLE-D EXCITATION COIL, WE HAVE DEVELOPED A MODEL BASED METHOD TO DO PRECISE DETECTION OF THE POSITIONS OF THE CRACKS IN A METALLIC STRUCTURE BY USING EDDY CURRENT SQUID NDE MEASUREMENTS. CONVENTIONALLY, THE STRUCTURE OF THE DEFECTS IS FOUND BY ITERATIVELY

SOLVING A NUMERICAL FORWARD PROBLEM WHICH IS USUALLY BASED ON FEM, BEM OR VIM METHODS. THIS HOWEVER INCURS A HEAVY NUMERICAL BURDEN, AS EVERY TIME THE FORWARD PROBLEM IS TO BE SOLVED, A RIGOROUS NUMERICAL MODEL SHOULD BE INEVITABLY EMPLOYED TO EXTRACT THE COMPLEX DISTRIBUTION PATTERN OF THE INDUCED CURRENT ENCOUNTERING DEFECTS OF THE STRUCTURE. IN THIS WORK AN ANALYTICAL APPROACH IS USED FOR THE MODELING OF THE INTERACTION OF THE INDUCED CURRENT AND A SERIES OF CRACKS IN THE SAMPLE. IT DULY CONSIDERS THE DISTRIBUTION OF THE INDUCED CURRENT IN THE FLAWED SAMPLES, DOES NOT CALL FOR EXTREMELY HIGH COMPUTATIONAL RESOURCE, AND THUS PERMITS EFFICIENT NON-DESTRUCTIVE EVALUATION AS THE FORWARD PROBLEM CAN BE SOLVED WITHIN A REASONABLE TIME. HERE, A HIGH-T_C FIRST ORDER RF SQUID GRADIOMETER IS EMPLOYED AS THE MAGNETIC SENSOR OF THE NDE SYSTEM TO SCAN THE SAMPLES WITH DIFFERENT CRACKS. THE ACCURACY OF THE PROPOSED ALGORITHM IS VERIFIED BY HAVING THE EXTRACTED SHAPE OF THE DEFECTS OBTAINED BY APPLYING THE PROPOSED ALGORITHM ON THE SQUID NDE MEASUREMENTS AGAINST THE ACTUAL CRACKS.

INDEX TERMS— SQUID NDE, MAGNETIC FORWARD MODELING, CRACK MODELING.

3EP3F-05

SQUID SUSCEPTOMETER FOR SMALL-SCALE SAMPLES AT LOW TEMPERATURES ***A. KIRSTE****, M. PETERS, T. SCHURIG;* PHYSIKALISCH-TECHNISCHE BUNDESANSTALT (PTB). — WE HAVE DEVELOPED AND CHARACTERIZED A PROTOTYPE OF A SQUID SUSCEPTOMETER FOR THE INVESTIGATION OF SMALL-SCALE (~MM) SAMPLES AT LOW TEMPERATURES. IT CONSISTS OF AN AXIAL FIRST-ORDER GRADIOMETER COIL CONNECTED TO A HIGH-INPUT INDUCTANCE DC SQUID CURRENT SENSOR. A LONG SOLENOID MADE FROM THIN COPPER WIRE IS MOUNTED SYMMETRICALLY WITH RESPECT TO THE CENTER OF THE GRADIOMETER AND USED AS A FIELD COIL TO MAGNETIZE THE SAMPLE. DEPENDING ON THE NUMBER OF LAYERS (AND TURNS) OF THE FIELD COIL, THE SQUID SENSOR CAN BEHAVE QUITE DIFFERENTLY. WHILE A DOUBLE- AND A FOUR-LAYER FIELD COIL SHOW THEIR FIRST AS WELL AS HIGHER SELF-RESONANCES BUT ALLOW A STABLE SQUID OPERATION AT ALL WORKING POINTS, AN EQUALLY SIZED SINGLE-LAYER FIELD COIL CAN CAUSE HIGH-FREQUENCY OSCILLATIONS IN THE SQUID IN THE MHZ RANGE AT SOME WORKING POINTS.UPON INTEGRATION OF THE COIL SYSTEM IN A SUPERCONDUCTING SHIELD, THE BALANCE OF THE GRADIOMETER INSIDE THE FIELD COIL IS TUNED FROM THE GEOMETRIC COMPENSATION RATIO OF THE GRADIOMETER OF ABOUT 0.05 TO VALUES BETTER THAN 1E-6 FOR FREQUENCIES UP TO 1 KHZ BY MEANS OF AN INDEPENDENT COMPENSATION COIL. WE PRESENT MEASUREMENTS ON DIFFERENT SAMPLES IN DIRECT COMPARISON TO DATA OBTAINED IN A COMMERCIAL SQUID SUSCEPTOMETER (QD MPMS XL).

THIS WORK HAS BEEN PARTLY SUPPORTED BY THE EUROPEAN COMMISSION UNDER GRANT NO. 228464.

3EP3F-06

PHASE-DIFFUSION IN SWITCHING PROCESS OF UNDERDAMPED JOSEPHSON JUNCTIONS ***X. TAN****, C. PAN, Y. YU;* NANJING UNIVERSITY. — THERMAL ACTIVATED ESCAPE OVER A POTENTIAL BARRIER IS UBIQUITOUS IN MANY FIELDS. A CURRENT BIASED JOSEPHSON JUNCTION SERVE AS AN EXCELLENT SYSTEM TO QUANTITATIVELY STUDY THE THERMAL ESCAPE FROM A POTENTIAL WELL. ALTHOUGH THE OBSERVED THERMAL ESCAPE AGREED WITH THEORETICAL PREDICTION VERY WELL, PHASE-DIFFUSION HAS BEEN REPORTED AT CERTAIN SITUATIONS, WITH THE ORIGINATION UNCLEAR. HERE WE MEASURED THE SWITCHING PROCESS, TRANSITION FROM A SUPERCONDUCTING STATE TO A QUASIPARTICLE-TUNNELING STATE, IN A DC SQUID, WHICH HAS MORE TUNABLE PARAMETERS THAN A SINGLE JOSEPHSON JUNCTION. IT WAS FOUND THAT THE WIDTH AND THE MEAN OF THE SWITCHING CURRENT DISTRIBUTION DEPEND ON THE TEMPERATURE AND MAGNETIC FIELD. THE PHASE-DIFFUSION FOR THE SWITCHING CURRENT DISTRIBUTION WAS OBSERVED WITH TEMPERATURE INCREASE. A MODIFIED METHOD BASED ON THE RETRAPPING MODEL WAS DEVELOPED TO ADDRESS THE EXPERIMENTAL RESULTS.

THE AUTHORS WOULD LIKE TO THANK S. ZHAO FOR SAMPLE FABRICATION. THIS WORK WAS PARTIALLY SUPPORTED BY NSFC (10725415), THE STATE KEY PROGRAM FOR BASIC RESEARCH OF CHINA (2006CB921801).

3EP3F-07

ROTATING AXIAL HTS SQUID GRADIOMETER WITH AN ON-AXIS SQUID READ-OUT SCHEME ***K. E. LESLIE****, K. BLAY, R. A. BINKS, P. CUSACK, J. DU;* CSIRO. — THE CONCEPT AND CONSTRUCTION OF AN HTS FLEXIBLE-TAPE ROTATING AXIAL GRADIOMETER HAS BEEN DESCRIBED PREVIOUSLY. IN THE ORIGINAL DESIGN, A SUPERCONDUCTING SHIELD WAS USED TO REDUCE THE READ-OUT SQUID'S SENSITIVITY TO UNWANTED MAGNETIC FIELDS. THE LEVEL OF SHIELDING ACHIEVED PROVED INADEQUATE; THE GRADIOMETER'S RESPONSE WAS CONTAMINATED BY SIGNALS RELATED TO THE MOVEMENT OF THE GRADIOMETER IN THE EARTH'S FIELD. THE NEED FOR SHIELDING THE READ-OUT SQUID CAN BE AVOIDED BY MAKING THIS SENSOR AN INHERENT PART OF THE GRADIOMETER DESIGN. IN THE ALTERNATIVE DESIGN, AN ASYMMETRICALLY-PATTERNED TAPE IS MAGNETICALLY COUPLED TO AN AXIALLY-ORIENTED SQUID TO FORM AN AXIAL GRADIOMETER. THE COMMON-MODE BALANCE OF THIS AXIAL GRADIOMETER CAN BE ADJUSTED BY VARYING THE STRENGTH OF COUPLING BETWEEN THE SQUID AND THE TAPE. THE LEVEL OF COUPLING REQUIRED FOR AN IDEAL BALANCE IS CALCULATED THEORETICALLY USING THE FASTHENRY MODELLING PACKAGE. THE LEVEL OF COUPLING REQUIRED FOR A GOOD BALANCE WAS FOUND EXPERIMENTALLY TO DIFFER SIGNIFICANTLY FROM THAT PREDICTED VIA THEORY. WORK TO MORE FULLY UNDERSTAND THIS MISMATCH IS CURRENTLY UNDERWAY. THE MEASURED COMMON-MODE PERFORMANCE OF THIS NEW DESIGN WILL BE USED TO DETERMINE THE FEASIBILITY OF THIS DESIGN FOR

DEPLOYMENT IN A FULL THREE-AXIS ROTATING GRADIOMETER.

3EP3F-08

IMAGING OF ELECTRIC CURRENTS BY ULTRASONOGRAPHY AND SQUID MAGNETOMETRY ***D. OYAMA***[1], *M. HIGUCHI*[1], *Y. ADACHI*[1], *J. KAWAI*[1], *G. UEHARA*[1], *H. KADO*[1], *K. KOBAYASHI*[2]; [1]KANAZAWA INSTITUTE OF TECHNOLOGY, [2]IWATE UNIVERSITY. — WE PROPOSE A NEW SQUID IMAGING METHOD OF MAGNETIC SOURCES BY SONOGRAPHIC MODULATION, WHICH WE CALL "SONOMAGNETOMETRY". WE EXPECT THE METHOD ENABLES THE SIMULTANEOUS OBSERVATION OF MAGNETIC SOURCE DISTRIBUTION IN A BIOLOGICAL OBJECT AND ITS MORPHOLOGICAL IMAGE.HOWEVER, THERE IS A CONCERN THAT ULTRASOUND SCANNER MIGHT INTERFERE WITH SQUID MAGNETOMETERS DEPENDING ON THE POSITION OF TWO DEVICES. TO EXAMINE IT, WE USED A GELATIN BLOCK, AS A MODEL OF BIOLOGICAL OBJECT, PIERCED THROUGH BY A COPPER WIRE.AN ELECTRIC CURRENT WAS APPLIED TO THE WIRE AND THE MAGNETIC SIGNAL WAS MEASURED BY THE SQUID, WHILE THE ECHO IMAGE OF THE WIRE WAS TAKEN BY ULTRASOUND SCANNER. THE DISTANCE BETWEEN TWO DEVICES WAS 7 CM. AT THE SQUID SYSTEM, THE WHITE NOISE LEVEL INCREASED APPROXIMATELY 1 FT/HZ$^{1/2}$ AND PERIODIC NOISES WERE OBSERVED AT 25.8 HZ AND ITS HARMONICS. THE ORIGIN OF 25.6 HZ NOISE WAS ULTRASONIC SCANNING. THESE INTERFERENCES WERE NOT FATAL TO THE SQUID MAGNETOMETERS AS WE HAVE CONCERNED BEFORE.A MAGNETIC FIELD IMAGE WAS ALIGNED WITH THE ECHO IMAGE IN REFERENCE TO MARKER COILS SET ON THE ULTRASOUND PROBE. A MAGNETIC SOURCE WAS LOCALIZED BY SOLVING INVERSE PROBLEM AND WAS COMPARED WITH THE ECHO IMAGE OF THE WIRE. THE POSITION ERROR WAS 6.3MM. THESE RESULTS SHOW POSSIBILITY OF A NEW SQUID IMAGING METHOD WITH AN ULTRASOUND SCANNER.

3EP3F-09

A SIMPLE TEMPERATURE SENSOR WITH NANOKELVIN SENSITIVITY FROM 250-1000MK ***W. A. HOLMES****, K. I. PENANEN;* JET PROPULSION LABORATORY/CALTECH. — WE HAVE DEMONSTRATED A CRYOGENIC THERMOMETER CAPABLE OF RESOLVING NANOKELVIN TEMPERATURE CHANGES OVER A TEMPERATURE RANGE 0.25-1K. THE THERMOMETER IS BASED ON THE CHANGE OF THE MAGNETIC SUSCEPTIBILITY WITH TEMPERATURE OF ND DOPED YTTRIUM ALUMINUM GARNET (ND-YAG) MEASURED WITH A QUANTUM DESIGN DC SQUID READOUT WITH APPLIED PHYSICS ELECTRONICS. THE SENSOR WAS MADE USING A CHUNK OF ND-YAG LASER ROD CRYSTAL BIASED WITH A PERMANENT MAGNETS INSIDE A SUPERCONDUCTING SHIELD. THE DC SQUID READOUT HAD FLUX COUNTING CAPABILITY WHICH ACCOMMODATED THE OPERATIONAL RANGE OF THE SENSOR. THE MEASURED SENSOR NOISE IS 30-50NKP-P IN A 10HZ BANDWIDTH OVER THE FULL TEMPERATURE RANGE 0.25-1K. THE LOW NEEL TEMPERATURE OF ND-YAG SUGGESTS SIMILAR PERFORMANCE CAN BE OBTAINED AT TEMPERATURES <50MK. THIS RESEARCH WAS CARRIED OUT AT THE JET PROPULSION LABORATORY, CALIFORNIA INSTITUTE OF TECHNOLOGY, UNDER A CONTRACT WITH THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION.

3EP3F-10

A NON-DESTRUCTIVE BEAM MONITORING SYSTEM BASED ON AN LTS-SQUID ***R. GEITHNER***[1], *R. NEUBERT*[1], *W. VODEL*[1], *M. SCHWICKERT*[2], *H. REEG*[2], *R. VON HAHN*[3], *P. SEIDEL*[1]; [1]FRIEDRICH-SCHILLER-UNIVERSITÄT JENA, GERMANY, [2]GESELLSCHAFT FÜR SCHWERIONENFORSCHUNG (GSI) DARMSTADT, GERMANY, [3]MAX-PLANCK-INSTITUT FÜR KERNPHYSIK HEIDELBERG, GERMANY. — MONITORING OF BEAM CURRENTS IN PARTICLE ACCELERATORS WITHOUT AFFECTING THE BEAM GUIDING ELEMENTS, INTERRUPTING THE BEAM OR INFLUENCING ITS PROFILE IS A MAJOR CHALLENGE IN ACCELERATOR TECHNOLOGY. A SOLUTION TO THIS PROBLEM IS THE DETECTION OF THE MAGNETIC FIELD GENERATED BY THE MOVING CHARGED PARTICLES. WE PRESENT A NON-DESTRUCTIVE BEAM MONITORING SYSTEM FOR PARTICLE BEAMS IN ACCELERATORS BASED ON THE CRYOGENIC CURRENT COMPARATOR PRINCIPLE (CCC). THE CCC CONSISTS OF A HIGH-PERFORMANCE LOW TEMPERATURE DC SUPERCONDUCTING QUANTUM INTERFERENCE DEVICE (LTS DC SQUID) SYSTEM, A TOROIDAL PICK-UP COIL AND A MEANDER-SHAPED SUPERCONDUCTING NIOBIUM SHIELD. THIS DEVICE ALLOWS MEASURING CONTINUOUS AS WELL AS PULSED BEAM CURRENTS IN THE NA-RANGE. THE RESOLUTION AND THE FREQUENCY RESPONSE OF THE DETECTOR STRONGLY DEPEND ON THE TOROIDAL PICK-UP COIL AND ITS EMBEDDED FERROMAGNETIC CORE. INVESTIGATIONS OF BOTH THE TEMPERATURE AND FREQUENCY DEPENDENCE OF THE RELATIVE PERMEABILITY AND THE NOISE CONTRIBUTION OF SEVERAL NANOCRYSTALLINE FERROMAGNETIC CORE MATERIALS ARE CRUCIAL TO OPTIMIZE THE CCC WITH RESPECT TO A BETTER SIGNAL-TO-NOISE RATIO AND EXTENDED TRANSFER BANDWIDTH.

THIS WORK WAS SUPPORTED IN PART BY THE GESELLSCHAFT FÜR SCHWERIONENFORSCHUNG (GSI) DARMSTADT, GERMANY UNDER CONTRACT JVODEL.

3EP3G-01

MAGNETIC FIELD PROVISION FOR MILLIKELVIN EXPERIMENTAL ENVIRONMENTS INCORPORATING AN ULTRA-HIGH VACUUM CAPABILITY ***A. TWIN****, H. AGRAWAL, G. BATEY, J. BURGOYNE, J. BROWN, M. CUTHBERT, T. FOSTER, H. JONES, S. KINGSLEY, C. KING, A. J. MATTHEWS, R. MORRIS, G. TELEBERG, K. TIMMS;* OXFORD INSTRUMENTS NANOSCIENCE. — THE PROVISION OF ULTRA-LOW TEMPERATURE AND MAGNETIC FIELD ENVIRONMENTS FOR ELECTRONIC RESEARCH APPLICATIONS WAS FOR MANY YEARS ACHIEVED BY MEANS OF LIQUID HELIUM FILLED CRYOSTATS AND INSERTS THAT REQUIRED A HIGH LEVEL OF EXPERTISE TO BOTH SET UP AND MAINTAIN. DEVELOPMENTS IN CRYOGEN FREE TECHNOLOGY HAVE NOW ENABLED SUPERCONDUCTING MAGNETS AND DILUTION REFRIGERATORS TO BE COOLED ON A SINGLE PULSE TUBE REFRIGERATOR. THIS GIVES THE EXPERIMENTALIST UNPARALLELED EASE OF ACCESS TO FULL B-T ENVIRONMENTS. THE FUNCTIONALITY AND DETAILED PERFORMANCE OF BOTH

LOW FIELD (NBTI) AND HIGH FIELD (NB_3SN) MAGNETS INTEGRATED ONTO DILUTION REFRIGERATORS ARE DESCRIBED.RECENTLY, PULSE TUBES WITH ULTRA-HIGH VACUUM COMPATIBILITY HAVE BECOME AVAILABLE. THIS HAS WIDENED THE APPLICATION OF CRYOGEN FREE REFRIGERATION TECHNOLOGY INTO THE LOW PRESSURE REGIME. TO FURTHER EXTEND THE EXPERIMENTAL ENVIRONMENTS AVAILABLE TO THE RESEARCHER, LARGE LIQUID CRYOGEN MAGNET SYSTEMS HAVE RECENTLY BEEN BUILT WITH ULTRA-HIGH VACUUM COMPATIBLE LOW TEMPERATURE INSERTS. THE DESIGN AND FULL FUNCTIONALITY OF THESE LEADING EDGE SYSTEMS ARE DESCRIBED IN SOME DETAIL.

3EP3G-02

YBCO CURRENT LEADS IN A CRYOCOOLED SUPERCONDUCTING ELECTRONICS SYSTEM ***R. J. WEBBER****, J. DELMAS, V. DOTSENKO;* HYPRES, INC.. — WE REPORT ON THE INTEGRATION AND OPERATION OF YBCO FLEXIBLE MULTI-LINE LEADS WITH COMPLEX RAPID SINGLE FLUX QUANTUM (RSFQ) CIRCUITS ON A 2-STAGE CRYOCOOLER. THE LEADS ARE USED TO SUPPLY DC BIAS CURRENTS OF ABOUT 30 MA PER LINE TO THE NIOBIUM-BASED RSFQ CIRCUITRY OPERATING AT 4 K. THEY SPAN THE TEMPERATURE DIFFERENCE BETWEEN THE 1^{ST} AND 2^{ND} STAGES OF A GIFFORD-MCMAHON CRYOCOOLER, CUTTING THE HEAT LOAD TO THE 2^{ND} STAGE BY NEARLY A FACTOR OF 10 COMPARED TO OPTIMIZED NORMAL METAL LEADS. THE HEAT LOAD IS DOMINATED BY CONDUCTION THROUGH THE CABLE SUBSTRATE, WHICH IS HASTELLOY, BUT INTERESTINGLY, WHAT WE MEASURE IS APPROXIMATELY 60 % OF WHAT ONE WOULD CALCULATE FROM THE ACCEPTED VALUE OF ITS THERMAL CONDUCTIVITY. WE HAVE MEASURED THE THERMAL AND ELECTRICAL CONDUCTIVITIES OF THE HASTELLOY TAPE AND BELIEVE THAT THEY ARE CHANGED DURING OXYGEN ANNEALING OF THE YBCO OR PERHAPS AT ANOTHER STAGE OF THE SUPERCONDUCTING TAPE MANUFACTURE.

THIS WORK WAS FUNDED IN PART BY THE OFFICE OF NAVAL RESEARCH

3EP3G-03

CRYOGENIC TEST-BED APPLIED TO 9K NBN RSFQ DEVICES OPERATION ***M. AURINO****[1], S. BOUAT[1], E. BAGGETTA[1], V. MICHAL[1], D. RENAUD[2], C. BORNIER[3], M. LAINE[3], J. VILLEGIER[1];* [1]CEA-INAC, [2]CEA-LETI, [3]ID3 SEMICONDUCTORS. — **CRYOGENIC TEST-BED APPLIED TO 9K NBN RSFQ DEVICES OPERATION**NBN RSFQ CIRCUITS OPERATING AT 9K INSTEAD OF NB ONES, REDUCE THE COOLING CONSTRAINTS ESPECIALLY FOR PORTABLE, REMOTE, TELECOMS OR IMAGING APPLICATIONS, FOCUS OF THE HYPERSCAN AD-CONVERTER PROJECT. WE HAVE DEVELOPED A TEST-BED TO STUDY THE OPERATING TEMPERATURE OF THE VARIOUS MIXED RF AND DIGITAL CIRCUIT BLOCKS OF NBN TEST VEHICLE $1X1CM^2$ CHIPS. THE USE OF A WIDESPREAD HELIUM CRYOSTAT ('ORANGE-ILL') ALLOWS US TO OPERATE THE CHIP IN THE RANGE 1.8K-20K WITH A PRECISE NOISELESS STABILIZATION. THE CHIP MOUNTED ON A PCB, SHIELDED BY THE EXTERNAL FIELD, PERMITS TO ADAPT THE CONNECTIONS TO THE DIFFERENT NBN DEVICES DESIGNS: 500 MHZ BW/30GHZ NBTIN CPW FILTERS; RSFQ CLOCK AND TFF DIVIDERS; SQUIDS AND NBN/TAN/NBTIN $0.5\mu M^2$ SNS JUNCTION ARRAYS. WE PRESENT COMPARISON BETWEEN ELECTRICAL SIMULATIONS AND TESTS MADE ON FLEXIBLE, ~80CM LONG, MICROSTRIP-LINE RIBBON CABLE CARRYING 32 SIGNAL AND BIAS LINES IN THE RANGE DC-2GHZ, COMBINED WITH 4 SEMI-RIGID ~40GHZ COAXIAL CABLES. TEMPERATURE AND FREQUENCY OPERATION RANGES OF NBN DEVICES WILL BE SHOWN. THE VALIDATION OF HYPER-FREQUENCY, LOW THERMAL LEAK, CONNECTING SOLUTIONS WILL BE THE BASE OF A FUTURE 9K NBN ADC PORTABLE SYSTEM DEVELOPMENT.

3EP3G-04

COMPARISON OF RANGE CALCULATIONS FOR GSM SIGNALS USING CRYOGENICALLY COOLED RECEIVER SYSTEM MODELS AGAINST LINE-OF-SIGHT PROPAGATION CONSTRAINTS ***A. M. LEESE DE ESCOBAR****[1], M. DE ANDRADE[1], T. GATHMAN[1], D. GUPTA[2];* [1]SPAWAR SYSTEMS CENTER PACIFIC, [2]HYPRES, INC.. — THE USE OF CRYOGENICALLY COOLED FRONT-ENDS IN COMMERCIAL CELLULAR PHONE SYSTEMS IS NOW WIDE SPREAD FOR 77 KELVIN SYSTEMS. CONTINUED USE OF CRYOGENIC COOLING IN COMMERCIAL CELLULAR PHONE SYSTEMS IS LIKELY. THIS WORK EXPLORES THE BENEFITS OF CRYOGENICALLY COOLED FRONT ENDS IN TERMS OF PROPAGATION DISTANCE. SYSTEM NOISE TEMPERATURES FOR THREE RF SYSTEM MODELS AT 300 KELVIN, 77 KELVIN AND 4 KELVIN WERE USED TO CALCULATE THE PROPAGATION DISTANCE OF A GSM-LIKE SIGNAL AND RESULTS COMPARED TO RADIO LINE OF SIGHT CONSTRAINTS.

TACTICAL SIGINT TECHNOLOGY PROGRAM AND THE OFFICE OF NAVAL RESEARCH INTOP INP

3EP3G-05

ADVANCES IN CRYOPACKAGING OF SUPERCONDUCTOR DIGITAL SYSTEMS ***V. DOTSENKO****, J. DELMAS, R. WEBBER, J. TANG, S. GOSWAMI, D. GUPTA;* HYPRES, INC.. — THE CRYOPACKAGING DESIGN OF SUPERCONDUCTOR DIGITAL SYSTEMS HAS BEEN CONTINUOUSLY ADVANCING DURING THE PAST SEVERAL YEARS, RESULTING IN THREE GENERATIONS OF INCREASINGLY SUPERIOR SYSTEMS. MAJOR IMPROVEMENTS WERE ACHIEVED IN HIGH SPEED DIGITAL DATA OUTPUT BY IMPLEMENTING A HIGH QUALITY DATA LINK. IT CONSISTS OF A VACUUM-TIGHT FEEDTHROUGH AND A CRYOGENIC DATA CABLE. A FEEDTHROUGH CONTAINING 20 INDIVIDUAL COAXIAL CONNECTORS WITH GLASS-TO-METAL SEAL, EACH RATED UP TO 60 GHZ, WAS DESIGNED AND MANUFACTURED. EACH CRYOGENIC DATA CABLE COMPRISES 10 STRIPLINES; TWO ARE CONNECTED TO EACH FEEDTHROUGH. THE LATEST SYSTEM, CALLED ADR-005, WAS DESIGNED TO ACCOMMODATE TWO CHIP MODULES RATHER THAN ONE AS IN PREVIOUS GENERATIONS, AND INCLUDES FOUR SUCH 20-COAX FEEDTHROUGHS TO SUPPORT THE ENHANCED DATA THROUGHPUT REQUIREMENTS. IT WAS ALSO MADE SUBSTANTIALLY MORE COMPACT. THE DESIGN IS MODULAR AND ALLOWS FOR INDEPENDENT SERVICE OF EACH CHIP

MODULE AND QUICK FIELD REPLACEMENT WHEN NECESSARY. COMPACT DESIGN AND REDUCED WEIGHT MAKE THE SYSTEM MORE ROBUST AND RESISTANT TO SHOCKS DURING TRANSPORTATION. IMPROVED ACCESSIBILITY OF ALL PARTS SIMPLIFIES SERVICE, AND ADDITIONS OF OPTIONAL COMPONENTS WHEN DESIRED.

THIS WORK IS SUPPORTED IN PART BY THE OFFICE OF NAVAL RESEARCH

3EP3G-06

ADVANCES IN LARGE-SCALE HIGH-FREQUENCY 'PULSE-TUBE' COOLERS FOR HTS APPLICATIONS ***P. SPOOR****;* CFIC-QDRIVE. — THE INDUSTRIALIZATION OF HTS TECHNOLOGY REQUIRES THE DEVELOPMENT OF RELIABLE, EFFICIENT, AND COST-EFFECTIVE COOLING. MOST PROTOTYPE SYSTEMS TODAY USE CRYOGENS THAT MUST BE CONTINUALLY REPLENISHED (AND OFFER A LIMITED CHOICE OF OPERATING TEMPERATURES) OR GM COOLERS THAT HAVE RELATIVELY LOW EFFICIENCY IN THE 50-70K RANGE, IN ADDITION TO REQUIRING REGULAR MAINTENANCE. SO-CALLED 'PULSE-TUBE' OR ACOUSTIC CRYOCOOLERS HAVE NO INTRINSIC MAINTENANCE REQUIREMENTS AND HAVE HIGHER FUNDAMENTAL EFFICIENCY THAN GM COOLERS, BUT HAVE TYPICALLY BEEN DEVELOPED FOR SMALL AMOUNTS OF LIFT (< TENS OF WATTS) AND HAVE NOT ALLOWED FOR CONVENIENT SEPARATION OF THE COLDHEAD AND COMPRESSOR. THIS PAPER PRESENTS RECENT IMPROVEMENTS IN LARGE-SCALE PULSE TUBE COOLERS, WHICH PROVIDE OVER 200 WATTS OF COOLING AT 77K AT OVER 15% OF CARNOT USING A REMOTELY ATTACHED COAXIAL COLDFINGER. THREE OF THESE COLDFINGERS HAVE BEEN USED ON A LARGER ACOUSTIC COMPRESSOR TO PROVIDE OVER 1000 W OF COOLING AT 77K. A SIMILAR DESIGN IS BEING DEVELOPED TO COOL A SUPERCONDUCTING MAGNET AT 50K. THIS TECHNOLOGY OFFERS A RELIABLE AND EFFICIENT ALTERNATIVE TO EXISTING COOLING SOLUTIONS. PATHS TOWARD HIGH COOLING CAPACITY AT LOWER TEMPERATURES WILL ALSO BE DISCUSSED.

THIS WORK WAS SUPPORTED IN PART BY THE DEPARTMENT OF ENERGY AND BY THE DEPARTMENT OF DEFENSE.

3EP3H-01

FABRICATION OF HIGH PERFORMANCE TRANSITION EDGE SENSOR MICROCALORIMETER KILOPIXEL ARRAYS ***J. A. CHERVENAK****[1], C. N. BAILEY[1], S. R. BANDLER[2], R. P. BREKOSKY[1], A. D. BROWN[1], M. E. ECKART[1], F. M. FINKBEINER[3], R. L. KELLY[1], C. A. KILBOURNE[1], F. S. PORTER[1], J. E. SADLIER[1], S. J. SMITH[2];* [1]NASA GSFC, [2]NASA GSFC AND UNIVERSITY OF MARYLAND, [3]NASA GSFC AND WYLE INFORMATION SYSTEMS. — WHILE TRANSITION EDGE SENSOR (TES) PIXELS WITH HIGH RESOLVING POWER HAVE BEEN DEMONSTRATED, PRODUCING A HIGH QUANTUM EFFICIENCY ARRAY, WHERE PIXELS AND WIRING ARE NECESSARILY CLOSE-PACKED, REQUIRES ADDITIONAL FEATURES TO MAINTAIN THE SINGLE PIXEL PERFORMANCE. WE HAVE FABRICATED A KILOPIXEL ARRAY AND READ OUT PIXELS WITHIN THE ARRAY WITH 2.7 EV RESOLUTION AT 6 KEV X-RAYS. WE ALSO REPORT ON FABRICATION OF KILOPIXEL-SCALE ARRAYS OF TESS WHERE HEATSINKING AND WIRING TECHNIQUES ARE INTEGRATED WITH OUR HIGH RESOLUTION MICROCALORIMETER PROCESS. WE WILL PRESENT PROGRESS TOWARD PRODUCTION AND CHARACTERIZATION OF KILOPIXEL ARRAYS WITH HIGH DENSITY MICROSTRIPLINE WIRING TO EACH PIXEL AND COPPER-FILLED HEATSINKING TRENCHES SURROUNDING EACH PIXEL. WE DISCUSS THE EXTENT TO WHICH THE DESIGN ACHIEVES BETTER CROSSTALK SUPPRESSION AND UNIFORMITY UNDER BIAS AND X-RAY ILLUMINATION.

3EP3H-02

TI/AU TRANSITION-EDGE SENSORS COUPLED TO SINGLE MODE OPTICAL FIBERS ALIGNED BY SI V-GROOVE ***L. LOLLI****, E. TARALLI, C. PORTESI, M. RAJTERI, E. MONTICONE;* INRIM. — TRANSITION-EDGE SENSOR (TES) ARE PROMISING MICRO-CALORIMETERS FOR APPLICATIONS IN THE FIELD OF QUANTUM INFORMATION AND QUANTUM COMPUTATION THANKS TO THEIR PHOTON-NUMBER RESOLVING CAPABILITY. QUANTUM EFFICIENCY (QE) IS FUNDAMENTAL IN SINGLE-PHOTON DETECTION AT VISIBLE AND NEAR-INFRARED WAVELENGTHS, AND IT SHOULD BE AS HIGH AS POSSIBLE. FOR THIS REASON THE COUPLING BETWEEN THE LIGHT SOURCE AND THE SENSOR PLAYS A CRUCIAL ROLE.IN THIS WORK WE PRESENT THE FABRICATION OF TI/AU TESS DEPOSITED ON THE SILICON NITRIDE SUBSTRATE. TI/AU THICKNESSES ARE AROUND 80 NM, OBTAINING TRANSITION TEMPERATURES TC OF THE DEVICES FROM 95 MK TO 130 MK. TWO SENSORS IN THE SAME SUBSTRATE ARE COUPLED WITH TWO OPTICAL FIBERS PRE-ASSEMBLED AT A FIXED DISTANCE ON A SI V-GROOVE SUBSTRATE WHICH IS FIXED DIRECTLY ON THE CHIP WITH A LITTLE 90 DEGREE ANGLE BRACKET. THE ALIGNMENT BETWEEN THE DETECTORS AND THE FIBERS IS MADE BY HOME-MADE SYSTEM. SINGLE-PHOTON COUNTING DATA AT 690 NM AND 1310 NM USING PULSED LASER, ARE PRESENTED.THIS WORK HAS BEEN SUPPORTED IN PART BY EUROPEAN COMMUNITY SEVENTH FRAMEWORK PROGRAMME, ERA-NET PLUS, UNDER GRANT AGREEMENT NO. 217257.

THE AUTHORS WISH TO THANK F. DELPIANO FOR THE DEVELOPMENT OF THE DETECTOR ALIGNMENT SYSTEM.

3EP3H-03

INTEGRATION OF THE NANO-HEB DETECTOR ARRAY WITH MSQUIDS ***B. KARASIK****, P. DAY, J. KAWAMURA, S. MONACOS, B. BUMBLE, H. LEDUC;* JET PROPULSION LABORATORY/CALTECH. — WE REPORT ON THE MULTIPLEXED OPERATION OF AN ARRAY OF HOT-ELECTRON NANOBOLOMETERS (NANO-HEB) USING A MICROWAVE SQUID (MSQUIDS) READOUT. A 4-ELEMENT ARRAY OF TI NANO-HEBS OPERATED AT 415 MK IN A HE3 DEWAR WITH AN OPTICAL FIBER ACCESS. THE MSQUIDS WAS COUPLED TO A COMMON TRANSMISSION LINE VIA INDIVIDUAL RESONATORS. THE STATE OF EACH SQUID WAS PROBED BY REACTION TO A WEAK MICROWAVE SIGNAL TRANSMITTED THROUGH THE LINE. THE SIGNAL EXHIBITED 10-MHZ WIDE RESONANCES AT INDIVIDUAL MSQUD FREQUENCIES BETWEEN 9 GHZ AND 10 GHZ. THE

RESONANCE DEPTH WAS MODULATED BY THE CURRENT THROUGH THE BOLOMETER VIA A CHANGE OF THE SQUID FLUX STATE. THE TRANSMITTED SIGNAL WAS AMPLIFIED BY A LOW-NOISE (T_N ≈ 5 K) CRYOGENIC AMPLIFIER AND DOWNCONVERTED TO BASEBAND USING AN IQ MIXER. A 1-DB PER Φ_0/2 RESPONSIVITY WAS SUFFICIENT FOR KEEPING THE SYSTEM NOISE AT THE LEVEL OF ~ 2 PA/HZ^1/2. THIS IS MORE THAN AN ORDER OF MAGNITUDE SMALLER THAN THE PHONON NOISE IN THE NANO-HEB DETECTORS. THE DEVICES WERE ABLE TO DETECT SINGLE NEAR-IR PHOTONS (1550 NM) WITH A TIME CONSTANT OF 3.5 μS. IN THE ON-GOING WORK TARGETING A 16-PIXEL CAMERA WITH ANTENNA-COUPLED DEVICES AT 650 GHZ A FULL DIGITAL FREQUENCY COMB GENERATION AND DETECTION HAS BEEN IMPLEMENTED USING A COMMERCIAL A/D AND D/A HARDWARE AND AN FPGA BASED CHANNELIZER. THE NEW MSQUID CHIP FEATURING LUMPED ELEMENT INDUCTORS AND MUCH CLOSER PACKED RESONANCE FREQUENCIES HAS BEEN DESIGNED FOR THIS WORK.

THIS RESEARCH WAS CARRIED OUT AT THE JET PROPULSION LABORATORY, CALIFORNIA INSTITUTE OF TECHNOLOGY, UNDER A CONTRACT WITH THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

3EP3H-04

DEVELOPMENT OF LIGHT DETECTOR USING SUPERCONDUCTING THERMOMETER FOR RARE EVENT SEARCH IN SCINTILLATING $CAMOO_4$ CRYSTAL ***S. LEE***[1], *Y. KIM*[2], *M. LEE*[2], *K. LEE*[2], *Y. JANG*[2], *W. YOON*[2], *I. KIM*[2], *M. KIM*[2], *J. LEE*[2], *S. KIM*[1], *S. MYUNG*[1], *S. KIM*[1], *J. CHOI*[1], *J. LEE*[1], *H. KIM*[3], *J. SO*[3], *Y. KIM*[4], *J. LEE*[4], *W. KANG*[4]; [1]SEOUL NATIONAL UNIVERSITY, [2]KOREA RESEARCH INSTITUTE OF STANDARDS AND SCIENCE, [3]KYUNGPOOK NATIONAL UNIVERSITY, [4]SEJONG UNIVERSITY. — SEARCH FOR NEUTRINOLESS DOUBLE BETA DECAY IS ONE OF MAIN ISSUES IN NEUTRINO PHYSICS. MEASUREMENT OF ITS DECAY RATE WILL PROVIDE EFFECTIVE NEUTRINO MASS AND WILL BE CONCLUSIVE EVIDENCE FOR MAJORANA NATURE OF NEUTRINO AS WELL.SCINTILLATING $CAMOO_4$ CRYSTAL DEVELOPED BY KIMS COLLABORATION IS PROMISING MATERIAL TO INVESTIGATE ^{100}MO AS A CANDIDATE FOR NEUTRINOLESS DOUBLE BETA DECAY. SCINTILLATION LIGHT FROM THE CRYSTAL CAN BE USED FOR ACTIVE BACKGROUND REJECTION WHEN COMBINED WITH PHONON SIGNAL OF THE CRYSTAL.BOTH LIGHT DETECTOR AND PHONON DETECTOR ARE STRONGLY RECOMMENDED FOR THE ACTIVE BACKGROUND REJECTION. IN OUR PREVIOUS EXPERIMENTS, PHONON SIGNAL OF $CAMOO_4$ CRYSTAL FROM ALPHA BOMBARDMENT WAS MEASURED WITH HIGH ENERGY-RESOLUTION METALLIC MAGNETIC CALORIMETER ALONE. IN CONSECUTIVE EXPERIMENTS, A LIGHT DETECTOR WAS EMPLOYED TO MEASURE SCINTILLATION LIGHT FROM THE $CAMOO_4$ CRYSTAL.THE LIGHT DETECTOR CONSISTS OF SILICON WAFER AND A SUPERCONDUCTING THERMOMETER. THE WAFER IS UNDOPED SILICON OF 10 MM × 10 MM × 0.25 MM IN SIZE. THE THERMOMETER IS A TI/AU BILAYER STRIP WITH AREA OF 1.2 MM × 0.4 MM FABRICATED ON ONE SIDE OF THE WAFER. DETAILED EXPERIMENTAL SETUPS AND RESULTS WILL BE DESCRIBED.

3EP3H-05

OPTIMIZATION OF A TES ARRAY FOR A PASSIVE VIDEO-RATE THZ SECURITY CAMERA *G. ZIEGER*[1], *T. MAY*[1], *V. ZAKOSARENKO*[1], *S. ANDERS*[1], *M. SCHUBERT*[1], *H. MEYER*[1], *E. KREYSA*[2], ***E. HEINZ***[1]; [1]INSTITUTE OF PHOTONIC TECHNOLOGY, [2]MAX-PLANCK-INSTITUTE FOR RADIO ASTRONOMY. — TERAHERTZ RADIATION CAN BE USED FOR THE DETECTION OF HIDDEN SECURITY THREATS. PASSIVE SYSTEMS DETECT THE INFLUENCE OF CLOTHING-COVERED OBJECTS ON THE NATURAL EMISSION OF THE HUMAN BODY AND THUS CAN SUPPORT SECURITY SCANS WITHOUT IRRADIATION. IN A CERTAIN FREQUENCY RANGE THIS ALSO AVOIDS THE IMPRESSION OF NUDITY ON THE IMAGES. DESIGNED AS A FAST SCANNING CAMERA SUCH A DEVICE IS ABLE TO BE APPLIED IN A FLEXIBLE WAY AND CAN INCREASE THE THROUGHPUT AT CHECK POINTS.HERE WE DESCRIBE THE OPTIMIZATION OF TES BOLOMETERS BY SIMULATIONS AND MEASUREMENTS FOR THEIR USAGE IN A VIDEO RATE TERAHERTZ CAMERA. THEY ARE OPERATED IN A PULSE TUBE COOLED SYSTEM WITH AN ADDITIONAL 3HE SORPTION COOLER AT A BASE TEMPERATURE OF ABOUT 400MK. THEIR SENSITIVITY HAS TO MEET THE REQUIREMENT OF DETECTING HIDDEN OBJECTS FROM A DISTANCE OF SEVERAL METERS WITH VIDEO RATE.

THIS WORK WAS SUPPORTED BY THE GERMAN FEDERAL MINISTRY OF EDUCATION AND RESEARCH (BMBF) UNDER GRANT NO. 13N9307.

3EP3H-06

ANALYSIS OF THE CAPABILITIES OF LARGE GAMMA-RAY MICROCALORIMETER ARRAYS FOR NUCLEAR SAFEGUARDS APPLICATIONS ***N. HOTELING***[1], *A. S. HOOVER*[1], *M. W. RABIN*[1], *P. J. KARPIUS*[1], *M. P. CROCE*[1], *M. K. BACRANIA*[1], *J. N. ULLOM*[2], *D. A. BENNET*[2]; [1]LOS ALAMOS NATIONAL LABORATORY, [2]NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY. — GAMMA-RAY MICROCALORIMETER DETECTORS OFFER THE SIGNIFICANT ADVANTAGE OF NEARLY AN ORDER OF MAGNITUDE BETTER ENERGY RESOLUTION THAN EVEN THE BEST-PERFORMING HIGH-PURITY GERMANIUM (HPGE) DETECTORS. THIS ADVANTAGE TRANSLATES INTO AN IMPROVED ABILITY TO ANALYZE COMPLEX SPECTRA, A CRITICAL ASSET IN THE FIELD OF NUCLEAR SAFEGUARDS WHERE, FOR INSTANCE, THE CUMULATIVE EFFECT OF EVEN RELATIVELY SMALL UNCERTAINTIES IN SPECTRAL ANALYSES CAN TRANSLATE INTO SIGNIFICANT MATERIAL UNCERTAINTIES OVER TIME. IN THIS PAPER, WE REPORT ON NEW DATA COLLECTED WITH AN UNPARALLELED 256-PIXEL ARRAY OF TRANSITION EDGE SENSOR (TES) MICROCALORIMETER DETECTORS. THESE DATA, COLLECTED WITH A STANDARD MIXED-ISOTOPE PLUTONIUM SOURCE, ARE COMPARED WITH THE RESULTS OF A PARALLEL HPGE STUDY IN ORDER TO QUANTIFY THE ADVANTAGES OF MICROCALORIMETER DETECTORS. WE ALSO DESCRIBE OPERATIONAL AND ANALYTICAL CHALLENGES ASSOCIATED WITH INCREASINGLY LARGE ARRAYS SUCH AS MULTIPLEXING CAPABILITIES, PIXEL RESPONSE SPEED, AND DATA ANALYSIS TECHNIQUES.

3EP3H-07

VACUUM LOAD-LOCKED SAMPLE LOADER FOR TES-BASE ALPHA-PARTICLE SPECTROMETER ***V. KOTSUBO***[1], *R. HORANSKY*[1], *M. BACRANIA*[2], *M. CROCE*[2], *J. ULLOM*[1], *M. RABIN*[2]; [1]NIST, [2]LANL. — WE ARE DEVELOPING A TES-BASED ALPHA-PARTICLE SPECTROMETER FOR ANALYSIS OF TRACE QUANTITIES OF RADIOACTIVE MATERIALS RELEVANT TO NUCLEAR SAFEGUARDS AND FORENSICS. CONVENTIONAL ANALYSIS IS A TIME-CONSUMING, MULTI-DAY PROCESS INVOLVING WET CHEMISTRY FOLLOWED BY ALPHA COUNTING AND THEN MASS SPECTROMETRY FOR ISOTOPIC MEASUREMENTS. IN CONTRAST, TES SENSORS EASILY RESOLVE ELEMENTAL AND ISOTOPIC LINE OVERLAPS, POTENTIALLY REDUCING ANALYSIS TIMES TO TWO DAYS. SINCE ALPHA-PARTICLES DO NOT PENETRATE SOLIDS, SOURCES MUST BE LOCATED IN THE CRYOSTAT'S VACUUM SPACE IN CLOSE PROXIMITY TO THE DETECTORS. TO AVOID THE TIME AND INCONVENIENCE OF CYCLING THE CRYOSTAT BETWEEN 100MK AND 300K, A LOAD-LOCK SYSTEM IS BEING DEVELOPED FOR RAPID SOURCE INSERTION WHILE MAINTAINING VACUUM AND LOW TEMPERATURES. THIS PAPER DESCRIBES THE DESIGN AND PRESENTS RESULTS OF PRELIMINARY FEASIBILITY TESTS. THE LOAD-LOCK IS BUILT INTO A STANDARD PULSE-TUBE COOLED ADR CRYOSTAT, AND UTILIZES HEAT SWITCHES AT 60K AND 3K FOR COOLING THE SOURCES. SHUTTERS AT 60K AND 3K OPEN DURING SOURCE LOADING AND THEN CLOSE DURING MEASUREMENT TO MINIMIZE PARASITIC RADIATION LOADS. SOURCES ARE MOUNTED AT 3K TO AVOID THE MECHANICAL COMPLEXITY OF MATING TO THE ADR PLATFORM. PRELIMINARY TESTS HAVE DEMONSTRATED FEASIBILITY OF EXPOSING SOURCES MOUNTED AT 3K TO DETECTORS AT 120MK WITHOUT SIGNIFICANT DEGRADATION OF SENSOR RESOLUTION.

THIS WORK SUPPORTED BY THE US DEPARTMENT OF HOMELAND SECURITY AND THE DEPARTMENT OF ENERGY THROUGH THE OFFICE OF NONPROLIFERATION RESEARCH AND DEVELOPMENT.

3EP3H-09

FABRICATION AND DEVICE CHARACTERIZATION OF THE FOCAL PLANE ARRAYS FOR THE SPIDER AND BICEP2/KECK CMB POLARIMETERS ***J. A. BONETTI***[1], *A. D. TURNER*[1], *M. E. KENYON*[1], *R. LEDUC*[1], *A. ORLANDO*[2], *J. A. BREVIK*[2], *A. TRANGSRUD*[2], *R. SUDIWALA*[2], *H. T. NGUYEN*[1], *P. K. DAY*[1], *J. J. BOCK*[1], *S. R. GOLWALA*[2], *J. M. KOVAC*[3], *W. C. JONES*[4], *C. L. KUO*[5]; [1]JPL/CALTECH, [2]CALTECH, [3]HARVARD UNIVERSITY, [4]PRINCETON UNIVERSITY, [5]STANFORD UNIVERSITY. — SPIDER AND BICEP2/KECK ARE PROJECTS TO STUDY THE POLARIZATION OF THE COSMIC MICROWAVE BACKGROUND. BOTH REQUIRE LARGE FORMAT ARRAYS OF ANTENNA-COUPLED, MEMBRANE-ISOLATED, TRANSITION EDGE SENSORS. A MAJOR CHALLENGE FOR BOTH PROJECTS WAS OBTAINING HIGH UNIFORMITY IN DEVICE PARAMETERS ACROSS A WAFER AND ALSO FROM WAFER TO WAFER. A FABRICATION PROCESS MEETING THIS CHALLENGE IS DESCRIBED. AFTER FABRICATION, SELECTED WAFERS ARE PRESCREENED IN A QUICK TURN AROUND, CRYOGEN-FREE, 3HE FRIDGE. THE PRESCREENING IS PERFORMED WITH A COMMERCIAL RESISTANCE BRIDGE AND MEASURES TRANSITION TEMPERATURES AND NORMAL STATE RESISTANCES. DURING THE FABRICATION PROCESS WAFERS ARE CUT INTO SQUARES, OR TILES. THEY ARE THEN TILED TOGETHER TO CREATE A FOCAL PLANE. FULL CHARACTERIZATION OF ENTIRE FOCAL PLANES VIASQUID MULTIPLEXING IS DESCRIBED. THE FOCAL PLANE FOR BICEP2 IS CURRENTLY IN ACTION TAKING DATA AT THE SOUTH POLE. PRELIMINARY RESULTS WILL BE PRESENTED. THE FOCAL PLANES FOR SPIDER, A BALLOON-BASED OBSERVATORY, ARE UNDER CONSTRUCTION.

3EP3H-10

DEVELOPMENT OF SUPERCONDUCTING SILICON DIOXIDE EMBEDDED HEATSINKING LAYERS FOR COMPACT ARRAYS OF X-RAY TES MICROCALORIMETERS ***F. M. FINKBEINER***[1], *C. N. BAILEY*[2], *S. R. BANDLER*[3], *R. P. BREKOSKY*[4], *A. D. BROWN*[5], *J. A. CHERVENAK*[2], *M. E. ECKART*[2], *R. L. KELLEY*[2], *D. P. KELLY*[5], *C. A. KILBOURNE*[2], *F. S. PORTER*[2], *C. RAY*[5], *J. E. SADLEIR*[2], *S. J. SMITH*[3]; [1]NASA/GSFC & WYLE INFORMATION SYSTEMS, INC., [2]NASA/GSFC, [3]UNIVERSITY OF MARYLAND & NASA/GSFC, [4]NASA/GSFC & NORTHROP GRUMMAN, [5]NASA/GSFC & MEI TECHNOLOGIES, INC.. — TRANSITION EDGE SENSOR MICROCALORIMETER ARRAYS IN COMPACT GEOMETRIES AND LARGE FORMATS EXPERIENCE LOCAL HEATING FROM BIAS POWER AND X-RAY HITS THAT MUST BE DISSIPATED IN THE FRAME. FOR DEVICES ON SOLID, NON-PERFORATED SILICON SUBSTRATES, WE HAVE INTRODUCED AN UNDERLYING EMBEDDED COPPER HEATSINKING LAYER TO ENHANCE THE ABILITY OF THE FRAME TO REMOVE THIS HEAT. IN PARTICULAR, SUCH A LAYER CAN MITIGATE THERMAL CROSS-TALK BETWEEN NEARBY PIXELS WITHIN THE ARRAY. FURTHER IMPROVEMENTS IN ARRAY PERFORMANCE, SUCH AS DECREASED MAGNETIC FIELD SENSITIVITY AND STRAY INDUCTANCE, ARE POSSIBLE BY TURNING THE HEATSINKING LAYER INTO A SUPERCONDUCTING GROUND PLANE. IN THIS PRESENTATION, WE REPORT ON THE DEVELOPMENT OF HEATSINKING LAYERS CONSISTING OF A 1-2 μM THICK HIGH-QUALITY COPPER LAYER WHICH IS SANDWICHED BETWEEN TWO THIN REFRACTORY METAL-BASED DIFFUSION BARRIERS. THESE DIFFUSION BARRIERS ARE DESIGNED TO AVOID COPPER MIGRATION INTO THE SURROUNDING MATERIAL OVER TIME, ESPECIALLY DURING OUR HIGH TEMPERATURE TES FABRICATION PROCESS WHICH TAKES PLACE IN EXCESS OF 400ºC. A 0.3 - 0.5 μM THICK PECVD SIO2 COVER LAYER ISOLATES THE HEATSINKING LAYER FROM THE DETECTOR CIRCUIT. WE PRESENT FIRST RESULTS ON OUR ATTEMPT TO TAILOR THE MATERIALS FORMING THE DIFFUSION BARRIER TO FABRICATE BOTH WELL DEFINED SUPERCONDUCTING GROUND PLANES AND NON-SUPERCONDUCTING LAYERS WITH THE DESIRED BARRIER CHARACTERISTICS.

THIS WORK WAS FUNDED UNDER UNDER NASA'S ROSES PROGRAM FOR SOLAR AND HELIOSPHERIC PHYSICS RESEARCH.

3EP3H-11

CHARACTERIZATION OF MULTI-ABSORBER TRANSITION-EDGE SENSORS ***S. J. SMITH***[1]*, C. N. BAILEY*[2]*, S. R. BANDLER*[1]*, R. P. BREKOSKY*[3]*, J. A. CHERVENAK*[4]*, M. E. ECKART*[2]*, A. E. EWIN*[4]*, F. M. FINKBEINER*[5]*, R. L. KELLEY*[4]*, C. A. KILBOURNE*[4]*, F. S. PORTER*[4]*, J. E. SADLEIR*[6]*;* [1]NASA GSFC AND UNIVERSITY OF MARYLAND, [2]NASA GSFC AND NPP, [3]NASA GSFC AND NORTHROP GRUMMAN, [4]NASA GSFC, [5]NASA GSFC AND WYLE INFORMATION SYSTEMS, [6]NASA GSFC AND UNIVERSITY OF ILLINOIS. — WE REPORT ON THE DEVELOPMENT OF MULTI-ABSORBER TRANSITION-EDGE SENSORS (TES'S) KNOWN AS HYDRAS. HYDRAS CONSIST OF MULTIPLE, DISCRETE ABSORBERS EACH WITH A DIFFERENT THERMAL COUPLING TO A SINGLE TES. THIS DIFFERENTIAL THERMAL COUPLING BETWEEN ABSORBERS AND TES RESULTS IN DIFFERENT CHARACTERISTIC PULSE SHAPES, WHICH ENABLES POSITION DISCRIMINATION BETWEEN ABSORBER PIXELS. THE DEVELOPMENT OF HYDRAS IS MOTIVATED BY A DESIRE TO ACHIEVE MAXIMUM FOCAL-PLANE AREA WITH THE LEAST NUMBER OF READOUT CHANNELS AND AS SUCH, ARE IDEALLY SUITED TO PROVIDE AN EXTENDED FOCAL-PLANE ARRAY FOR FUTURE ASTRONOMY MISSIONS SUCH AS THE INTERNATIONAL X-RAY OBSERVATORY (IXO). WE HAVE RECENTLY FABRICATED HYDRAS WITH 4 TO 16 AU/BI ABSORBERS ON A 300 MICRON PITCH, AS WELL AS 4-PIXEL HYDRAS WITH 600 MICRON PITCH. IN ORDER TO INVESTIGATE DIFFERENT OPTIMIZATIONS FOR HIGH SPECTRAL AND POSITION RESOLUTION, THESE DEVICES ARE DESIGNED WITH DIFFERENT COMBINATIONS OF THERMAL CONDUCTANCES BETWEEN THE ABSORBERS AND TES, AS WELL AS TO THE HEAT SINK. WE PRESENT FIRST RESULTS INCLUDING MEASUREMENTS OF ENERGY RESOLUTION, POSITION SENSITIVITY AND CHARACTERIZATION OF THE INTERNAL AND EXTERNAL THERMAL CONDUCTANCES FOR THESE NEW DEVICES.

3EP3J-01

OPTICAL TRANSITION-EDGE SENSORS SINGLE PHOTON PULSES ANALYSIS *D. ALBERTO*[1]*,* ***M. RAJTERI***[2]*, E. TARALLI*[2]*, L. LOLLI*[2]*, C. PORTESI*[2]*, E. MONTICONE*[2]*, R. GARELLO*[3]*, M. GRECO*[4]*;* [1]UNIVERSITY AND INFN TORINO, DEPT. GENERAL PHYSICS, ITALY & DIP. DI ELETTRONICA, POLITECNICO DI TORINO, TORINO,ITALY, [2]INRIM, TORINO, ITALY, [3]DIP. DI ELETTRONICA, POLITECNICO DI TORINO, TORINO,ITALY, [4]UNIVERSITY AND INFN TORINO, DEPT. GENERAL PHYSICS, ITALY. — TRANSITION-EDGE SENSORS (TES) ARE DETECTORS ABLE TO COUNT SINGLE PHOTONS FROM X-RAY TO INFRARED, GENERATING PULSES WITH AMPLITUDES PROPORTIONAL TO THE ABSORBED PHOTON ENERGY. THE TES PERFORMANCES DEPEND ON THE SENSOR PARAMETERS BUT ALSO ON THE NOISE LEVEL. THE EVALUATION OF THE ENERGY RESOLUTION IS THUS DEPENDENT ON THE TYPE OF SIGNAL ANALYSIS APPLIED.IN THIS WORK WE REPORT THE RESULTS OF AN OFFLINE ANALYSIS APPLIED TO PULSES MEASURED WITH A TIAU TES FOR THE OPTICAL REGION. THE PULSES ARE ACQUIRED WITH A DIGITAL OSCILLOSCOPE AND FURTHER ELABORATED WITH NUMERICAL SOFTWARE.DIFFERENT KIND OF DIGITAL FILTERS WERE APPLIED FOR IMPROVING THE TES ENERGY RESOLUTION, STARTING FROM SIMPLE LOW-PASS AND BAND-PASS FILTERS TO MORE COMPLEX SAVITZKY-GOLAY AND WIENER FILTERS. PARTICULAR ATTENTION HAS BEEN PAID BOTH TO TIME-DOMAIN AND FREQUENCY-DOMAIN ANALYSES. THE FIRST AIMED TO THE EXTRACTION OF FEATURES OF INTEREST AS THE PHOTON PULSE AMPLITUDE, RISE-UP AND ARRIVAL TIMES. THE SECOND CAN HELP FOR THE NOISE REDUCTION, AIMING TO IDENTIFY AND ENHANCE ONLY THE PHOTON PULSE FREQUENCY COMPONENTS AND REDUCING THE NOISY ONES.

THIS WORK HAS BEEN SUPPORTED IN PART BY EUROPEAN COMMUNITY SEVENTH FRAMEWORK PROGRAMME, ERA-NET PLUS, UNDER GRANT AGREEMENT NO. 217257.

3EP3J-02

FREQUENCY DIVISION MULTIPLEXED READOUT OF TES DETECTORS WITH BASEBAND FEEDBACK ***R. H. DEN HARTOG****, D. BOERSMA, B. VAN LEEUWEN, R. HOU, P. A. J. DE KORTE, J. VAN DER KUUR, M. P. BRUIJN, L. GOTTARDI, H. F. C. HOEVERS;* SRON. — SRON IS DEVELOPING AN ELECTRONIC READ-OUT SYSTEM FOR AN ARRAY OF TRANSISTION EDGE SENSORS (TES) WHICH COMBINES THE TECHNIQUES OF FREQUENCY DOMAIN MULTIPLEXING (FDM) WITH BASE-BAND FEEDBACK. BBFB ATTEMPTS TO CANCEL THE ERROR SIGNAL IN THE SQUID SUM-POINT TO FURTHER IMPROVE THE BANDWIDTH AND THE LOOP GAIN.ITS ASTRONOMICAL APPLICATIONS ARE IN THE READ-OUT OF SOFT X-RAY MICROCALORIMETERS IN THE XMS INSTRUMENT ON THE INTERNATIONAL X-RAY OBSERVATORY AND FAR-IR BOLOMETERS FOR THE SAFARI INSTRUMENT ON THE JAPANESE MISSION SPICA. FOR THE FORMER INSTRUMENT THE GOAL IS TO READ OUT UP TO 40 PIXELS PER SQUID IN THE FREQUENCY RANGE FROM 1 TO 6 MHZ, FOR THE LATTER 160 TES PIXELS IN THE RANGE FROM 1 TO 2 MHZ, OWING TO THE SMALLER INFORMATION BANDWIDTH OF THE BOLOMETERS.IN THIS PAPER WE FOCUS ON THE EXPERIMENTAL VERIFICATION OF THE SYSTEM, DEMONSTRATING FOR 16 PIXELS THAT SIMULTANEOUS LOCKING DOES NOT DEGRADE THE NOISE PERFORMANCE OR THE DYNAMIC RANGE REQUIRED FOR THESE MISSIONS, AND THAT THE CROSS-TALK BETWEEN PIXELS STAYS WITHIN THE REQUIRED BOUNDS. A DETAILED ANALYSIS OF THE SYSTEM IS PRESENTED, IDENTIFYING ITS LIMITATIONS AND ROUTES FOR IMPROVEMENT. THIS ANALYSIS INCLUDES THE POWER REQUIREMENTS OF THE SYSTEM, SHOWING THAT A LOW-POWER IMPLEMENTATION IN A PRACTICAL INSTRUMENT IS FEASIBLE.

3EP3J-03

SUPERCONDUCTING L-C FILTER CIRCUITS FOR FREQUENCY DIVISION MULTIPLEXED READOUT OF TES DETECTORS ***M. P. BRUIJN****, L. GOTTARDI, R. H. DEN HARTOG, H. F. C. HOEVERS, P. A. J. DE KORTE, J. VAN DER KUUR;* SRON- NETHERLANDS INSTITUTE FOR SPACE RESEARCH. — INDUCTOR-CAPACITOR (L-C) FILTER CIRCUITS FORM AN ESSENTIAL COMPONENT OF THE READOUT CHAIN OF TES DETECTORS, IN CASE OF MULTIPLEXING BY FREQUENCY DIVISION. THEY SERVE THE FUNCTIONS OF BLOCKING WIDE BAND NOISE FROM ADJACENT PIXELS AND SEPARATION OF BIAS FREQUENCIES. KEY REQUIREMENT IS A HIGH QUALITY FACTOR Q (NARROW BAND RESONANCE), IMPLYING A FULL SUPERCONDUCTING CIRCUIT,

LOW DIELECTRIC LOSS CAPACITORS AND LOW MAGNETIC LOSS INDUCTORS. TYPICALLY Q SHOULD BE LARGER THAN 500*F[MHZ]*L[MUH]. HERE F IS THE BIAS FREQUENCY AND L, THE INDUCTOR VALUE, IS COUPLED TO THE DETECTOR SPEED FOR STABLE ELECTROTHERMAL FEEDBACK RESPONSE. IN OUR CASES Q MUST BE IN THE RANGE OF 1000 TO 10000.THE ASTRONOMICAL APPLICATIONS FOR WHICH THESE FILTERS ARE BEING DEVELOPED ARE MICROCALORIMETERS FOR IXO AND FAR INFRARED BOLOMETERS FOR THE SAFARI INSTRUMENT ON THE JAPANESE MISSION SPICA. FOR THE LATTER MISSION THE GOAL IS TO READOUT 160 TES PIXELS WITH ONE SQUID IN THE FREQUENCY RANGE 1 TO 2 MHZ.WE DESCRIBE FABRICATION PROCEDURES FOR FULLY SUPERCONDUCTING CIRCUITS, RESULTING IN A MAXIMUM OBSERVED Q OF 12000 FOR A-SI BASED CAPACITORS. WE ALSO REPORT ON EFFORTS TO MINIMIZE THE REQUIRED SURFACE AREA FOR THE FILTERS AND ON A STUDY TO THE CENTER FREQUENCY PREDICTABILITY OF THE FILTERS.WE PLAN TO SHOW MEASUREMENTS ON FILTERS IN A PROTOTYPE 16 CHANNEL FDM READOUT SETUP.

THE AUTHORS ACKNOWLEDGE DR. J. RATH (UNIVERSITY OF UTRECHT) FOR DEPOSITION OF A-SI FILMS. THE WORK IS PARTLY FINANCED BY ESA CONTRACT TRP5417 AND PARTLY BY NWO (NETHERLANDS ORGANISATION FOR SCIENTIFIC RESEARCH).

3EP3J-04

TIME-DIVISION SQUID MULTIPLEXERS WITH REDUCED SENSITIVITY TO EXTERNAL MAGNETIC FIELDS ***G. M. STIEHL***[1], *H. M. CHO*[1], *G. C. HILTON*[1], *K. D. IRWIN*[1], *J. A. B. MATES*[1], *C. D. REINTSEMA*[1], *B. L. ZINK*[2]; [1]NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY, [2]UNIVERSITY OF DENVER. — AT THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY, WE HAVE DEVELOPED TIME-DIVISION SQUID MULTIPLEXERS TO READ OUT LARGE ARRAYS OF TRANSITION-EDGE SENSOR (TES) DETECTORS. THESE MULTIPLEXERS ARE USED IN MANY APPLICATIONS. ONE IMPORTANT APPLICATION IS THE MEASUREMENT OF THE POLARIZATION OF THE COSMIC MICROWAVE BACKGROUND (CMB). CMB POLARIZATION MEASUREMENTS REQUIRE EXQUISITE CONTROL OF SYSTEMATIC ERROR SOURCES, SINCE THE SIGNALS OF INTEREST ARE MANY ORDERS OF MAGNITUDE SMALLER THAN THE AMPLITUDE OF THE CMB. A MAJOR POTENTIAL SOURCE OF SYSTEMATIC ERROR IS THE PICKUP OF EXTERNAL MAGNETIC FIELDS BY THE SQUID MULTIPLEXERS. THUS, WE PRESENT A MEASUREMENT OF THE SENSITIVITY OF DIFFERENT DESIGNS OF NIST SQUID MULTIPLEXERS. THESE DESIGNS INCLUDE A NEW VARIETY WHICH HAS BEEN SHOWN TO HAVE MORE THAN AN ORDER OF MAGNITUDE REDUCTION IN EXTERNAL FIELD SENSITIVITY.

3EP3J-05

DEVELOPMENT OF MONOLITHIC MICROWAVE INTEGRATED AMPLIFIERS AS READOUT FOR DETECTORS AT 4.2 K ***S. H. WUENSCH***[1], *D. BRUCH*[2], *E. CROCOLL*[1], *I. KALLFASS*[2], *M. SIEGEL*[1]; [1]KARLSRUHE INSTITUTE OF TECHNOLOGY, [2]FRAUNHOFER INSTITUTE FOR APPLIED SOLID STATE PHYSICS (IAF). — READOUT AMPLIFIERS WITH HIGH BANDWIDTH AND EXTREMELY LOW POWER DISSIPATION AT LIQUID HELIUM TEMPERATURE FOR VARIOUS SUPERCONDUCTING DETECTORS (E.G. SSPD, HEB AND MKID) ARE NECESSARY TO INCREASE THE SMALL DETECTOR OUTPUT SIGNALS. WE DEVELOPED DIFFERENT TYPES OF CRYOGENIC AMPLIFIERS FOR THESE APPLICATIONS. THE REQUIRED COMBINATION OF LOW NOISE, LARGE BANDWIDTH, HIGH VOLTAGE GAIN AND LOW CONSUMPTION POWER IS A DRIVING FORCE FOR AN ON-GOING PROCESS OF IMPROVEMENTS. WE WILL REPORT AND DISCUSS THE DEVELOPMENTS OF OUR CRYOGENIC ULTRA-LOW POWER HYBRID AMPLIFIERS WHICH ARE BASED ON COMMERCIAL P-HEMT TRANSISTORS. IN ADDITION, WE WILL PRESENT SIMULATION AND MEASUREMENT RESULTS OF OUR FIRST DEVELOPED MONOLITHIC MICROWAVE INTEGRATED CIRCUIT (MMIC) AMPLIFIERS FOR LOW POWER OPERATION. THE MMICS ARE BASED ON A METAMORPHIC HEMT TECHNOLOGY AND ARE REALIZED ON A 3 × 1.5 MM^2 AREA. FIRST MEASUREMENTS SHOWED A BANDWIDTH OF 0.3 GHZ UP TO 9 GHZ WITH A GAIN OF 23 DB AND 1.3 GHZ UP TO 8 GHZ WITH 20 DB OF GAIN, RESPECTIVELY. THE NOISE FIGURE NF DECREASES TO VALUES LESS THAN 1 DB AT A TOTAL POWER CONSUMPTION OF ABOUT 30 MW AT CRYOGENIC TEMPERATURES.

3EP3K-01

A COMPACT SQUID MAGNETOMETER FOR THERMOREMANENT MAGNETIZATION IMMUNOASSAYS *H. R. CARVALHO,* ***A. C. BRUNO****;* CATHOLIC UNIVERSITY OF RIO DE JANEIRO. — MAGNETIC BEADS ARE A POWERFUL AND EFFECTIVE DIAGNOSTIC TOOL IN MEDICINE AND BIOLOGY. THEY HAVE A SUPERPARAMAGNETIC CORE AND AN APPROPRIATE ANTIBODY ON THE SURFACE. THE BEADS ARE USED TO LABEL SPECIFIC MOLECULES, MICROORGANISMS AND OTHER NANOSTRUCTURES. TO AVOID AGGLOMERATION, THEY ARE DESIGNED TO PRESENT NO REMANENCE AT ROOM TEMPERATURE. IN ORDER TO PERFORM THE MAGNETIC IMMUNOASSAY, ONLY SUSCEPTIBILITY OR RELAXATION METHODS CAN BE USED. HOWEVER, IF ONE LOWERS THE TEMPERATURE BELOW THE BEADS BLOCKING TEMPERATURE, WHILE APPLYING A MAGNETIC FIELD, THEIR MAGNETIZATION RELAXATION TIME BECOMES VERY BIG AND REMANENCE IS ESTABLISHED AT THE NEW TEMPERATURE. WE BUILT A COMPACT SQUID MAGNETOMETER DESIGNED TO PERFORM THERMOREMANENT MAGNETIZATIONS IN SUPERPARAMAGNETIC BEADS USED IN IMMUNOASSAYS. THE MAGNETOMETER IS BASED ON A MINIATURIZED BULK RF SQUID AND IT IS CAPABLE OF MEASURING MAGNETIC MOMENTS DOWN TO 20 FEMTOAM2. COMMERCIAL BEADS USED FOR PERFORMING IMMUNOASSAYS WERE TESTED. SPECIAL CARE WAS TAKEN TO CALIBRATE THE MAGNETOMETER IN TERMS OF MAGNETIC MOMENT. THIS IS IMPORTANT WHEN THE SAMPLE SIZE IS COMPARABLE TO THE SENSOR SIZE. DISREGARDING THE SAMPLE GEOMETRY AND MODELING IT AS A MAGNETIC DIPOLE MAY LEADS ONE TO UNDERESTIMATE THE SAMPLE ACTUAL MAGNETIC MOMENT AND AS A RESULT TO OVERESTIMATE THE REAL MAGNETOMETER SENSITIVITY.

WORK PARTIALLY SUPPORTED BY CNPQ AND FAPERJ

3EP3K-02

IMPROVEMENT OF THE SQUID MAGNETOMETER SYSTEMS FOR EXPANDED APPLICATION OF SPINAL CORD EVOKED MAGNETIC FIELD MEASUREMENT ***Y. ADACHI***[1]*, M. MIYAMOTO*[1]*, J. KAWAI*[1]*, G. UEHARA*[1]*, H. OGATA*[1]*, H. KADO*[1]*, S. KAWABATA*[2]*, K. SEKIHARA*[3]*;* [1]KANAZAWA INSTITUTE OF TECHNOLOGY, [2]TOKYO MEDICAL AND DENTAL UNIVERSITY, [3]TOKYO METROPOLITAN UNIVERSITY. — SQUID SPINAL CORD EVOKED MAGNETIC FIELD (SCEF) MEASUREMENT SYSTEMS ARE BEING DEVELOPED FOR DIAGNOSIS OF SPINAL CORD DISEASES SUCH AS MYELOPATHY. IN PRECEDING STUDIES, SEVERAL SQUID MAGNETOMETERS OPTIMIZED FOR THE DETECTION OF THE MAGNETIC FIELD EVOKED FROM THE CERVICAL AREA OF SUBJECTS IN SITTING OR SUPINE POSITIONS WERE REPORTED. THE SCEF MEASUREMENT AND THE MAGNETIC SOURCE RECONSTRUCTION BY SPATIAL FILTER TECHNIQUES ENABLED TO VISUALIZE THE NEURAL CURRENT DISTRIBUTION AROUND THE SPINAL CORD. NON-INVASIVE FUNCTIONAL IMAGING OF CERVICAL SPINAL CORD WAS MADE POSSIBLE. RECENTLY, WE PUT TWO IMPROVEMENTS INTO THE SQUID SCEF SYSTEM TO EXPAND ITS APPLICATION AND TO MAKE IT FIT FOR PRACTICAL USE IN ACTUAL HOSPITALS. ONE WAS THE NEWLY DESIGNED CRYOSTAT TO APPLY THE SCEF MEASUREMENT NOT ONLY TO THE CERVICAL SUPINE BUT ALSO TO THE WIDER REGION SUCH AS THE LUMBAR REGION. ANOTHER IMPROVEMENT WAS THE SQUID DRIVING ELECTRONICS WITH THE DIRECT FLUX FEEDBACK FROM 3-AXIS SQUID REFERENCE MAGNETOMETERS FOR NOISE REDUCTION. THE FLUX LOCKED LOOP WAS ALSO MODIFIED TO DETECT NOT ONLY THE FAST SCEF COMPONENTS ACCOMPANIED WITH THE ACTION POTENTIALS BUT ALSO THE LOWER BAND FOR THE ACTIVE NOISE REDUCTION.

3EP3K-04

NOISE MODELING FROM HIGH-PERMEABILITY SHIELDS USING KIRCHHOFF EQUATIONS ***H. SANDIN****, P. L. VOLEGOV, M. A. ESPY, A. N. MATLASHOV, I. M. SAVUKOV, L. J. SCHULTZ;* LOS ALAMOS NATIONAL LABORATORY. — PROGRESS IN THE DEVELOPMENT OF HIGH-SENSITIVITY MAGNETIC-FIELD MEASUREMENTS HAS STIMULATED INTEREST IN UNDERSTANDING MAGNETIC NOISE OF CONDUCTIVE MATERIALS, ESPECIALLY OF MAGNETIC SHIELDS (DC OR RF) BASED ON HIGH-PERMEABILITY MATERIALS AND/OR HIGH-CONDUCTIVITY MATERIALS. FOR EXAMPLE, SQUIDS AND ATOMIC MAGNETOMETERS HAVE BEEN USED IN MANY EXPERIMENTS WITH MU-METAL SHIELDS, AND ADDITIONALLY SQUID SYSTEMS FREQUENTLY HAVE RF SHIELDING BASED ON THIN CONDUCTIVE MATERIALS. TYPICAL EXISTING APPROACHES TO MODELING NOISE ONLY WORK WITH SIMPLE SHIELD AND SENSOR GEOMETRIES WHILE COMMON EXPERIMENTAL SETUPS TODAY CONSISTS OF MULTIPLE SENSOR SYSTEMS IN ARBITRARY SHAPES AND COMPLEX SHIELD GEOMETRY. WITH COMPLEX SENSOR ARRAYS USED IN, FOR EXAMPLE, MEG AND ULTRA LOW FIELD MRI STUDIES THE KNOWLEDGE OF THE NOISE CORRELATION BETWEEN SENSORS IS AS IMPORTANT AS KNOWING THE NOISE ITSELF. THIS IS CRUCIAL FOR INCORPORATING EFFICIENT NOISE CANCELATION SCHEMES FOR THE SYSTEM. WE DEVELOPED AN APPROACH THAT ALLOWS US TO CALCULATE THE JOHNSON NOISE FOR ANY GEOMETRICAL SHAPED SHIELD AND MULTIPLE SENSOR SYSTEMS. THE APPROACH USES A FRACTION OF THE PROCESSING POWER OF OTHER APPROACHES AND WITH A MULTIPLE SENSOR SYSTEM OUR APPROACH NOT ONLY CALCULATES THE NOISE FOR EACH SENSOR BUT IT ALSO CALCULATES THE NOISE CORRELATION MATRIX BETWEEN SENSORS. HERE WE WILL SHOW THE ALGORITHM AND EXAMPLES WHERE IT CAN BE IMPLEMENTED.

THE AUTHORS GRATEFULLY ACKNOWLEDGE THE SUPPORT OF THE U.S. DEPARTMENT OF ENERGY, THE U.S. NATIONAL INSTITUTES OF HEALTH AND THE U.S. DEPARTMENT OF HOMELAND SECURITY FOR THIS WORK.

3EP3K-05

DEVELOPMENT OF MICE BIOMAGNETIC MEASUREMENT SYSTEM BY USING HIGH-T_C SQUID MAGNETOMETER ***I. KIM***[1]*, C. LEE*[2]*, Y. LEE*[1]*;* [1]KOREA RESEARCH INSTITUTE OF STANDARDS AND SCIENCE, [2]KOREA RESEARCH INSTITUTE OF BIOSCIENCE AND BIOTECHNOLOGY. — WE HAVE DEVELOPED A BIOMAGNETIC MEASUREMENT SYSTEM FOR MICE BY USING HIGH-T_C SQUID MAGNETOMETER PREPARED ON 10 MM X 10 MM SUBSTRATE. THE SYSTEM CONSISTS OF A HIGH-T_C SQUID SYSTEM, A MAGNETICALLY SHIELDED BOX WITH INTERNAL DIMENSION OF 30 CM X 30 CM X 30 CM, AND A NONMAGNETIC DEWAR WITH A WARM-TO-COOL DISTANCE OF ABOUT 4 MM. MICE WITH WEIGHTS OF ABOUT 40 G WERE ANESTHETIZED AND FIXED ON A PLASTIC X-Y-Z STAGE INSIDE THE SHIELD BOX. THE SIGNAL WAS RECORDED AND DIGITIZED WITH SAMPLING RATE OF 1280 HZ THROUGH A BAND PASS FILTER OF 0.5 HZ - 1000 HZ. WE CARRIED OUT GRID MEASUREMENTS IN INTERVAL OF 20 MM BY ADJUSTING X-Y STAGE INSIDE THE SHIELD BOX TO OBTAIN CLEAR QRS COMPLEX DATA RATHER THAN MCG MAPPING DATA. MEASURED MCG SIGNALS WERE RECORDED FOR 30 S AND TIME AVERAGED WITH PEAK-FIND-ALGORITHM. WE COULD OBTAIN CLEAR MCG SIGNALS OF 15 PT IN PEAK WITH WELL DEFINED *QRS* COMPLEXES. WE DEMONSTRATED THE HIGH-T_C SQUID BASED BIOMAGNETIC MEASUREMENT SYSTEM IS USEFUL FOR MONITORING MICE MCG SIGNALS WITH GOOD NOISE-TO-SIGNAL RATIO.

3EP3K-06

MEASUREMENT OF RAT MAGNETOCARDIOGRAMS BY USING HIGH-T_C SQUID MAGNETOMETER ***I. KIM***[1]*, S. AHN*[1]*, C. LEE*[2]*, J. SONG*[3]*, Y. LEE*[1]*;* [1]KOREA RESEARCH INSTITUTE OF STANDARDS AND SCIENCE, [2]KOREA RESEARCH INSTITUTE OF BIOSCIENCE AND BIOTECHNOLOGY, [3]CHUNGNAM NATIONAL UNIVERSITY. — WE HAVE MEASURED BIOMAGNETIC SIGNALS FROM RAT BY USING A SINGLE CHANNEL HIGH-T_C SQUID MAGNETOMETER, AIMING TO A BASIC PHYSIOLOGICAL STUDY ON CARDIAC ELECTRICAL ACTIVITY OF SMALL ANIMALS. THE MEASUREMENTS DETECTING VERY WEAK MCG SIGNALS FROM RAT HEART WERE CARRIED OUT INSIDE A SMALL MAGNETICALLY SHIELDED BOX. MAGNETIC FIELD NOISE OF

THE HIGH-T_C SQUID MAGNETOMETERS MEASURED IN THE SHIELD BOX WAS ABOUT 40 FT/HZ$^{1/2}$ WITH 1/*F* CORNER FREQUENCY OF 6 HZ. FOR THE RAT MCG MEASUREMENTS, RATS WITH WEIGHTS OF ABOUT 350 G WERE ANESTHETIZED AND FIXED ON A PLASTIC TABLE IN SUPINE POSITION INSIDE THE SHIELD BOX. THE SQUID SENSOR IN THE DEWAR WAS POSITIONED DIRECTLY ABOVE THE HEART OF A RAT. THE BIOMAGNETIC SIGNALS WERE RECORDED FOR TYPICALLY 30 S WITH SAMPLING RATE OF 1280 HZ. WITH A GAP OF 4 MM OF THE DEWAR TAIL, WE COULD OBTAIN STRONG *R*-PEAK SIGNALS OF 30 PT WITH WELL DEFINED *P*-, *QRS*-, AND *T*-WAVE COMPLEXES. BY THE INVASIVE METHOD AVOIDING ANIMAL SACRIFICE, WE MEASURED AND ANALYZED THE RAT MCG WAVEFORM SIGNALS FOR FURTHER STUDIES OF ANIMAL MODELS OF CARDIAC ELECTRICAL ACTIVITIES.

3EP3K-07

IMPROVEMENT OF SENSITIVITY IN THE LOW FREQUENCY RANGE FOR SUPERCONDUCTING-MAGNETORESISTIVE MAGNETOMETER *H. POLOVY[1], **R. GUERRERO SANCHEZ**[1], M. PANNETIER-LECOEUR[1], C. FERMON[1], S. CARDOSO[2], R. FERREIRA[2], P. P. FREITAS[2];* [1]DSM/IRAMIS/SPEC, CEA SACLAY, 91191 GIF SUR YVETTE CEDEX FRANCE, [2]INSTITUTO DE SISTEMAS E COMPUTADORES – MICROSISTEMAS E NANOTECNOLOGIAS. — COMBINING A GIANT MAGNETORESISTIVE FIELD SENSOR (GMR) TO A SUPERCONDUCTING PICK UP LOOP CAN LEAD TO FEMTOTESLA-RANGE MAGNETOMETERS. FOR APPLICATIONS WHERE SIGNAL DETECTION IS IN THE KHZ TO MHZ RANGE, THESE KIND OF SENSORS PRESENT A DETECTIVITY OF SEVERAL FEMTOTESLAS. HOWEVER, FOR LOW FREQUENCY APPLICATIONS, SUCH AS BIOMAGNETIC SIGNAL MEASUREMENT, THEIR PERFORMANCE IS LIMITED BY THE 1/F NOISE. IN A FIRST PART WE PRESENT A MODULATION TECHNIQUE THAT SUPPRESSES THE 1/F NOISE. THE PROPOSED TECHNIQUE TOGGLES AT KHZ FREQUENCIES THE SUPERCURRENT IN THE SUPERCONDUCTING LOOP. THE MODULATION DRIVES OUT OF THE DETECTION BANDWIDTH THE 1/F NOISE. THE PROPOSED TECHNIQUE PRESENTS FEW LIMITATIONS THAT WILL BE DISCUSSED IN DETAIL, FOR INSTANCE LOSS OF THE SIGNAL DURING THE TOGGLING PROCESS OR CAPACITIVE COUPLING OF THE DIFFERENT CURRENT LINES.IN A SECOND PART, WE WILL PRESENT THE POSSIBILITY OF INCORPORATING TUNNEL MAGNETORESISTANCE (TMR) DEVICES IN THE PROPOSED FIELD SENSORS. THESE MAGNETORESISTIVE DEVICES PRESENT A MUCH HIGHER SENSITIVITY THAN GMR SENSORS. HOWEVER, THEY PRESENT A HIGHER LOW FREQUENCY NOISE. WE PRESENT A NEW APPROACH TO USE TMR DEVICES IN ARRAYS OF SERIES AND PARALLEL ELEMENTS IN ORDER TO FIX THOSE DRAWBACKS. THE PROPOSED CONFIGURATION ENHANCES THE TOTAL MAGNETIC VOLUME AND THEREFORE LEADS TO AN EXTRA REDUCTION OF THE 1/F NOISE.

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3EP3K-08

COMPARISON OF NOISE PERFORMANCE OF THE SQUID BOOTSTRAP CIRCUIT WITH THAT OF THE STANDARD FLUX MODULATION DC SQUID READOUT SCHEME ***Y. ZHANG**[1], H. WANG[2], Y. WANG[2], G. ZHANG[2], H. DONG[1], X. XIE[2], M. MÜCK[3], H. KRAUSE[1], A. I. BRAGINSKI[1], A. OFFENHÄUSSER[1], M. JIANG[2];* [1]IBN-2, FORSCHUNGSZENTRUM JÜLICH, [2]SHANGHAI INSTITUTE OF MICROSYSTEM AND INFORMATION TECHNOLOGY, [3]INSTITUT FÜR ANGEWANDTE PHYSIK, JUSTUS-LIEBIG-UNIVERSITÄT GIEßEN. — WE RECENTLY PRESENTED A READOUT SCHEME FOR THE DC SUPERCONDUCTING QUANTUM INTERFERENCE DEVICE (SQUID) OPERATED IN THE VOLTAGE BIAS MODE, AND NAMED IT SQUID BOOTSTRAP CIRCUIT (SBC) [1]. THE SBC COMBINES ADDITIONAL VOLTAGE AND CURRENT FEEDBACKS [2] TO MINIMIZE THE PREAMPLIFIER NOISE. THE MAIN POINT OF THIS PAPER IS TO COMPARE THE FLUX NOISE PERFORMANCE OF THE SBC READOUT WITH THAT OF THE STANDARD FLUX MODULATION (FM) SCHEME. WE CHARACTERIZED SEVERAL LIQUID-HELIUM-COOLED SQUID MAGNETOMETERS WITH DIFFERENT LAYOUTS AND LOOP INDUCTANCES USING THESE TWO READOUT SCHEMES. MEASURED NOISE WAS COMPARABLE TO OR EVEN LOWER THAN THAT MEASURED BY FM ELECTRONICS. FOR EXAMPLE, WHITE NOISE OF A MAGNETOMETER WITH 110 PH INDUCTANCE WAS 1.3 $\mu\Phi_0$/POOTHZ WHEN MEASURED USING SBC WHILE WITH FM IT WAS 1.6 $\mu\Phi_0$/POOTHZ. FURTHERMORE, WE DISCUSS THE NOISE PERFORMANCE WHEN THE SBC CRITICAL NOISE SUPPRESSION CONDITION IS NEARLY FULFILLED. WE BELIEVE SBC TO BE A PROMISING CANDIDATE FOR MULTI-CHANNEL SQUID SYSTEMS.[1]. X. XIE *ET AL*., SUBMITTED TO *SUPERCOND. SCI. TECHNOL*. (2010).[2] D. DRUNG, IN SQUID SENSORS: FUNDAMENTALS, FABRICATION AND APPLICATIONS, (ED. H. WEINSTOCK), KLUWER ACAD. PUBL., DORDRECHT 1996, PP.63-116.

3EP3K-09

MAGNETIC RESONANCE IMAGING OF HYPERPOLARIZED ^{3}HE DETECTED WITH A HIGH-T_C SQUID IN MICROTESLA MAGNETIC FIELD AT LABORATORY ENVIRONMENT ***H. H. CHEN**[1], H. C. YANG[2], H. E. HORNG[1], S. H. LIAO[2], S. Y. YANG[3], L. J. CHANG[4], M. J. CHEN[2];* [1]INSTITUTE OF ELECTRO-OPTICAL SCIENCE AND TECHNOLOGY, NATIONAL TAIWAN NORMAL UNIVERSITY, [2]DEPARTMENT OF PHYSICS, NATIONAL TAIWAN UNIVERSITY, [3]MAGQU CO., LTD., [4]NUCLEAR SCIENCE AND TECHNOLOGY DEVELOPMENT CENTER, NATIONAL TSING HUA UNIVERSITY. — NUCLEAR MAGNETIC RESONANCE (NMR) AND MAGNETIC RESONANCE IMAGING (MRI) OF OPTICALLY PUMPED (OP) HYPERPOLARIZED ^{3}HE WAS STUDIED USING A HIGH-T_C SQUID MAGNETOMETER DEVICE IN MICROTESLA MAGNETIC FIELDS. THE OP CELL FILLED WITH A FEW MILLIGRAMS OF RB METAL, 60 TORR N_2 GAS AND 530 TORR ^{3}HE GAS. THE ^{3}HE CELL HAD BEEN HYPERPOLARIZED AT AN OPTICAL PUMPING SYSTEM FIRST FOR 5~6 HOURS, THEN IT WAS MOVED TO THE SQUID-DETECTED NUCLEAR MAGNETIC RESONANCE AND IMAGING SYSTEM. AN APPROPRIATE B_1 PULSE LEVEL AND TIME DURATION GENERATED A 5° LOW FLIP ANGLE OF POLARIZATION AND THE FREE INDUCTION DECAY NMR SIGNALS WERE MEASURED. THE MEASURED THE SPIN-LATTICE RELAXATION TIME (T_1) OF ^{3}HE IS 4.7 HOURS. WE IMPROVED

THE LINEWIDTH OF NMR SPECTRUM TO 0.8 HZ BY COMPENSATING THE INHOMOGENEOUS GRADIENT FIELD OF ENVIRONMENT. THE FILTERED BACK PROJECTION IMAGE OF HYPERPOLARIZED ^{3}HE TAKEN SHOWS CLEAR IMAGE IN ONE SHOT. THE SQUID-DETECTED NMR/MRI WILL BE OF GREAT INTEREST FOR BIOLOGICAL IMAGING.

3EX-01

(INVITED) **LONG RANGE PROXIMITY EFFECTS AND WEAK-LINK BEHAVIOR IN SUPERCONDUCTING / NORMAL-METAL BILAYER TESS** ***J. E. SADLEIR***[1], *C. N. BAILEY*[2], *S. R. BANDLER*[2], *R. P. BREKOSKY*[2], *J. R. CLEM*[3], *J. A. CHERVENAK*[2], *M. E. ECKART*[2], *F. M. FINKBEINER*[2], *R. L. KELLEY*[2], *C. A. KILBOURNE*[2], *F. S. PORTER*[2], *S. J. SMITH*[2]; [1]NASA GSFC AND UIUC PHYSICS DEPT., [2]NASA GSFC, [3]AMES LABORATORY AND DEPARTMENT OF PHYSICS AND ASTRONOMY, IOWA STATE UNIVERSITY. — DESPITE RECORD-SETTING PERFORMANCE DEMONSTRATED BY SUPERCONDUCTING TRANSITION EDGE SENSORS (TESS) AND GROWING UTILIZATION OF THE TECHNOLOGY, A THEORETICAL MODEL OF THE PHYSICS GOVERNING TES DEVICES' SUPERCONDUCTING PHASE TRANSITION HAS PROVEN ELUSIVE. WE HAVE RECENTLY SHOWN THAT TESS EXHIBIT WEAK-LINK BEHAVIOR, WHERE, UNLIKE PREVIOUS MODELS, THE AVERAGE STRENGTH OF THE ORDER PARAMETER VARIES OVER THE TES. MEASUREMENTS ARE PRESENTED OF THE TEMPERATURE AND MAGNETIC FIELD DEPENDENCE OF THE CRITICAL CURRENT MEASURED OVER 7 ORDERS OF MAGNITUDE ON SQUARE MO/AU BILAYERS RANGING IN LENGTH FROM 8 TO 290 MM. WE FIND OUR MEASUREMENTS HAVE A NATURAL EXPLANATION IN TERMS OF A SPATIALLY VARYING ORDER PARAMETER THAT IS ENHANCED IN PROXIMITY TO THE HIGHER TRANSITION TEMPERATURE SUPERCONDUCTING LEADS (THE LONGITUDINAL PROXIMITY EFFECT) AND SUPPRESSED IN PROXIMITY TO THE ADDED NORMAL METAL STRUCTURES (THE LATERAL INVERSE PROXIMITY EFFECT). CONSEQUENCES OF THIS IMPROVED UNDERSTANDING ARE DISCUSSED INCLUDING THE SIGNIFICANT ROLE THE CRITICAL CURRENT AND NONEQUILIBRIUM SUPERCONDUCTIVITY PLAY IN DESCRIBING THE RESISTIVE TRANSITION.

3EX-02

MICROSCOPIC MODEL OF A TRANSITION EDGE SENSOR AS A WEAK LINK ***A. KOZOREZOV***[1], *A. GOLUBOV*[2], *D. MARTIN*[3]; [1]DEPARTMENT OF PHYSICS, LANCASTER UNIVERSITY, UK, [2]DEPARTMENT OF APPLIED PHYSICS, UNIVERSITY OF TWENTE, THE NETHERLANDS, [3]ESA-ESTEC, NOORDWIJK, THE NETHERLANDS. — WE HAVE DEVELOPED MICROSCOPIC MODEL OF A TRANSITION EDGE SENSOR (TES). TO DESCRIBE TES AS LATERALLY PROXIMISED S-S' -S WEAK LINK WE SOLVED THE USADEL EQUATIONS. WE HAVE DEVELOPED A FULLY SELF-CONSISTENT APPROACH, ACCOUNTING FOR THE APPROPRIATE BOUNDARY CONDITIONS AT THE CONTACTS WITH THE LARGE GAP SUPERCONDUCTING LEADS. WE HAVE FOUND ANALYTICAL SOLUTION OF THE USADEL EQUATIONS FOR THE SIMPLEST GEOMETRY OF TES AND ANALYSED ITS BEHAVIOUR FOR THE SITUATION WHEN TES SIZE IS LARGER THAN THE COHERENCE LENGTH. THE DETAILS OF ANALYTICAL SOLUTION ARE DISCUSSED FOR THE TWO EXTREME CASES OF SMALL AND LARGE PHASE CHANGE ACROSS THE LINK. FOR A MORE GENERAL SITUATION WE DISCUSS NUMERICAL SOLUTIONS. WE PRESENT THE EXPLICIT FORMS OF THE LATERAL PROFILE OF THE ORDER PARAMETER FOR A TYPICAL TES SENSOR AS A FUNCTION OF TEMPERATURE, SIZE AND BIAS CURRENT. WE CALCULATE CURRENT-PHASE RELATIONS AND THE CRITICAL JOSEPHSON CURRENT, AND ANALYSE THE IMPORTANT DIFFERENCES BETWEEN MODELLING OF TES AS EIHTER S-S' -S OR S-N-S LINK.

3EX-03

PHYSICS OF PROXIMITY JOSEPHSON SENSOR ***J. VOUTILAINEN***, *M. A. LAAKSO, T. T. HEIKKILÄ;* AALTO UNIVERSITY SCHOOL OF SCIENCE AND TECHNOLOGY. — PHYSICS OF PROXIMITY JOSEPHSON SENSORWE STUDY THE PROXIMITY JOSEPHSON SENSOR (PJS), THE RADIATION DETECTOR PROPOSED IN APPL. PHYS. LETT. 92, 162507 (2008). THE SENSOR EXPLOITS THE FACT THAT BY CONNECTING A NORMAL-CONDUCTING ABSORBER WITH SUB-MICRON DIMENSIONS TO TWO SUPERCONDUCTING TERMINALS, SOME SUPERCONDUCTIVITY IS INDUCED ALSO IN THE ABSORBER DUE TO THE SUPERCONDUCTING PROXIMITY EFFECT. WHEN THE ABSORBER IS IRRADIATED EITHER BY SINGLE PHOTONS OR A CONTINUOUS ELECTROMAGNETIC POWER THE NUMBER OF HOT ELECTRONS IN THE ABSORBER INCREASES AND THE STRENGTH OF THE INDUCED SUPERCONDUCTIVITY DECREASES.THE PROCESS CAN BE MONITORED BY MEASURING THE KINETIC INDUCANCE OF THE SYSTEM WHICH THUS FUNCTIONS AS A SENSITIVE DETECTOR. THE BENEFITS OF THE SENSOR INCLUDE SMALL AND WELL-DEFINED ABSORBER REGION AND THE ABSENCE OF BIAS NOISE SINCE THE SENSOR OPERATES IN A DISSIPATIONLESS STATE.IN THE ORIGINAL WORK, THE DETECTION SCHEME IS EVALUATED FOR OPERATION BOTH AS A BOLOMETER AND AS A SINGLE-PHOTON DETECTOR. WE GO DEEPER IN THE ANALYSIS AND FIND CONDITIONS UNDER WHICH THE DETECTOR CAN BE OPERATED EFFICIENTLY. WE STUDY BOTH THE COUPLING OF ELECTROMAGNETIC RADIATION TO THE DEVICE AND THE EFFECTS OF THE INDUCED SUPERCONDUCTIVITY ON THE DETECTOR PERFORMANCE. (ARXIV:0906.5470, TO BE PUBLISHED IN JAP)

3EX-04

IMPLICATIONS OF WEAK-LINK EFFECTS ON THE PERFORMANCE OF MO/AU TRANSITION-EDGE SENSORS ***S. J. SMITH***[1], *C. N. BAILEY*[2], *S. R. BANDLER*[1], *R. P. BREKOSKY*[3], *J. A. CHERVENAK*[4], *M. E. ECKART*[2], *F. M. FINKBEINER*[5], *R. L. KELLEY*[4], *C. A. KILBOURNE*[4], *F. S. PORTER*[4], *J. E. SADLEIR*[4]; [1]NASA GSFC AND UNIVERSITY OF MARYLAND, [2]NASA GSFC AND NPP, [3]NASA GSFC AND NORTHRUP GRUMMAN, [4]NASA GSFC, [5]NASA GSFC AND WYLE INFORMATION SYSTEMS. — UNDERSTANDING THE PHYSICAL PROPERTIES OF THE SUPERCONDUCTING-TO-NORMAL TRANSITION IS FUNDAMENTAL FOR OPTIMIZING THE DESIGN AND PERFORMANCE OF TRANSITION-EDGE SENSORS (TES'S). RECENT CRITICAL CURRENT MEASUREMENTS OF MO/AU BILAYER TEST STRUCTURES SHOW THEY ACT AS WEAK SUPERCONDUCTING LINKS EXHIBITING OSCILLATORY,

FRAUNHOFER-LIKE, BEHAVIOR WITH APPLIED MAGNETIC FIELD. IN THIS CONTRIBUTION WE INVESTIGATE THE IMPLICATIONS OF THIS BEHAVIOR FOR REAL TES DETECTORS, UNDER OPERATIONAL BIAS CONDITIONS. THESE DEVICES HAVE ADDITIONAL NORMAL METAL FEATURES USED FOR ABSORBER ATTACHMENT AND UNEXPLAINED NOISE SUPPRESSION. WE SHOW THESE FEATURES CAUSE MODIFICATIONS TO PREVIOUSLY OBSERVED CRITICAL CURRENT BEHAVIOR AND PRESENT MEASUREMENTS OF THE LOGARITHMIC RESISTANCE SENSITIVITY WITH TEMPERATURE ALPHA, AND CURRENT BETA, AS A FUNCTION OF MAGNETIC FIELD AND BIAS POINT WITHIN THE PHASE-TRANSITION. RESULTS SHOW THAT THESE IMPORTANT DEVICE PARAMETERS SHOW SIMILAR OSCILLATORY BEHAVIOR WITH APPLIED MAGNETIC FIELD, WHICH IN-TURN AFFECTS THE SIGNAL RESPONSIVITY AND NOISE, AND HENCE THE ENERGY RESOLUTION.

3EX-05

CHARACTERIZATION OF NOISE AND TRANSITION SHAPES IN SUPERCONDUCTING TRANSITION-EDGE SENSORS USING A PULSED LASER DIODE ***D. S. SWETZ****, J. N. ULLOM, D. A. BENNETT, W. B. DORIESE, G. C. HILTON, K. D. IRWIN, C. D. REINTSEMA, D. R. SCHMIDT;* NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY. — WE ARE DEVELOPING SOFT X-RAY SUPERCONDUCTING TRANSITION-EDGE SENSORS (TESS) FOR MATERIALS ANALYSIS AND ASTROPHYSICS. OUR SENSORS ARE BASED ON MO/CU BILAYER THERMISTORS WITH ADDITIONAL NORMAL-METAL FEATURES TO CONTROL THE TRANSITION SHAPE. WE HAVE MEASURED THE NOISE, HEAT CAPACITY AND DERIVATIVES OF RESISTANCE WITH TEMPERATURE AND CURRENT IN A VARIETY OF DEVICES WHERE BOTH PIXEL SIZE AND NORMAL-METAL FEATURES WERE VARIED. TRADITIONALLY, INTERDIGITATED NORMAL BARS HAVE BEEN USED TO SUPPRESS EXCESS HIGH-FREQUENCY NOISE. HERE, WE PRESENT RESULTS FROM DEVICES WITH A BROADER RANGE OF FEATURES INCLUDING ARRAYS OF NORMAL-METAL DOTS WITH VARYING DOT DENSITY AND UNIFORMITY. WE ALSO PRESENT A NEW TECHNIQUE FOR CHARACTERIZING TES SENSORS USING A FIBER-FED 1550 NM LASER TO GENERATE PULSES ON COMMAND WITH CONTROLLED SHAPE, AMPLITUDE AND DURATION. WE HAVE USED THIS NEW CAPABILITY TO MEASURE SENSOR RESPONSE AS A FUNCTION OF BIAS RESISTANCE WITH GREATER PRECISION THAN IN OUR PREVIOUS EXPERIMENTS. USING THE LASER AND OTHER TECHNIQUES, WE HAVE MEASURED THE INTERRELATIONS BETWEEN PIXEL SPEED, TRANSITION SHAPE AND NOISE IN THE TES SENSORS AS A FUNCTION OF OPERATING RESISTANCE AND EXTERNALLY APPLIED MAGNETIC FIELD. WE PRESENT EARLY RESULTS OF SPECTRA AND ENERGY RESOLUTION FROM SELECT DEVICES.

THIS WORK IS SUPPORTED BY THE NASA APRA PROGRAM

3EX-06

CHARACTERIZATION OF TI/AU TRANSITION-EDGE SENSORS USING COMPLEX IMPEDANCE: UNDERSTANDING THE SENSOR, ABSORBER, AND SIN MEMBRANE ***M. A. LINDEMAN****[1], B. DIRKS[1], A. G. KOZOREZOV[2], M. P. BRUIJN[1], P. A. J. DE KORTE[1], R. H. DEN HARTOG[1], L. GOTTARDI[1], R. A. HIJMERING[1], H. F. C. HOEVERS[1], J. VAN DER KUUR[1], M. L. RIDDER[1];* [1]SRON NATIONAL INSTITUTE FOR SPACE RESEARCH, SORBONNELAAN 2, UTRECHT 3584 CA, THE NETHERLANDS, [2]DEPARTMENT OF PHYSICS, LANCASTER UNIVERSITY, LANCASTER, LA1 4YB, UK. — SRON IS DEVELOPING TRANSITION EDGE SENSOR (TES) MICROCALORIMETERS FOR THE INTERNATIONAL X-RAY OBSERVATORY (IXO). THESE MICROCALORIMETERS MEASURE INDIVIDUAL X-RAY PHONONS WITH HIGH ENERGY RESOLUTION. THE SENSITIVITY OF A MICROCALORIMETER DEPENDS ON THE PROPERTIES OF ITS COMPONENTS (THE TES, THE X-RAY ABSORBER, AND THE SILICON NITRIDE MEMBRANE THAT SUSPENDS THE TES) AND ON THE THERMAL COUPLINGS BETWEEN THE COMPONENTS. WE PRESENT COMPLEX IMPEDANCE MEASUREMENTS THAT CHARACTERIZE THE HEAT CAPACITIES, THERMAL COUPLINGS, AND OTHER PARAMETERS OF OUR TES MICROCALORIMETERS. THE MEASUREMENTS SUGGEST THE PRESENCE OF A HEAT CAPACITY WHICH IS THERMALLY COUPLED TO THE TES. WE INVESTIGATE THE CAUSE AND EFFECTS OF THIS DANGLING HEAT CAPACITY TO BETTER UNDERSTAND HOW TO OPTIMIZE TES MICROCALORIMETERS AND BOLOMETERS.

3EX-07

IMPEDANCE MEASUREMENTS FOR NEAR INFRARED-OPTICAL TI/PD AND TI/AU TRANSITION-EDGE SENSORS. ***E. TARALLI****[1], C. PORTESI[1], L. LOLLI[1], E. MONTICONE[1], M. RAJTERI[1], I. NOVIKOV[2], J. BEYER[3];* [1]ISTITUTO NAZIONALE DI RICERCA METROLOGICA (INRIM), [2]NOVOSIBIRSK STATE TECHNICAL UNIVERSITY (NSTU), [3]PHYSIKALISCH-TECHNISCHE BUNDESANSTALT (PTB). — **IMPEDANCE MEASUREMENTS FOR NEAR INFRARED-OPTICAL TI/PD AND TI/AU TRANSITION-EDGE SENSORS** WE PRESENT COMPLEX IMPEDANCE MEASUREMENTS FOR 20 μM X 20 μM TIPD AND TIAU TRANSITION-EDGE SENSORS SUITABLE FOR APPLICATION IN THE OPTICAL AND NEAR-INFRARED RANGE. THESE TYPES OF FAST SUPERCONDUCTING SINGLE PHOTON DETECTORS STILL HAVE NOT BEEN TAKEN INTO ACCOUNT FOR THIS RECENT METHOD OF MEASURING WHERE WE NEED FREQUENCIES UP TO 250 KHZ TO OBTAIN A COMPLETE FREQUENCY RESPONSE IN THE COMPLEX PLANE. FROM THESE MEASUREMENTS WE OBTAIN INFORMATION ABOUT THE SHARPNESS ΑΛΠΗΑ, THE RESISTANCE CURRENT SENSITIVITY BETA AND OF THE MOST IMPORTANT DEVICE THERMAL PARAMETERS: HEAT CAPACITY C, THERMAL CONDUCTANCE G AND EFFECTIVE RESPONSE TIME TAY_{ETF}. A COMPARISON BETWEEN THESE VALUES FOR THE TWO DIFFERENT DETECTORS IS SHOWN.A PRELIMINARY STUDY OF THE TIAU TES AS DETECTOR HAS BEEN DONE BY MEANS OF HEAT PULSES SIMULATING ABSORPTION OF SINGLE PHOTONS AT DIFFERENT ENERGIES. THE DETECTOR RESPONSE PULSES ARE COMPARED WITH A REAL SINGLE PHOTON COUNTING AT 690 NM AND 1310 NM MADE ON A TWIN DEVICE FABRICATED IN THE SAME PROCESSES.

3EY-01

(INVITED) **100-GHZ SINGLE-FLUX-QUANTUM BIT-SERIAL ADDER BASED ON 10-KA/CM2 NIOBIUM PROCESS** ***M.***

TANAKA[1], H. AKAIKE[1], A. FUJIMAKI[1], Y. YAMANASHI[2], N. YOSHIKAWA[2], S. NAGASAWA[3], K. TAKAGI[1], N. TAKAGI[1]; [1]NAGOYA UNIVERSITY, CREST-JST, [2]YOKOHAMA NATIONAL UNIVERSITY, CREST-JST, [3]ISTEC, CREST-JST. — WE REPORT DESIGN AND TEST RESULTS OF A SINGLE-FLUX-QUANTUM (SFQ) BIT-SERIAL ADDER, WHICH WE DESIGNED WITH A TARGET CLOCK FREQUENCY OF 100 GHZ IN ORDER TO INVESTIGATE SEVERAL TECHNIQUES TO MAKE ULTRAHIGH-SPEED COMPUTATIONS USING SFQ CIRCUITS. A BIT-SERIAL ADDER IS A BASIC COMPONENT OF VARIOUS ARITHMETIC CIRCUITS, AND IS A GOOD EXAMPLE OF A RANDOM LOGIC WITH RELATIVELY COMPLEX DATA-PATHS SUCH AS A FEEDBACK OF A CARRY SIGNAL.RECENTLY, WE HAVE DEVELOPED THE NB ADVANCED PROCESS AND A NEW CELL LIBRARY. COMPARED WITH THE CONVENTIONAL PROCESS AND CELL LIBRARY, THE CRITICAL CURRENT DENSITY AND MCCUMBER PARAMETERS ARE INCREASED FROM 2.5 KA/CM2 TO 10 KA/CM2 AND FROM 1.0 TO 2.0, RESPECTIVELY. AS A RESULT, MAXIMUM CLOCK FREQUENCY OF A TYPICAL BIT-SERIAL ADDER IS EXPECTED TO BE INCREASED BY 220%, ABOUT 70 GHZ. TO OBTAIN MUCH HIGHER FREQUENCIES, WE ADOPTED A CIRCUIT DESIGN BASED ON STATE TRANSITIONS, WHERE THE CARRY SIGNAL IS NOT FED BACK BUT STORED IN A NON-DESTRUCTIVE READ-OUT GATE. IN ADDITION, WE TUNED A NOR GATE, WHICH IS A KEYSTONE OF THE STATE-TRANSITION-BASED SERIAL ADDER.WE FABRICATED THE DESIGNED SERIAL ADDER USING THE ISTEC ADVANCED PROCESS (ADP 2.1), AND TESTED ON THE CHIP. WE OBTAINED THE SUFFICIENT DC BIAS MARGIN OF +/-18% FROM LOW FREQUENCIES TO 60 GHZ, AND VERIFIED SUCCESSFUL OPERATIONS UP TO 93 GHZ. CURRENTLY WE ARE OPTIMIZING OTHER CIRCUIT PARAMETERS AND WILL CONTINUE HIGH-SPEED TESTS.

NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY PARTIALLY CONTRIBUTED TO THE CIRCUIT FABRICATION.

3EY-02

HYBRID SEMICONDUCTOR-SUPERCONDUCTOR FAST-READOUT MEMORY FOR DIGITAL RF RECEIVERS ***O. A. MUKHANOV****, A. F. KIRICHENKO, T. V. FILIPPOV, S. SARWANA;* HYPRES. — WE PRESENT RESULTS ON THE DEVELOPMENT OF A NEW TYPE OF A HYBRID MEMORY FOR A SUPERCONDUCTING CROSS-CORRELATION-BASED DIGITAL-RF RECEIVER SUPPORTING 30 GBPS MEMORY FETCH SPEED. THE MAIN FEATURE OF THIS MEMORY IS A COMBINATION OF A HIGH CAPACITY ROOM-TEMPERATURE MEMORY AND A HIGH SPEED ON-CHIP SUPERCONDUCTIVE CACHE IN ORDER TO PROVIDE DIGITAL WAVEFORM TEMPLATES FOR DIGITAL-RF RECEIVER. AS A ROOM-TEMPERATURE HIGH-CAPACITY MEMORY WITH FAST READOUT, WE SELECTED SYMPULS PATTERN GENERATOR BMG 30G-64M CAPABLE OF PRODUCING A 30 GBPS SERIAL DATA STREAM OF PROGRAMMABLE PATTERN OF 67,108,864 BITS. WE DESIGNED, FABRICATED, AND TESTED AN ON-CHIP CACHE WHICH RECEIVES HIGH-SPEED TEMPLATE SERIAL DATA FROM THE ROOM TEMPERATURE MEMORY AND CONVERTS IT INTO A STREAM OF 3-BIT WORDS OF A LOCAL OSCILLATOR (LO) TEMPLATE FOR DIGITAL MIXER. WE INTEGRATED THE MEMORY WITH A 1X3-BIT DIGITAL I/Q MIXER (1-BIT DIGITIZED RF STREAM MULTIPLIED BY 3-BIT DIGITAL LO) TO FORM DIGITAL CORRELATING CIRCUIT FOR DIGITAL RF RECEIVERS. IN THIS PAPER, WE WILL PRESENT DESIGN AND TEST RESULTS OF THE ENTIRE HYBRID SEMICONDUCTOR/SUPERCONDUCTOR MEMORY SYSTEM CAPABLE OF FAST LOADING OF TEMPLATE DATA INTO A SUPERCONDUCTOR CORRELATOR CIRCUIT. INTEGRATION ISSUES OF HETEROGENEOUS TECHNOLOGIES CO-LOCATED AT DIFFERENT TEMPERATURE STAGES WILL BE DISCUSSED.

THE WORK IS SUPPORTED IN PART BY THE ONR CONTRACT N00014-08-C-0149

3EY-03

DEMONSTRATION OF A 4X4 SFQ SWITCH FABRICATED WITH A 10KA/CM^2 NB MULTI-LAYER PROCESS ***M. ITO[1]****, I. KATAEVA[1], R. KASAGI[1], M. OKADA[1], T. KOKETSU[1], M. TANAKA[1], S. NAGASAWA[2], H. AKAIKE[1], A. FUJIMAKI[1];* [1]NAGOYA UNIVERSITY, [2]SUPERCONDUCTIVITY RESEARCH LABORATORY. — WE HAVE DESIGNED AND EVALUATED THE PERFORMANCE OF A 4X4 SFQ SWITCH FABRICATED USING ISTEC 10-KA/CM^2 NB ADVANCED PROCESS 2 (ADP2). THE ADP2 DEVICE CONSISTING OF 9-NB-LAYERS HAS 5 LAYERS DEDICATED TO PASSIVE TRANSMISSION LINE (PTL) INTERCONNECTS BELOW A JOSEPHSON JUNCTION. HIGH CRITICAL CURRENT DENSITY OF ADP2, 10-KA/CM^2 , INCREASES CLOCK FREQUENCY TWICE AND DECREASES THE AREA OF LOGIC CELLS DOWN TO 9/16 IN COMPARISON WITH A PREVIOUS PROCESS. WE HAVE EVALUATED EFFECTS OF THESE FEATURES BY DESIGNING AND TESTING THE 4X4 SFQ SWITCH BECAUSE THE 4X4 SWITCH USES A LOT OF PTLS AND HAS NO FEEDBACK LOOPS.WE HAVE SUCCESSFULLY TESTED THE 4X4 SWITCH AT THE DATA RATES UP TO 89 GBPS PER CHANNEL WITH A WIDE BIAS MARGIN OF -5% TO +13%. DUE TO 5 ADDITIONAL LAYERS DEDICATED TO PTLS AND REDUCTION OF CELL SIZE, WE HAVE ACHIEVED 81% REDUCTION OF THE OCCUPIED AREA IN COMPARISON WITH THE SAME DESIGN FOR THE PREVIOUS PROCESS. THE INTEGRATION DEGREE OF THE CIRCUIT WAS 177 KJJ/CM^2.

NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY PARTIALLY CONTRIBUTED TO THE CIRCUIT FABRICATION.

3EY-04

A COMPARISON OF MULTI-CRITERIA EVALUATION METHODS FOR RSFQ CIRCUIT OPTIMIZATION ***H. R. GERBER[1]****, F. G. ORTMANN[1], A. VAN DER MERWE[1], C. J. FOURIE[2];* [1]NIOCAD, [2]STELLENBOSCH UNIVERSITY. — RESEARCH HAS BEEN DONE ON THE METAHEURISTIC OPTIMIZATION OF RSFQ CIRCUITS, BUT THESE ARE TYPICALLY LIMITED TO SINGLE CRITERIA (E.G. YIELD). SUCH OPTIMIZATION TECHNIQUES REQUIRE GOOD EVALUATION METHODS OF POSSIBLE SOLUTIONS IN ORDER FOR THEM TO BE SUCCESSFUL. AMONGST OTHER REASONS, RSFQ CIRCUIT DESIGN OPTIMIZATION IS CHALLENGING DUE TO THE MANY POSSIBLE CRITERIA ONE MAY WISH TO INCLUDE IN EVALUATIONS. THE IMPORTANCE OF USING MULTIPLE

CRITERIA AND THE RELEVANCE OF EACH OF THE CRITERIA IS DISCUSSED. THE APPLICATION OF DATA ENVELOPMENT ANALYSIS AND AN INTERACTIVE NORMALISATION TECHNIQUE AS MULTI-CRITERIA EVALUATION METHODS FOR THE OPTIMISATION OF RSFQ CIRCUITS ARE INVESTIGATED. RESULTS FOR OPTIMIZATION OF RSFQ CELLS WITH THESE TECHNIQUES ARE COMPARED TO THOSE OBTAINED WITH OTHER OPTIMIZATION TECHNIQUES. THE CHALLENGES OF IMPLEMENTING THESE TECHNIQUES IN AN INTEGRATED DESIGN ENVIRONMENT, WITH A SPECIFIC FOCUS ON SOFTWARE AUTOMATION, ARE DISCUSSED.

3EY-05

SINGLE-FLUX-QUANTUM-BASED READOUT SYSTEM FOR AN ARRAY OF SUPERCONDUCTIVE NEUTRON DETECTORS ***S. MIYAJIMA***[1]*, I. NAKANISHI*[1]*, Y. HIGASHI*[1]*, T. KUSUMOTO*[1]*, A. FUJIMAKI*[1]*, K. ARAI*[2]*, Y. AKITA*[2]*, I. YAGI*[2]*, T. ISHIDA*[2]*;* [1]NAGOYA UNIVERSITY, [2]OSAKA PREFECTURE UNIVERSITY. — WE HAVE DEVELOPED A READOUT SYSTEM BASED ON A SINGLE-FLUX-QUANTUM (SFQ) SIGNAL PROCESSING CIRCUIT FOR A COMPACT NEUTRON DIFFRACTOMETER. THE DETECTORS THEMSELVES ARE MADE OF MGB_2 NANOWIRE. INCIDENT OF A NEUTRON TO DETECTOR CAUSES REDUCTION OF CURRENT OF A FEW MA FOR LESS THAN 2 NS. ENERGY OF A NEUTRON CAN BE OBTAINED BY MEASURING TIME-OF-FLIGHT BETWEEN THE START SIGNAL FROM EXTERNAL GENERATOR AND STOP SIGNAL FROM THE OUTPUT OF A DETECTOR. A DETECTOR ARRAY IS ESSENTIAL FOR CONSTRUCTING A DIFFRACTOMETER AND SOME MULTIPLEXER IS REQUIRED TO REDUCE HEAT INFLOW THROUGH THE CABLES CONNECTING DETECTORS WITH ROOM-TEMPERATURE ELECTRONICS.THE SFQ SIGNAL PROCESSING CIRCUITS DESIGNED HERE MEASURE THE TIME-OF-FLIGHT WITH TIME RESOLUTION OF 20 NS IN DIGITAL DOMAIN AND MULTIPLEX THESE DATA. HIGHLY SENSITIVE QUASI-ONE-JUNCTION SQUIDS (QOSS) WORKING AS COMPARATORS GENERATE SFQ PULSES CORRESPONDING TO STOP SIGNALS AT THE REPETITION RATE OF 12.8 GHZ BY OUTPUT SIGNALS OF DETECTORS. THE TIME-OF-FLIGHT WILL BE CALCULATED BY COUNTING 50-MHZ-CLOCKS AT SFQ COUNTER.WE ARE ALSO DEVELOPING REAL-TIME ROOM-TEMPERATURE ELECTRONICS FOR OBTAINING DIFFRACTION PATTERNS BASED ON A FPGA. WE CAN HANDLE 16 DETECTORS IN THIS ROOM-TEMPERATURE ELECTRONICS.

THIS DEVELOPMENT WAS SUPPORTED BY SENTAN, JST

3EY-06

NEW JOSEPHSON-CMOS INTERFACE AMPLIFIER *D. WEI, S. R. WHITELEY, H. PARK, L. ZHENG, H. KIM,* ***T. VAN DUZER****;* UNIVERSITY OF CALIFORNIA. — THERE ARE VARIOUS APPLICATIONS IN WHICH THE MILLIVOLT-LEVEL SIGNALS IN A JOSEPHSON CIRCUIT MUST DRIVE CMOS VOLT-LEVEL CIRCUITS. OUR APPLICATION IS A HYBRID MEMORY IN WHICH THE MEMORY CORE IS SILICON. IN OUR CURRENT DESIGN, A 64 KBIT CMOS MEMORY IS MADE IN 180 NM CMOS AND FITS IN AN AREA OF ABOUT 0.5 MM X 1 MM. THE MOST CHALLENGING PART IS THE INTERFACE AMPLIFIER. OUR EARLIER WORK EMPLOYED A TWO-STAGE AMPLIFIER REFERRED TO AS THE GHOSHAL AMPLIFIER. THE FIRST STAGE IS A SO-CALLED SUZUKI STACK THAT PRODUCES A 40 MV CLOCKED OUTPUT. THE SECOND STAGE IS A HYBRID CIRCUIT WITH A MOS DEVICE LOADED BY A LONG SERIES ARRAY OF JOSEPHSON JUNCTIONS.IN A SEARCH FOR AN ALTERNATIVE AMPLIFIER THAT HAS STILL LOWER POWER DISSIPATION AND ROBUST OPERATION, WE HAVE INVESTIGATED A CMOS AMPLIFIER FOR THE SECOND STAGE, WHICH IS A MODIFICATION OF AN AMPLIFIER USED AS A SENSE AMPLIFIER IN ROOM-TEMPERATURE CMOS MEMORY CIRCUITS. THE JOSEPHSON PREAMPLIFIER FOR THIS SECOND STAGE IS REQUIRED TO SUPPLY BOTH TRUE AND COMPLEMENT INPUTS, EACH AT A LEVEL OF 80 MV. FOR THAT PURPOSE, WE HAVE DESIGNED A PAIR OF “SUPER-STACKS,” EACH COMPRISING A SERIES OF FOUR SHORT SUZUKI STACKS.CALCULATIONS SHOW THE POWER DISSIPATION OF THE COMPLETE TWO-STAGE AMPLIFIER TO BE SLIGHTLY LOWER THAN THAT OF THE GHOSHAL AMPLIFIER. SIMULATION AND EXPERIMENTAL EVALUATION OF THIS NEW TWO-STAGE HYBRID AMPLIFIER WILL BE PRESENTED WITH AN EVALUATION OF ITS ROBUSTNESS.

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3EZ-01

NON-LINEAR MAGNETIC RESPONSE OF SUPERCONDUCTING RF METAMATERIALS ***C. KURTER***[1]*, A. P. ZHURAVEL*[2]*, A. V. USTINOV*[3]*, S. M. ANLAGE*[1]*;* [1]CENTER FOR NANOPHYSICS AND ADVANCED MATERIALS, DEPARTMENT OF PHYSICS, UNIVERSITY OF MARYLAND, COLLEGE PARK, MD 20742-4111 USA, [2]B. VERKIN INSTITUTE FOR LOW TEMPERATURE PHYSICS & ENGINEERING, NATIONAL ACADEMY OF SCIENCES OF UKRAINE, 61164 KHARKOV, UKRAINE, [3]PHYSIKALISCHES INSTITUT, UNIVERSITÄT KARLSRUHE, D-76131 KARLSRUHE, GERMANY. — SUPERCONDUCTING METAMATERIALS HAVE THE ADVANTAGE OF LOW-LOSS, LARGE INDUCTANCE, AND EXTREME TUNABILITY COMPARED TO THEIR NORMAL METAL COUNTERPARTS. WE HAVE RECENTLY DEVELOPED A COMPACT RADIO FREQUENCY (RF) METAMATERIAL EMPLOYING NB THIN FILMS PATTERNED INTO PLANAR SPIRALS. THOUGH NB IS A NON-MAGNETIC MATERIAL, THE CIRCULATING CURRENTS IN THE SPIRALS INDUCED BY RF SIGNALS PRODUCE A STRONG MAGNETIC RESPONSE, WHICH CAN BE TUNED SENSITIVELY EITHER BY TEMPERATURE OR MAGNETIC FIELD THANKS TO THE SUPERCONDUCTING NATURE OF THE DESIGN. WE PRESENT RESULTS ON THE LINEAR RESPONSE PROPERTIES OF THESE NOVEL SUPERCONDUCTING METAMATERIALS, SHOWING NEGATIVE EFFECTIVE PERMEABILITY IN THE SUB-100 MHZ FREQUENCY RANGE. WE HAVE ALSO OBSERVED STRONG NONLINEARITY AND META-STABLE JUMPS IN THE TRANSMISSION DATA WITH INCREASING RF POWER UNTIL THE NB METAMATERIAL IS DRIVEN INTO THE NORMAL STATE. RF LASER SCANNING MICROSCOPY OF THE SPIRALS HAS BEEN PERFORMED IN THE SUPERCONDUCTING STATE TO IDENTIFY THE MICROSCOPIC BREAKDOWN MECHANISMS AT HIGH POWER. THE POWER DEPENDENCE IS RELATED TO INTRINSIC AND EXTRINSIC FACTORS WHICH CAN MODIFY THE TRANSMISSION FEATURES.

WE ACKNOWLEDGE SUPPORT FROM ONR AWARD NO. N000140811058.

3EZ-02

SCALING OF SQIF PROPERTIES WITH PARALLEL AND SERIES SQUIDS ***J. TALVACCHIO**, J. M. MURDUCK, Q. P. HERR, B. A. NECHAY;* NORTHROP GRUMMAN. — WE BROADEN THE DEFINITION OF A SQIF (SUPERCONDUCTING QUANTUM INTERFERENCE FILTER) TO INCLUDE ANY SERIES AND PARALLEL CONNECTIONS OF SQUIDS IN 2-DIMENSIONAL ARRAYS. COMPARED TO A SINGLE SQUID, THESE CONNECTED SQUIDS OFFER POSSIBILITIES FOR INCREASING OUTPUT VOLTAGE AND DYNAMIC RANGE, CONTROLLING RESPONSE LINEARITY AND OUTPUT IMPEDANCE, AND MAKING THE RESPONSE ROBUST TO VARIATION IN JUNCTION CRITICAL CURRENTS. THE LAST OF THESE IS PARTICULARLY IMPORTANT FOR HTS IMPLEMENTATIONS.WE WILL PRESENT CALCULATIONS, SIMULATIONS, AND EXPERIMENTAL RESULTS ON THE SCALING OF SQIFS WITH N PARALLEL JUNCTIONS AND M SERIES JUNCTIONS FOR SENSING RF MAGNETIC FIELDS WITH THE SQIF DC-BIASED IN THE VOLTAGE STATE. MOST OF THE IMPORTANT PERFORMANCE PARAMETERS -- OUTPUT VOLTAGE, POWER GAIN, SIGNAL-TO-NOISE DYNAMIC RANGE, SPUR-FREE DYNAMIC RANGE (SFDR), NOISE TEMPERATURE, AND SENSITIVITY TO VARIATIONS IN IC - IMPROVE WITH LARGER M AND N. OUTPUT RESISTANCE IS USUALLY TARGETED, FOR EXAMPLE AT 50 OHMS, BY THE RATIO OF M/N, WHILE POWER DISSIPATION IS THE ONLY PROPERTY WHERE LARGER SQIFS ARE UNDESIRABLE.SEVERAL STEPS HAVE BEEN EXPLORED EXPERIMENTALLY TO INCREASE SFDR. WE EMPLOYED DIFFERENTIAL PAIRS OF COUNTER-BIASED ARRAYS TO GREATLY REDUCE EVEN-ORDER SPURS AND AN APPROACH OF KORNEV, ET AL, TO SCALE LOOP AREAS BY FACTORS OF 1:3:5 TO CREATE A TRIANGLE-WAVE PERIODIC RESPONSE TO REDUCE THIRD-ORDER SPURS.

SUPPORTED BY THE OFFICE OF NAVAL RESEARCH

3EZ-03

LINEAR BI-SQUID ARRAYS FOR ELECTRICALLY SMALL ANTENNAS ***I. I. SOLOVIEV**[1], V. K. KORNEV[2], N. V. KLENOV[2], O. A. MUKHANOV[3];* [1]SINP MSU, [2]PHYSICS DEPARTMENT, MSU, [3]HYPRES, INC.. — RECENTLY WE PROPOSED SO-CALLED BI-SQUID BASED ON A 3-JUNCTION SQUID CIRCUIT CAPABLE OF ACHIEVING HIGHLY LINEAR VOLTAGE RESPONSE. IN THIS REPORT, WE PRESENT MORE RIGOROUS THEORETICAL ANALYSIS OF BI-SQUID CIRCUITS TAKING INTO CONSIDERATION UNAVOIDABLE PARASITIC PARAMETERS. WE ALSO PRESENT RESULTS OF EXPERIMENTAL EVALUATIONS OF BI-SQUIDS AND BI-SQUID ARRAYS FOR APPLICATIONS AS ELECTRICALLY SMALL ANTENNAS CAPABLE OF DIRECT SENSING OF MAGNETIC COMPONENT OF RF SIGNALS. A POSSIBLE EXTENSION OF THE PROPOSED LINEARIZATION METHOD TO MULTI-LOOP SQUIDS AND PARALLEL JOSEPHSON-JUNCTION ARRAYS IS DISCUSSED.

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3EZ-04

NANOSTRIP THREE-TERMINAL SUPERCONDUCTING DEVICE ***S. PAGANO**[1], N. MARTUCCIELLO[2], R. CRISTIANO[3], M. EJRNAES[3], A. CASABURI[3], R. LEONI[4], A. GAGGERO[4], F. MATTIOLI[4], J. C. VILLEGIER[5], P. CAVALIER[5];* [1]DEPT. OF MATEMATICS AND INFORMATICS AND CNR-SPIN SALERNO, UNIVERSITY OF SALERNO, 84084 FISCIANO, ITALY, [2]CNR-SPIN SALERNO, UNIVERSITY OF SALERNO, 84084 FISCIANO, ITALY, [3]CNR-ISTITUTO DI CIBERNETICA "E. CAIANIELLO", 80078 POZZUOLI, ITALY, [4]CNR-ISTITUTO DI FOTONICA E NANOTECNOLOGIE, 00156 ROME, ITALY, [5]INSTITUTE OF NANOSCIENCES AND CRYOGENICS SPSMS, CEA-GRENOBLE - 38054, GRENOBLE-CEDEX 9, FRANCE. — A SUPERCONDUCTING 3-TERMINAL DEVICE BASED ON NBN NANOSTRIPS IS PRESENTED. THE DEVICE HAS BEEN REALIZED USING ULTRA-THIN NBN FILMS AND ITS ACTIVE PART COVERS AN AREA LESS THEN 100 MM^2. THE DEVICE IS CAPABLE OF PROVIDING PULSE DISCRIMINATION AND SHAPING AND GIVES POWER GAIN WITH STANDARD 50 Ω INPUT AND OUTPUT IMPEDANCE. WE REPORT EXPERIMENTAL RESULTS OBTAINED ON SEVERAL DEVICES, HAVING DIFFERENT DESIGN AND MATERIAL CHARACTERISTICS. OUTPUT PULSE OF 20 NS DURATION AND HAVING AMPLITUDES UP TO 10 MV, WHEN DRIVEN BY 1 MV INPUT PULSE, HAVE BEEN ACHIEVED. THE DEVICE OPERATES AT 4.2 K AND IS IDEALLY SUITED AS OUTPUT PULSE BOOSTER FOR NANOWIRE DETECTORS AND RSFQ OUTPUT INTERFACES.

3EZ-05

THREE-TERMINAL SUPERCONDUCTING NONEQUILIBRIUM DEVICE WITH A FERROMAGNETIC SCREEN ***I. P. NEVIRKOVETS**[1], O. CHERNYASHEVSKYY[2], J. B. KETTERSON[3], A. V. PAN[4];* [1]ISEM UNIVERSITY OF WOLLONGONG, FAIRY MEADOW NSW 2519, AUSTRALIA; DEPARTMENT OF PHYSICS AND ASTRONOMY, NORTHWESTERN UNIVERSITY, EVANSTON IL 60208, USA, [2]DEPARTMENT OF PHYSICS AND ASTRONOMY, NORTHWESTERN UNIVERSITY, EVANSTON IL 60208, USA, [3]DEPARTMENT OF PHYSICS AND ASTRONOMY, AND DEPARTMENT OF ELECTRICAL ENGINEERING & COMPUTER SCIENCE, NORTHWESTERN UNIVERSITY, EVANSTON IL 60208, USA, [4]ISEM UNIVERSITY OF WOLLONGONG, FAIRY MEADOW NSW 2519, AUSTRALIA. — DOUBLE-BARRIER NB/AL/ALO_X/AL/NB/NI/AL/ALO_X/AL/NB ($S_1IS_2FIS_3$) MULTI-TERMINAL SUPERCONDUCTING TRANSISTOR-LIKE DEVICES HAVE BEEN FABRICATED AND CHARACTERIZED AT 4.2 K. A THIN FERROMAGNETIC NI LAYER SCREENS SUPERCONDUCTIVITY OF THE MIDDLE NB LAYER ON THE INJECTOR-BARRIER SIDE, SO THAT THE NB/NI BILAYER MANIFESTS ITSELF AS A SUPERCONDUCTOR IN THE CURRENT-VOLTAGE CHARACTERISTIC (CVC) OF THE ACCEPTOR S_1IS_2F JUNCTION, BUT AS A NORMAL METAL IN THE CVC OF THE INJECTOR S_2FIS_3 JUNCTION. IT IS SHOWN THAT THIS PROPERTY ALLOWS FOR CONSIDERABLE IMPROVEMENT OF THE INPUT-OUTPUT ISOLATION OF THE QUASIPARTICLE-INJECTION DEVICES AS COMPARED WITH THAT FOR THE FORMERLY REPORTED QUITERON [S. M. FARIS, PHYSICA B&C **126,** 165 (1984)].

3EZ-06

3D ACTIVE DEMAGNETIZATION OF LOW-TEMPERATURE MAGNETIC SHIELDS ***Y. A. POLYAKOV***[1]*, V. K. SEMENOV*[1]*, S. K. TOLPYGO*[2]*;* [1]STONY BROOK UNIVERSITY, [2]HYPRES, INC.. — PASSIVE MAGNETIC SHIELDING AND ACTIVE CANCELING OF MAGNETIC FIELD HAVE THEIR OWN ADVANTAGES AND DISADVANTAGES. TO GET THE BEST OF BOTH WORLDS WE COMBINED THE TWO TECHNIQUES. IN PARTICULAR, WE ACTIVELY DEMAGNETIZE A SET OF ORIGINAL MU-METAL MAGNETIC SHIELDS INSTEAD OF APPLYING A COMPENSATING FIELD TO THE SHIELDED "PAYLOAD". AS A RESULT, THE NEW SYSTEM IS FREE OF BULKY HELMHOLTZ COILS. IT PROVIDES REASONABLE SHIELDING EVEN WHEN THE ACTIVE FLUX LOCKED LOOP (FLL) ELECTRONICS IS TURNED OFF. AN ORIGINAL 3D SUPERCONDUCTOR QUANTUM INTERFERENCE FILTER (SQIF) BASED MAGNETIC SENSOR MONITORS THE RESIDUAL MAGNETIC FIELD WITH VERY HIGH SENSITIVITY, AND AN ACTIVATION OF FLL ELECTRONICS ADDITIONALLY DEPRESSES LOW (UP TO 1 KHZ) FREQUENCY MAGNETIC NOISE INCLUDING ITS DC COMPONENT BY AT LEAST TWO ORDERS OF MAGNITUDE. A DEVELOPED OR SIMILAR SETUP COULD BE A USEFUL ADDITION FOR EXPERIMENTS WITH ANY SUPERCONDUCTING CIRCUITS THAT COULD BE AFFECTED BY TRAPPED MAGNETIC FLUX. AT THE CONFERENCE WE WILL PRESENT DETAILS OF THE SHIELD DESIGN AND MEASUREMENT RESULTS.

THE PROJECT IS SUPPORTED IN PART BY OFFICE OF NAVAL RESEARCH

3EZ-07

DESIGN AND FABRICATION OF INTEGRATED CRYOGENIC CURRENT COMPARATORS *C. URANO*[1]*,* ***M. MAEZAWA***[1]*, M. MARUYAMA*[1]*, T. YAMADA*[1]*, T. OE*[1]*, M. HIDAKA*[2]*, T. SATOH*[2]*, S. NAGASAWA*[2]*, K. HINODE*[2]*, S. KIRYU*[3]*, N. KANEKO*[1]*;* [1]AIST, [2]ISTEC, [3]TOKYO CITY UNIV.. — A CRYOGENIC CURRENT COMPARATOR (CCC) IS A KEY DEVICE IN ELECTRICAL METROLOGY, WHICH PROVIDES A RATIO OF TWO CURRENTS WITH ULTIMATE ACCURACY BASED ON SUPERCONDUCTIVITY. CONVENTIONAL CCCS GENERALLY CONSIST OF MULTI-TURN COILS OF WIRE WINDINGS, A MULTI-LAYERED SHIELD OF SUPERCONDUCTOR PLATES AND AN EXTERNAL SQUID SENSOR. THIS IMPLEMENTATION RESULTS IN A BULKY DEVICE TOO MASSIVE TO COOL WITH A MECHANICAL CRYOCOOLER, MAKING A SYSTEM COMPLICATED AND INCONVENIENT. WE PROPOSE A NEW IMPLEMENTATION OF CCC, AN INTEGRATED CCC (ICCC), WHICH ENABLES A USER-FRIENDLY CURRENT COMPARATOR INSTRUMENT OPERATED WITH A COMPACT CRYOCOOLER. THE ICCC CONSISTS OF THIN-FILM SPIRAL COILS, A THIN-FILM SUPERCONDUCTIVE SHIELD AND A SQUID SENSOR WHICH ARE INTEGRATED ON A SINGLE CHIP. PROTOTYPE ICCC CHIPS WERE DESIGNED AND FABRICATED BY USING A SUPERCONDUCTING NB INTEGRATED CIRCUIT TECHNOLOGY WITH CHEMICAL-MECHANICAL POLISHING. THE BASIC OPERATION OF THE PROTOTYPE ICCCS WAS CONFIRMED BY MONITORING PERIODIC FLUX-VOLTAGE CHARACTERISTICS OF THE SQUIDS. THE TEST RESULTS SUGGESTED THAT THE CURRENT COMPARISON ERRORS, LIMITED MAINLY BY OUR TESTING SET-UP, WERE SMALLER THAN 0.1%.

3LA-01

(INVITED) **REVIEW OF DESIGN ASPECTS FOR HIGH CURRENT NB3SN CONDUCTORS** ***P. BRUZZONE****;* EPFL-CRPP. — CABLED CONDUCTORS BASED ON NB3SN TECHNOLOGY WITH OPERATING CURRENT IN THE RANGE OF 20 KA AND ABOVE ARE MAINLY RESTRICTED TO THE FUSION MAGNETS AND HIGH FIELD FACILITIES. THE EXPERIENCE OF LAST DECADE HAS DRAMATICALLY SHOWN THAT, OPPOSITE TO THE NBTI CONDUCTORS, EASY EXTRAPOLATION RULES FROM THE STRANDS PROPERTIES ARE NOT ADEQUATE FOR A RELIABLE CONDUCTOR DESIGN. REVERSIBLE AND IRREVERSIBLE DEGRADATION HEAVILY AFFECTS THE CONDUCTOR PERFORMANCE AND FRUSTRATES THE OUTSTANDING PROGRESS ON THE HIGH CURRENT DENSITY STRANDS. THE EVIDENCE OF PERFORMANCE DEGRADATION UPON ELECTROMAGNETIC AND THERMAL CYCLES IS A FURTHER CONCERN FOR A RELIABLE AND EFFECTIVE DESIGN. THE KNOWLEDGE TO IMPROVE THE DESIGN OF NB3SN HIGH CURRENT CONDUCTORS IS GAINED IN LITTLE STEPS, COLLECTING OVER A LONGER PERIOD THE RESULTS FROM DIFFERENT PROJECTS, INCLUDING THE TEST OF SHORT LENGTH CONDUCTORS AND MODEL COILS. THIS REVIEW HIGHLIGHTS THE KEY RESULTS FROM THE LAST DECADE WITH THE AIM OF DRAWING RELEVANT CONCLUSIONS ABOUT THE IMPACT OF THE INDIVIDUAL LAYOUT AND TECHNOLOGY PARAMETERS ON THE PERFORMANCE DEGRADATION, INCLUDING THE STRAND TECHNOLOGY, THE CABLING PATTERN, THE VOID FRACTION, THE ASPECT RATIO, THE ELECTROMAGNETIC LOAD, THE LONGITUDINAL STRAIN AND THE MAGNET TECHNOLOGY.

3LA-02

DIMENSIONAL CHANGES OF NB_3SN CONDUCTORS AND TWO CONDUIT ALLOYS DURING REACTION HEAT TREATMENT ***R. P. WALSH****, D. M. MCRAE;* NHMFL/FSU. — THE PERFORMANCE OF NB_3SN COMPOSITE SUPERCONDUCTING WIRES IS HIGHLY DEPENDENT ON THEIR STRAIN STATE, WHICH IS DIFFICULT TO PREDICT OR MEASURE ACCURATELY. THERE IS LITTLE EXPERIMENTAL DATA IN THE LITERATURE ON NB3SN OR CONDUIT ALLOYS FOR THE THERMAL EXPANSION/CONTRACTION THAT OCCURS DURING REACTION HEAT TREATMENTS. A WIDE TEMPERATURE RANGE (4 K - 1200 K) DILATOMETER SYSTEM AT THE NHMFL IS USED TO INDIVIDUALLY MEASURE THE THERMAL EXPANSION AND CONTRACTION OF TWO TYPES OF THE NB3SN WIRES AND TWO CONDUIT ALLOYS DURING THE REACTION HEAT TREATMENT. TWO COMMON TYPES OF NB3SN WIRE, INTERNAL TIN AND BRONZE-PROCESSED, HAVE DISTINCTLY DIFFERENT BEHAVIOR DURING THE REACTION HEAT TREATMENT, AS HAS BEEN SHOWN PREVIOUSLY IN EXPERIMENTS AND PREDICTIVE MODELS. THE TWO CONDUIT ALLOYS, 316LN MODIFIED AND JK2LB ARE ALSO DISTINCTLY DIFFERENT. IN ADDITION, THE EFFECT OF PRIOR COLD WORK, ON THE THERMAL EXPANSION OF 316LN MODIFIED, IS INVESTIGATED BY MEASURING SAMPLES OF THE MATERIAL IN THE ANNEALED STATE AND A 20% COLD WORKED STATE. THIS WORK SIGNIFICANTLY INCREASES THE AVAILABLE DATA FOR NB3SN SUPERCONDUCTORS AND CONDUIT ALLOYS THAT CAN BE USED IN MAGNET DESIGN AND PREDICTIVE MODELS.

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3LA-03

COUPLED MECHANICAL-ELECTRICAL MODELLING OF STRETCHED 45 NB3SN STRAND CICC ***A. TORRE***[1]*, H. BAJAS*[2]*, D. CIAZYNSKI*[1]*, K. WEISS*[3]*, D. DURVILLE*[2]*;* [1]CEA, [2]ÉCOLE CENTRALE DE PARIS, [3]KIT. — CABLE-IN-CONDUIT CONDUCTORS MADE WITH NB3SN STRANDS WILL BE USED IN ITER MAGNETS. THE CURRENT CARRYING CAPABILITY OF THESE NB3SN STRANDS IS KNOWN TO BE HIGHLY DEPENDANT ON THE STRAIN STATE RESULTING FROM MECHANICAL LOADING. THE INTRICATE CABLING PATTERN OF CICC, ADDED TO THE THERMAL DIFFERENTIAL SHRINKAGE BETWEEN CONDUCTOR JACKET AND NB3SN FILAMENTS INDUCE COMPLEX STRAND TRAJECTORIES AND A HIGHLY INHOMOGENEOUS STRAIN STATE. THIS "CABLE STRAIN MAP" ALSO EVOLVES WITH OPERATING LOADS (LORENTZ FORCE / HOOP STRESS). THE SAMAN EXPERIMENT, CONDUCTED IN THE FBI FACILITY AT KARLSRUHE INSTITUTE OF TECHNOLOGY, AIMED TO STRETCH SUBSIZE, ITER-RELEVANT CONDUCTORS, IN ORDER TO OBSERVE THE EVOLUTION OF THE CRITICAL CURRENT ASSOCIATED WITH THESE LOADINGS. THE APPLICATION OF MULTIFIL FINITE ELEMENT CODE, DEVELOPED AT ECOLE CENTRALE DE PARIS, HELPS QUANTIFYING THE AMPLITUDE OF LOCAL STRAINS ALONG EVERY INDIVIDUAL STRAND, AND ITS EVOLUTION WITH COOLDOWN (FROM HEAT TREATMENT), LORENTZ FORCE AND STRETCHING PHENOMENA. USING MULTIFIL'S OUTPUT MECHANICAL DATA AS INPUT FOR THE CEA ELECTRICAL CODE CARMEN ALLOWS COMPUTING THE CRITICAL CURRENT IN EVERY STRAND, THUS LEADING TO AN UNDERSTANDING OF THE CRITICAL CURRENT DEGRADATION OF SUCH SUBSIZE CONDUCTORS. THIS PAPER SHOWS, FOR DIFFERENT SAMAN SAMPLES, HOW BENDING STRAIN CONCENTRATION CAN HAVE A DECISIVE IMPACT ON A CICC CURRENT TRANSPORT CAPABILITY.

3LA-04

DESIGN OPTIMISATION OF NB3SN CICCS WITH THE NOVEL NUMERICAL MECHANICAL MODEL CORD; INFLUENCE OF CABLING AND STRAND ***J. QIN***[1]*, L. L. WARNET*[2]*, A. NIJHUIS*[3]*, Y. WU*[4]*;* [1]ENERGY, MATERIALS & SYSTEMS, FACULTY OF SCIENCE AND TECHNOLOGY, UNIVERSITY OF TWENTE, INSTITUTE OF PLASMA PHYSICS, CHINESE ACADEMY OF SCIENCES, [2]DIVISION OF DESIGN, PRODUCTION AND MANUFACTURING,FACULTY OF MECHANICAL ENGINEERING,UNIVERSITY OF TWENTE, [3]ENERGY, MATERIALS & SYSTEMS, FACULTY OF SCIENCE AND TECHNOLOGY, UNIVERSITY OF TWENTE, [4]INSTITUTE OF PLASMA PHYSICS, CHINESE ACADEMY OF SCIENCES. — THE STRAIN STATE OF THE SUPERCONDUCTING NB_3SN WIRES IN MULTI-STAGE TWISTED ITER CABLE-IN-CONDUIT CONDUCTORS (CICCS), STRONGLY DETERMINES THE TRANSPORT PROPERTIES. FOR AN ACCURATE PREDICTION OF THE PERFORMANCE AND A PROPER UNDERSTANDING OF THE UNDERLYING PHENOMENA, A DETAILED ANALYSIS OF THE STRESS AND STRAIN DISTRIBUTION ALONG ALL INDIVIDUAL WIRES IS IMPERATIVE. FOR THIS, THE THERMAL CONTRACTION OF THE DIFFERENT COMPONENTS AND THE HUGE ELECTROMAGNETIC FORCES IMPOSING BENDING AND CONTACT DEFORMATION MUST BE TAKEN INTO ACCOUNT. WE DEVELOPED A NUMERICAL MODEL FOR A SUPERCONDUCTING CABLE (CORD), WHICH CAN PREDICT THE STRAIN AND STRESS STATES OF ALL SINGLE WIRES INCLUDING INTERSTRAND CONTACT FORCE AND THE ASSOCIATED DEFORMATION. THE STRANDS IN THE CABLE CAN ALL HAVE SIMILAR PROPERTIES (NB_3SN/CU) OR WITH THE INCLUSION OF DIFFERENT STRAND MATERIALS FOR PROTECTION (CU, GLIDCOP). THE SIMULATION RESULTS ARE NOT ONLY IMPORTANT FOR ANALYSIS BUT EVEN MORE ESSENTIAL FOR CONDUCTOR DESIGN OPTIMISATION. WE DISCUSS THE INFLUENCE OF THE SEQUENTIAL CABLE TWIST PITCHES, THE INCLUSION OF COPPER STRANDS AND THE VOID FRACTION ON THE MECHANICAL PROPERTIES AND THUS ON THE EVENTUAL STRAIN DISTRIBUTION IN THE NB_3SN FILAMENTS WHEN SUBJECTED TO ELECTROMAGNETIC FORCES. RECOMMENDATIONS ARE GIVEN FOR CONDUCTOR DESIGN IMPROVEMENTS.

THE SUPPORT FROM THE IMPACT INSTITUTE AT THE UNIVERSITY OF TWENTE IS GREATLY ACKNOWLEDGED.

3LA-05

THE EFFECT OF STRAND BENDING ON THE VOLTAGE-CURRENT CHARACTERISTICS OF NB_3SN CABLE-IN-CONDUIT CONDUCTORS ***C. FIAMOZZI ZIGNANI****, L. MUZZI, A. DELLA CORTE;* ENEA. — ONE OF THE MAIN ISSUES FOR NB_3SN CABLE-IN-CONDUIT CONDUCTORS (CICCS) IS THE DEGRADATION OF THEIR PERFORMANCES WITH ELECTROMAGNETIC LOADING AND / OR THERMAL CYCLES. IN THE LAST YEARS AN OPTIMIZATION HAS BEEN FOUND FOR THOSE PARAMETERS THAT CAN IMPROVE THE CONSTRAINTS IMPOSED BY THE BRITTLE NATURE OF THE NB_3SN, SUCH AS CABLE TWIST PITCH, CONDUCTOR VOID FRACTION AND ASPECT RATIO. THE TRANSITION N-INDEX VALUES OBSERVED ON THE CONDUCTORS ARE STRONGLY DEPRESSED WITH RESPECT TO THE VALUES MEASURED ON SINGLE STRANDS. A WIDE EXPERIMENTAL CAMPAIGN ON NB_3SN WIRES PRE-COMPRESSED INTO STAINLESS-STEEL JACKETS, AND SUBJECT TO BENDING STRAIN, HAS SHOWN THAT AN APPRECIABLE DECREASE IN THE N-INDEX VALUES ALREADY OCCURS AT THE STRAND LEVEL, EVEN WELL BELOW THE IRREVERSIBLE LOAD REGIME FOR FILAMENT BREAKAGE. THIS RESULT IS DESCRIBED AND EXPLAINED IN TERMS OF EKIN'S MODEL, WITH THE SUPPORT OF ELECTRO-MAGNETIC SIMULATIONS, CONSIDERING THE DISTRIBUTION OF THE CRITICAL CURRENT DENSITY OVER THE WIRES' CROSS SECTION DUE TO THE SIMULTANEOUS PRESENCE OF A PRE-COMPRESSION AND A BENDING STRAIN. THE EFFECTIVE RESEMBLANCE BETWEEN PRE-COMPRESSED, BENT WIRES AND STRANDS INSIDE CICCS IN OPERATING CONDITIONS IS EMPHASIZED, AND AN INNOVATIVE INTERPRETATION OF CABLED CONDUCTORS TEST RESULTS IS PROPOSED, THAT, TOGETHER WITH THE PHENOMENON OF FILAMENT FRACTURE DUE TO LOADING, COULD CLARIFY SOME ASPECTS OF THEIR BEHAVIOUR.

3LB-01

A NOVEL ENERGY STORAGE CONCEPT BASED ON HYDROGEN AND SUPERCONDUCTORS ***M. SANDER****, R. GEHRING, M. NOE;* KARLSRUHE INSTITUTE OF TECHNOLOGY. — A NEW ENERGY STORAGE CONCEPT IS PROPOSED THAT COMBINES THE USE OF LIQUID HYDROGEN (LH2) WITH SUPERCONDUCTING MAGNETIC ENERGY STORAGE (SMES). THE ANTICIPATED INCREASE OF THE CONTRIBUTION OF INTERMITTENT RENEWABLE POWER PLANTS LIKE WIND OR SOLAR FARMS WILL SUBSTANTIALLY INCREASE THE NEED FOR BALANCING DEMANDS AND SUPPLIES FROM SECONDS TO SEVERAL HOURS OR EVEN DAYS. LH2 WITH ITS HIGH VOLUMETRIC ENERGY DENSITY IS THE PRIME CANDIDATE FOR LARGE SCALE STATIONARY ENERGY STORAGE BUT BALANCING LOAD OR SUPPLY FLUCTUATIONS WITH HYDROGEN ALONE IS UNREALISTIC DUE TO THE LOSSES RELATED TO THE RE-CONVERSION INTO ELECTRICITY AND ALSO DUE TO THE RESPONSE TIMES OF THE FLOW CONTROL. TO OPERATE THE HYDROGEN PART MORE STEADILY SOME SHORT-TERM ELECTRICAL ENERGY STORAGE WILL BE NEEDED. HERE A SMES BASED ON OF HIGH TEMPERATURE SUPERCONDUCTORS IS PROPOSED FOR THIS PURPOSE WHICH COULD BE OPERATED IN THE LH2 BATH. WITH THIS APPROACH THE CRYOGENICS-RELATED COSTS FOR THE SMES ARE WIDELY CUT. THE CONCEPT IS INTRODUCED. SIMPLE SIMULATIONS ON THE BUFFERING BEHAVIOUR AND COMPARISONS WITH COMPETING SHORT-TERM STORAGE DEVICES ARE PRESENTED

3LB-02

PERFORMANCE ANALYSIS OF A TOROIDAL-TYPE HTS SMES ADOPTED FOR FREQUENCY STABILIZATION ***A. KIM***[1]*, K. KIM*[1]*, J. KIM*[1]*, D. KIM*[1]*, S. HWANG*[1]*, M. PARK*[1]*, I. YU*[1]*, S. KIM*[2]*, K. SIM*[2]*, K. SEONG*[2]*;* [1]CHANGWON NATIONAL UNIVERSITY, [2]KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE. — WIND POWER GENERATION SYSTEM HAS CHANGED AS AN IMPORTANT RENEWABLE POWER SOURCE IN THESE DAYS. HOWEVER, OUTPUT POWER OF THE WIND POWER GENERATION SYSTEM FLUCTUATES DUE TO WIND SPEED VARIATION AND AFFECTS THE FREQUENCY AND VOLTAGE FLUCTUATIONS OF THE UTILITY. HENCE, IF A LARGE NUMBER OF WIND POWER GENERATION SYSTEMS ARE CONNECTED TO THE GRID SYSTEM, THEIR OUTPUT CAN CAUSE SERIOUS POWER QUALITY PROBLEMS. IN ORDER TO SOLVE THESE PROBLEMS, THE SMOOTHING CONTROL OF FREQUENCY FLUCTUATION IS VERY IMPORTANT. SUPERCONDUCTING MAGNETIC ENERGY STORAGE (SMES) IS KEY TECHNOLOGY TO OVERCOME THESE FLUCTUATIONS BECAUSE OF FAST RESPONSE TIME FOR ENERGY CHARGING AND DISCHARGING.THE AUTHORS FABRICATED A TOROIDAL-TYPE HTS SMES COOLED BY CONDUCTION COOLING METHOD AND A DC/DC CHOPPER FOR CURRENT CHARGING AND DISCHARGING. POWER NETWORK INCLUDING WIND POWER GENERATION SYSTEM WAS SIMULATED THROUGH A REAL TIME DIGITAL SIMULATOR (RTDS). TO STABILIZE THE FREQUENCY FLUCTUATION, THE HTS SMES SYSTEM IS CONNECTED TO THE TERMINAL OF THE WIND POWER GENERATION SYSTEM IN THE RTDS. THE RESULTS OF FREQUENCY STABILIZATION AND OPERATIONAL CHARACTERISTICS OF THE HTS SMES SUCH AS CURRENT AND TEMPERATURE VARIATIONS ARE INVESTIGATED AND DISCUSSED IN DETAIL.

THIS WORK WAS SUPPORTED BY ELECTRIC POWER INDUSTRY TECHNOLOGY EVALUATION AND PLANNING.

3LB-03

THERMAL ANALYSIS OF 2.5MJ HTS SMES CONSIDERING THE TIME VARYING MAGNETIZATION LOSS AND EDDY CURRENT LOSS ***S. KIM****, K. SIM, H. KIM, J. BAE, K. SEONG;* KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE. — 2.5 MJ HTS SMES SYSTEM ARE UNDER DEVELOPMENT TO COMPENSATE THE SAG OR INSTANTANEOUS BLACK OUT FOR SEVERAL SENSITIVE UTILITIES. ALTHOUGH THE SMES IS DC SUPERCONDUCTING MAGNET DURING THE STANDBY STATE, IT SHOWS LARGE MAGNETIZATION LOSS AND EDDY CURRENT LOSS DURING INITIAL CHARGING AND DISCHARGING PERIOD. INITIAL CHARGING SPEED CAN BE ADJUSTED CONSIDERING THE COOLING CAPACITY OF CRYOCOOLER, HOWEVER, HEAT GENERATION DURING DISCHARGING PERIOD CAN'T BE FULLY ABSORBED BY CRYOCOOLERS DUE TO ITS SHORT TIME PERIOD. TO VERIFY THE THERMAL STABILITY DURING CHARGING AND DISCHARGING PERIOD, THE MAGNETIZATION AND EDDY CURRENT LOSS SHOULD BE CAREFULLY ESTIMATED. EDDY CURRENT LOSS CAN BE ESTIMATED BY ELECTROMAGNETIC ANALYSIS FOR METALLIC STRUCTURES. HOWEVER, AC LOSS OR MAGNETIZATION LOSS CAN'T BE EASILY ESTIMATED BECAUSE THE VARIATION OF THE MAGNETIC FIELD AND THE TRANSPORT CURRENT SHOULD BE CONSIDERED SIMULTANEOUSLY, AND THE THEIR VARIATION PATTERN IS NOT A SINUSOIDAL AND THE SIMPLE ANALYTIC SOLUTION COULD NOT BE DIRECTLY APPLIED.TO INVESTIGATE THE TIME VARYING MAGNETIZATION LOSS DURING THE OPERATION SCENARIO, H-FIELD ELECTROMAGNETIC FEM ANALYSIS IS PERFORMED FOR THE VARIOUS MAGNETIC FIELD AND TRANSPORT CURRENT CONDITIONS. USING THE OBTAINED RESULTS, THERMAL ANALYSIS IS PERFORMED TO VERIFY THE THERMAL STABILITY OF THE HTS COIL DURING THE CHARGING AND DISCHARGING PERIOD.

THIS WORK WAS SUPPORTED BY ELECTRIC POWER INDUSTRY TECHNOLOGY EVALUATION & PLANNING

3LB-04

ANALYSIS OF CURRENT DISTRIBUTION IN MULTI-LAMINATED HTS TAPE CONDUCTOR FOR DOUBLE PANCAKE COIL OF SMES ***T. HAMAJIMA***[1]*, N. ATOMURA*[1]*, Y. CHIBA*[1]*, T. YAGAI*[1]*, M. TSUDA*[1]*, K. SHIKIMACHI*[2]*, N. HIRANO*[2]*, S. NAGAYA*[2]*;* [1]TOHOKU UNIVERSITY, [2]CHUBU ELECTRIC POWER CO., INC.. — A MULTI-LAMINATED HTS TAPE CONDUCTOR HAS BEEN RECENTLY DEVELOPED TO FABRICATE LARGE DOUBLE PANCAKE COILS. IF THE HTS TAPES ARE SIMPLY LAMINATED TO FORM THE CONDUCTOR, THE CURRENT DISTRIBUTION IN THE LAMINATED TAPE CONDUCTOR OF THE COIL IS IMBALANCED BECAUSE OF DIFFERENT INDUCTANCES OF ALL TAPES. TRANSPOSITION OF THE TAPES IN THE CONDUCTOR SEEMS TO BE EFFECTIVE FOR HOMOGENEOUS CURRENT DISTRIBUTION, BUT THE TAPE CAN BE EASILY DAMAGED DUE TO LATERAL

BENDING. A PANCAKE COIL HAS BEEN WIDELY USED FOR LARGE MAGNET, BECAUSE THE PANCAKE COIL IS TIGHTLY WOUND AND ENDURES LARGE ELECTROMAGNETIC FORCE. IT IS VERY IMPORTANT TO ANALYZE CURRENT DISTRIBUTIONS IN THE MULTI-LAMINATED TAPE CONDUCTOR USED FOR THE DOUBLE PANCAKE COIL. IN THIS PAPER, WE ANALYZE THE CURRENT DISTRIBUTION IN THE TAPE CONDUCTOR BY USING CIRCUIT MODEL, AND THEN DISCUSS HOW TO OBTAIN THE HOMOGENEOUS CURRENT DISTRIBUTION BY ADJUSTING GAPS BETWEEN HTS TAPES IN THE CONDUCTOR. FINALLY WE NUMERICALLY DEMONSTRATE THE HOMOGENEOUS CURRENT DISTRIBUTION IN THE 4-LAMINATED TAPES WITH ADJUSTING THE GAPS.

3LB-05

DESIGN AND TEST OF A HTS SMES FOR HIGH POWER PULSE OPERATION ***A. BADEL***[1]*, P. TIXADOR*[2]*, M. DELEGLISE*[3]*, P. DEDIE*[4]*;* [1]NEEL INSTITUTE - CNRS, [2]GRENOBLE ELECTRICAL ENGINEERING LABORATORY, [3]CNRS, [4]SAINT LOUIS INSTITUTE. — A SMES (SUPERCONDUCTING MAGNETIC ENERGY STORAGE) IS FUNDAMENTALLY A CURRENT SOURCE WITH A HIGH POWER DENSITY. ITS AREA OF APPLICATION THEREFORE EXTENDS WHERE A HIGH PULSED POWER CURRENT SOURCE IS NEEDED, FROM MAGNETO-FORMING TO MILITARY APPLICATIONS SUCH AS ELECTROMAGNETIC LAUNCHERS.WE DESIGNED AND CONSTRUCTED A CONDUCTION-COOLED SMES FROM 28 PANCAKES WOUNDED WITH BSSCO TAPES, ARRANGED IN TWO SEPARATED COILS OF 16 AND 12 PANCAKES. THE FIRST ONE IS DESIGNED FOR HIGH VOLTAGE OPERATION; THE SECOND ONE IS SPLIT IN 3 TO GET HIGH OUTPUT CURRENT FROM XRAM OPERATION (SERIES CHARGE, PARALLEL DISCHARGE). THE DISTANCE BETWEEN THE TWO COILS AND THEIR RESPECTIVE INDUCTANCES WERE ALSO CALCULATED TO OBTAIN IDENTICAL ENERGY DURING SEQUENTIAL DISCHARGES.WE REACHED A MAXIMUM CURRENT OF 250 A, WHICH LEADS TO 750 KW PEAK POWER UNDER 3 KV ON THE UPPER COIL. THE LOWER COIL, ALSO RATED AT 250 A WAS TESTED UP TO 100 A WITHOUT PROBLEM IN XRAM OPERATION, THEREFORE REACHING A 3*100 A MAXIMUM OUTPUT. TESTS WITH HIGHER CURRENTS ARE PLANNED; A MAXIMUM OUTPUT OF AT LEAST 600 A IS EXPECTED. THE ELECTROMAGNETIC AND THERMAL DESIGN WILL BE DESCRIBED AND THE DIFFERENT TESTS WILL BE REPORTED.

THIS WORK IS SUPPORTED BY THE DGA (THE FRENCH GENERAL DELEGATION FOR ORDNANCE).

3LB-06

COMMERCIAL INDUCTION HEATERS WITH HIGH-TEMPERATURE SUPERCONDUCTOR COILS ***M. RUNDE***[1]*, N. MAGNUSSON*[1]*, C. FÜLBIER*[2]*, C. BÜHRER*[2]*;* [1]SINTEF ENERGY RESEARCH, [2]ZENERGY POWER. — THE INDUCTION HEATER FOR ALUMINUM, COPPER AND BRASS EXTRUSION BILLETS IS AN APPLICATION WHERE HIGH-TEMPERATURE SUPERCONDUCTORS PROVIDE CLEAR BENEFITS COMPARED TO CONVENTIONAL TECHNOLOGY. WITH AN ENERGY EFFICIENCY OF JUST SOME 50% FOR CONVENTIONAL TECHNOLOGY AND LIMITATIONS IN PROCESSING SPEED, THE POTENTIAL FOR IMPROVEMENTS IS EVIDENT. A NOVEL HEATER DESIGN BASED ON SUPERCONDUCTORS, AND A FAST PRODUCT DEVELOPMENT HAVE LED TO AN INDUSTRIAL BREAKTHROUGH. WITH ONE UNIT IN OPERATION SINCE AUGUST 2008 AND FOUR MORE SOLD, THE SUPERCONDUCTING INDUCTION HEATER HAS BECOME THE FIRST TRUE COMMERCIAL HTS PRODUCT. RADICAL EFFICIENCY INCREASES, IMPROVEMENTS IN PROCESS SPEED, QUALITY AND COST HAVE BEEN DEMONSTRATED IN A ROUGH INDUSTRIAL ENVIRONMENT. IN THIS PAPER WE EXPLAIN HOW TO FULLY UTILIZE THE SUPERCONDUCTOR IN THIS APPLICATION BY ALTERING THE ESTABLISHED CONCEPTS OF INDUCTION HEATING. THE ELECTROMAGNETIC REALIZATION AS WELL AS CRYOGENIC INTEGRATION BASED ON OFF-THE-SHELF CRYOCOOLERS ARE DESCRIBED. FURTHERMORE, OPERATIONAL EXPERIENCE FROM HEATING UP 10,000 TONS OF ALUMINUM (350,000 BILLETS) IN THE FIRST COMMERCIAL INSTALLATION IS PRESENTED.

3LB-07

TESTING OF POWER SUPPLY FOR A HIGH TEMPERATURE SUPERCONDUCTING DEGAUSSING SYSTEM ***M. PYRYT***[1]*, J. KEPHART*[1]*, B. FITZPATRICK*[1]*, J. OVERBY*[1]*, M. ZAHZAH*[2]*, R. BORUCKI*[2]*, K. WOJCIECH*[2]*;* [1]NAVAL SURFACE WARFARE CENTER - CARDEROCK DIVISION, [2]L-3 COMMUNICATIONS, POWER PARAGON. — USING HTS (HIGH TEMPERATURE SUPERCONDUCTOR) INSTEAD OF LEGACY COPPER CABLES CURRENTLY IN USE FOR DEGAUSSING PROVIDES A GREAT BENEFIT TO THE U.S. NAVY. HTS DEGAUSSING CREATES A MORE EFFICIENT “COIL EFFECT” THAT REQUIRES LESS CABLES, REDUCES THE CABLE WEIGHT SIGNIFICANTLY, AND REDUCES POWER LOSSES IN THE COPPER THAT AMOUNT TO TENS OF KILOWATTS PER COIL IN COMPARISON TO LEGACY COPPER SYSTEMS. WEIGHT AND SPACE SAVINGS ONBOARD NAVAL VESSELS PROVIDE OPTIONS FOR FUEL SAVINGS AND EFFICIENCY WHICH IS BENEFICIAL TO THE FUTURE NAVY.L-3 COMMUNICATIONS HAS DEVELOPED A 100 AMP POWER SUPPLY PROTOTYPE TO BE USED FOR HTS DEGAUSSING. THIS POWER SUPPLY PROTOTYPE IS L-3’S FIRST ATTEMPT TOWARDS PRODUCING AN HTS DEGAUSSING POWER SUPPLY AND IS WORKING WITH NSWCCD’S HTS GROUP BY WAY OF A CRADA (COOPERATIVE RESEARCH AND DEVELOPMENT AGREEMENT). NSWCCD WILL TEST THE 100 AMP HTS POWER SUPPLY PROTOTYPE AT THE HTS TEST LABORATORY LOCATED IN PHILADELPHIA, PA. THE PROTOTYPE WILL BE SET UP WITH A CURRENT TEST CONFIGURATION AND WILL HAVE THE CURRENT RAMPED AT VARIOUS LEVELS TO SIMULATE AN ACTIVE DEGAUSSING CABLE. THE PROTOTYPE WILL GO THROUGH RIGOROUS TESTING TO DETERMINE FEASIBILITY OF USE FOR FUTURE NAVAL HTS APPLICATIONS. THIS PAPER WILL DISCUSS AND PRESENT THE TEST RESULTS OF THE PROTOTYPE AND DETERMINATION OF FUTURE USE FOR HTS APPLICATIONS.

3LC-01

(INVITED) **PROGRESS AND PROSPECT OF SUPERCONDUCTING MAGNET SYSTEMS IN J-PARC** ***T. OGITSU****;* KEK, HIGH ENERGY

ACCELERATOR RESEARCH ORGANIZATION. — THE CONSTRUCTION OF THE 1ST PHASE JAPAN PROTON ACCELERATOR RESEARCH COMPLEX (J-PARC) IS COMPLETED. THREE MAJOR EXPERIMENTAL FACILITIES, WHICH HAVE BEEN UTILIZED FOR USERS, ARE INSTRUMENTED WITH THE SUPERCONDUCTING MAGNET SYSTEMS; A MUON TRANSPORT SOLENOID IN MATERIALS AND LIFE SCIENCE EXPERIMENTAL FACILITY, A SUPERCONDUCTING SPECTROMETER IN HADRON EXPERIMENTAL FACILITY, AND A 150 M SUPERCONDUCTING BEAM LINE IN NEUTRINO EXPERIMENTAL FACILITY. THERE ARE ALSO SEVERAL SUPERCONDUCTING MAGNET SYSTEMS PROPOSED AS PART OF FUTURE EXPERIMENTS AT J-PARC. THE PAPER BRIEFLY SUMMARIZES THE CURRENT STATUS OF THE SUPERCONDUCTING MAGNET SYSTEMS CURRENTLY IN OPERATION, AND INTRODUCES THE SUPERCONDUCTING MAGNET SYSTEMS ASSOCIATED WITH THE NEW PROPOSALS.

3LC-02

SUPERCONDUCTING SOLENOID WITH HIGH MAGNETIC FIELD UNIFORMITY FOR NEW G-2 EXPERIMENT AT THE J-PARC ***K. SASAKI***[1], *H. IINUMA*[1], *N. KIMURA*[1], *T. OGITSU*[1], *A. YAMAMOTO*[1], *H. NAKAYAMA*[1], *T. MIBE*[1], *N. SAITO*[1], *T. OBATA*[2]; [1]KEK, HIGH ENERGY ACCELERATOR RESEARCH ORGANIZATION, [2]NIRS, NATIONAL INSTITUTE OF RADIOLOGICAL SCIENCES. — A NEW EXPERIMENT TO MEASURE THE ANOMALOUS MAGNETIC MOMENT OF THE POSITIVE MUON, G-2, IS PROPOSED AS ONE OF THE FUTURE J-PARC PROJECT. THE GOAL OF THIS EXPERIMENT IS TO MEASURE THE VALUE OF G-2 DOWN TO THE LEVEL OF 0.1 PPM. TO ACHIEVE THIS GOAL, TWO NOVEL TECHNIQUES ARE EMPLOYED, AN ULTRA COLD MUON BEAM OF 300 MEV/C AND A SUPERCONDUCTING SOLENOID WITH HIGH MAGNETIC FIELD UNIFORMITY AS A STORAGE RING. THE CENTER FIELD OF THE SOLENOID IS 3 T FOR THE BEAM ORBIT RADIUS OF 33.3 CM, AND HAS TO BE CONTROLLED BELOW THE LEVEL OF 0.1 PPM IN A GOOD FIELD REGION OF 35 CM IN RADIUS AND 20 CM IN HEIGHT.A DEVELOPMENT OF THE SOLENOID WITH THE HIGH FIELD UNIFORMITY REQUIRES A MAGNETIC FIELD MEASUREMENT WITH HIGH ACCURACY. THE MEASUREMENT SYSTEMS WITH NMR AND HALL PROBE ARE BEING DEVELOPED FOR THE GOOD FIELD REGION AND THE BEAM INJECTION REGION, RESPECTIVELY.A SEISMIC GROUND VIBRATION AT THE EXPERIMENT SITE SEEMS TO BE IMPORTANT TO GENERATE A STATIC AND UNIFORM MAGNETIC FIELD. THE VIBRATION RESEARCH AT J-PARC SITE IS ON GOING.THIS PAPER REPORTS THE CURRENT STATUS OF THE SOLENOID DEVELOPMENT, THE OVERVIEW OF THE FIELD MEASUREMENT SYSTEMS AND THE SEISMIC GROUND VIBRATION MEASUREMENT AT J-PARC.

3LC-03

SUPERCONDUCTING SOLENOID MAGNETS FOR THE MUSIC PROJECT ***M. YOSHIDA***[1], *M. FUKUDA*[2], *K. HATANAKA*[2], *Y. KUNO*[3], *T. OGITSU*[1], *A. SATO*[3], *A. YAMAMOTO*[1]; [1]HIGH ENERGY ACCELERATOR RESEARCH ORGANIZATION, KEK, [2]RESEARCH CENTER FOR NUCLEAR PHYSICS, OSAKA UNIVERSITY, [3]OSAKA UNIVERSITY. — THE NEW MUON BEAMLINE, MUSIC, IS BEING CONSTRUCTED AT THE RESEARCH CENTER FOR NUCLEAR PHYSICS (RCNP) AT OSAKA UNIVERSITY IN JAPAN. THE PROJECT UTILIZES SUPERCONDUCTING SOLENOID MAGNETS TO COLLECT PIONS AND TO TRANSPORT MUONS WITH THE ULTIMATE EFFICIENCY BY PUTTING PION-PRODUCTION TARGET INSIDE THE SOLENOID MAGNET. THIS IS THE FIRST OF SUCH A NOVEL METHOD TO PRODUCE INTENSE MUON BEAMS. ALL THE SUPERCONDUCTING COILS ARE COOLED WITH CONDUCTION COOLING USING GIFFORD-MCMAHON CRYOCOOLERS. A LARGE SUPERCONDUCTING COIL WITH THE DIAMETER OF 90 CM ENCLOSES THE PION-PRODUCTION TARGET AND THICK SHIELDING TO PROTECT THE COIL AGAINST SEVERE RADIATION FROM THE TARGET, SO THAT ENERGY DEPOSIT BY PARTICLES ON THE COIL SHOULD BE LESS THAN 1 W. PIONS ARE CAPTURED IN A 3.5 T MAGNETIC FIELD AND ARE INJECTED INTO THE SUBSEQUENT TOROIDAL MAGNETS WITH THE MAGNETIC FIELD OF 2 T. SUPERCONDUCTING DIPOLE COILS ARE EQUIPPED ON EACH SOLENOID COIL OF THE TRANSPORT SOLENOID TO CORRECT A PARTICLE TRAJECTORY IN THE TOROIDAL FIELD. THE DESIGN AND CONSTRUCTION STATUS OF THE SOLENOID CHANNEL IS DESCRIBED IN THIS PAPER.

3LC-04

TEST OF THE NEW CONDUCTION-COOLED SUPERCONDUCTING UNDULATOR FOR ANKA ***C. BOFFO***[1], *W. A. WALTER*[1], *T. BAUMBACH*[2], *S. CASALBUONI*[2], *S. GERSTL*[2], *A. GRAU*[2], *M. HAGELSTEIN*[2], *D. SEAZ DE JAUREGUI*[2]; [1]BABCOCK NOELL GMBH, [2]INSTITUTE FOR SYNCHROTRON RADIATION, KARLSRUHE INSTITUTE OF TECHNOLOGY. — BABCOCK NOELL GMBH (BNG) COMPLETED THE FABRICATION OF A 1.5 M LONG SUPERCONDUCTING INSERTION DEVICE FOR KIT. THE UNIT IS PLANNED TO BE INSTALLED IN THE ANKA STORAGE RING IN OCTOBER 2010 TO BECOME THE LIGHT SOURCE OF THE NEW BEAMLINE NANO FOR HIGH RESOLUTION X-RAY DIFFRACTION. THE PERIOD LENGTH OF THE DEVICE IS 15 MM FOR A TOTAL OF 100.5 FULL PERIODS PLUS AN ADDITIONAL MATCHING PERIOD AT EACH END. THE KEY SPECIFICATIONS OF THE SYSTEM ARE: A K VALUE HIGHER THAN 2 FOR A MAGNETIC GAP OF 5 MM, THE CAPABILITY OF WITHSTANDING A 4 W BEAM HEAT LOAD AND A PHASE ERROR SMALLER THAN 3.5 DEGREES. DURING THE FACTORY ACCEPTANCE TEST, THE CONDUCTION COOLING OPERATION HAS BEEN QUALIFIED. THE UNDULATOR IS NOW READY TO BE TESTED AT ANKA. THIS PAPER DESCRIBES THE MAIN FEATURES OF THE SYSTEM AND THE RESULTS OF THE FACTORY ACCEPTANCE TEST.

3LC-05

TRAINING AND MAGNETIC FIELD MEASUREMENTS OF THE ANKA SUPERCONDUCTING UNDULATOR ***S. CASALBUONI***[1], *T. BAUMBACH*[1], *S. GERSTL*[1], *A. GRAU*[1], *M. HAGELSTEIN*[1], *D. SAEZ DE JAUREGUI*[1], *C. BOFFO*[2], *J. STEINMANN*[2], *W. WALTER*[2]; [1]INSTITUTE FOR SYNCHROTRON RADIATION, KARLSRUHE INSTITUTE OF TECHNOLOGY, [2]BABCOCK NOELL GMBH. — IN THIS CONTRIBUTION WE REPORT THE RESULTS OF THE TRAINING AND OF THE LOCAL FIELD MEASUREMENTS PERFORMED IN A LIQUID HELIUM BATH OF THE ANKA SUPERCONDUCTING UNDULATOR. THE PERIOD LENGTH IS 15 MM AND THE COILS ARE 1.5 M LONG. THE KEY SPECIFICATIONS OF THE SYSTEM ARE AN UNDULATOR

PARAMETER K HIGHER THAN 2 (FOR A MAGNETIC GAP OF 5MM) AND A PHASE ERROR SMALLER THAN 3.5 DEGREES. THE SUPERCONDUCTING UNDULATOR IS PLANNED TO BE INSTALLED IN THE ANKA STORAGE RING IN OCTOBER 2010 TO BE THE LIGHT SOURCE OF THE NEW BEAMLINE NANO FOR HIGH RESOLUTION X-RAY DIFFRACTION.

3LC-06

THE RESULTS OF THE MICE SPECTROMETER SOLENOID TESTS ***M. A. GREEN****, S. VIRSOSTEK, M. ZISMAN;* LAWRENCE BERKELEY NATIONAL LABORATORY. — THE MUON IONIZATION COOLING EXPERIMENT (MICE) SPECTROMETER SOLENOID MAGNETS WILL BE THE FIRST MAGNETS TO BE INSTALLED WITHIN THE MICE COOLING CHANNEL. BOTH SPECTROMETER SOLENOIDS HAVE BEEN PARTIALLY TRAINED. THE MICE SPECTROMETER SOLENOIDS MAY BE THE LARGEST MAGNETS THAT HAVE BEEN COOLED USING SMALL COOLERS. THE LAST SOLENOID TESTED WAS NEARLY SUCCESSFUL IN TERMS OF COOLING AT 4.2 K. HOWEVER, THE COOLER FIRST STAGE TEMPERATURES WERE TOO HIGH. THE CAUSE OF SOME OF THE EXTRA FIRST STAGE HEAT LOAD HAS BEEN IDENTIFIED AND CORRECTED. THE REBUILT MAGNET HAS A SINGLE STAGE GM COOLER IN ADDITION TO THE THREE PULSE TUBE COOLERS. THE ADDED COOLER REDUCES THE TEMPERATURE OF THE TOP OF THE HTS LEADS AND OF THE FIRST STAGE OF THE PULSE TUBE COOLERS. AS A RESULT, THE MAGNET PERFORMANCE AT 4.2 K IS IMPROVED.

THIS WORK IS ALSO SUPPORTED BY THE OFFICE OF SCIENCE, US-DOE UNDER DOE CONTRACT DE-AC02-05CH11231.

3LC-07

DESIGN OF A LARGE 5T SUPERCONDUCTING MAGNET FOR POLARIZED TARGET FOR JLAB HALL B 12 GEV UPGRADE CLAS12 DETECTOR ***B. WANG****[1], B. WAHRER[1], C. TAYLOR[1], J. ZBASNIK[1], D. DELL'ORCO[1], J. ROSS[1], J. CHEN[1], L. XU[1], H. CHEN[1], B. WAGNER[1], R. PONG[1], T. JUANG[1], M. WANG[1], C. CARTER[1], P. CHENG[1], V. BURKERT[2], L. QUETTIER[2], D. KASHY[2];* [1]WANG NMR INC., [2]JEFFERSON SCIENCE ASSOCIATES, LLC. — HALL B AT JEFFERSON LABORATORY (JLAB) WILL NEED A 5T-78 CM BORE POLARIZED TARGET MAGNET WITH A FIELD UNIFORMITY OF DELTA B/ BO < 10-4 IN A USEFUL CYLINDER 0.04 ML X 0.02M DIAMETER. THE LARGE MAGNET IS DESIGNED WITH NEARLY PERFECT SHIELDING SUPERCONDUCTING COIL TO REDUCE FRINGING AT PHOTOMULTIPLIERS (PMT) TO LESS THAN 35G. BECAUSE THE SOLENOID IS ALSO VERY CLOSE TO THE CLAS12 TORUS, THE PERFECT SHIELDED SOLENOID GREATLY REDUCE FORCE, FIELD, AND TORQUE INFLUENCE TO A SIX-COIL TORUS MAGNET.THE SOLENOID COIL WILL CONSISTS OF 18 COIL MODULES. EACH COIL MODULE WILL CONSIST OF DUAL DOUBLE PANCAKE COILS WITH MAIN COILS AND SHIELD COIL PARTITIONED TO REDUCE RADIAL HOOP LOAD AND RADIAL MAGNETIC PRESSURE. EACH COIL MODULE IS ENCLOSED WITH ALUMINUM BOXES TO PARTITION THE AXIAL LOAD AND THUS, REDUCE COIL AXIAL MAGNETIC PRESSURE. THEREFORE, OVERALL MAGNETIC PRESSURE OF EACH COIL MODULE IS SMALL. THIS WILL GREATLY REDUCE THE COIL TRAINING QUENCH. THIS IS VERY IMPORTANT BECAUSE THE COIL STABILITY IS ADIABATIC AND IN-DIRECT CONDUCTION COOLED BY 4.5K SUPERCRITICAL HELIUM PROVIDE SMALL STABILITY MARGIN.DETAIL DESIGN OF THE COIL STRUCTURE, COIL ASSEMBLY, INDIRECT COOLED TRACING TUBE, COLD MASS SUSPENSIONS, MAGNET CRYOSTAT, AND CRYOGENIC CONTROL CRYOTOWER AS WELL AS MAGNET QUENCH PROTECTION, CHARGE/ DISCHARGE CONTROL, CONTROL INSTRUMENTATIONS, COOLDOWN ANALYSES, AND FEA ANALYSES WILL BE PRESENTED.

3LP1A-01

QUENCH BEHAVIOR AND PROTECTION IN CRYOCOOLER-COOLED YBCO PANCAKE COIL FOR SMES *H. UEDA[1],* ***Y. AOKI****[1], A. ISHIYAMA[1], K. SHIKIMACHI[2], N. HIRANO[2], S. NAGAYA[2];* [1]WASEDA UNIVERSITY, [2]CHUBU ELECTRIC POWER CO.. — THE THERMAL BEHAVIOR IN HIGH-TEMPERATURE SUPERCONDUCTING (HTS) COIL IS EXCEEDINGLY DIFFERENT FROM THAT IN LOW-TEMPERATURE SUPERCONDUCTING (LTS) COIL, BECAUSE IT HAS A GREATER VOLUMETRIC HEAT CAPACITY AT THE TEMPERATURE REQUIRED FOR PRACTICAL USE. IN THE APPLICATION ON SMES SYSTEM, ELECTRICAL CHARGING AND DISCHARGING ARE REPEATED, THUS THE SUPERCONDUCTING CHARACTERISTICS OF THE YBCO COATED CONDUCTOR MAY DETERIORATE DUE TO BE CYCLICALLY SUBJECTED TO TENSILE STRAIN. THEREFORE, THERE IS POSSIBILITY THAT THE LOCAL HOTSPOT GENERATES CAUSED BY VERY SLOW NORMAL ZONE PROPAGATION IN THE CASE OF NORMAL ZONE INITIATION BY THE LOCAL DEGRADATION. AND DETECTION OF SUCH HOTSPOTS IN THE WINDING PRESENTS A SERIOUS ENGINEERING PROBLEM.IN THIS STUDY, WE INVESTIGATED THE CHARACTERISTICS OF THE REDISTRIBUTION OF THE TRANSPORT CURRENT AND THE THERMAL BEHAVIOR OF THE CRYOCOOLER-COOLED YBCO PANCAKE COIL DURING A QUENCH BY USING A NOVEL COMPUTER CODE BASED ON THE FINITE ELEMENT METHOD AND AN EQUIVALENT CIRCUIT. AND WE INVESTIGATED A PROTECTION SCHEME THAT DUMPS THE MAGNETIC ENERGY STORED IN YBCO COIL. WHEN QUENCH IS DETECTED, THE STORED ENERGY OF THE COIL IS DUMPED ON THE DUMP RESISTOR. TO PROTECT THE COIL FROM BEING DAMAGED DURING QUENCHING, WE DESIGNED THE CONDUCTOR AND QUENCH PROTECTION SYSTEM SO THAT THE VOLTAGE AND TEMPERATURE DO NOT EXCEED CERTAIN THRESHOLDS.

THIS WORK WAS SUPPORTED BY THE NEW ENERGY AND INDUSTRIAL TECHNOLOGY DEVELOPMENT ORGANIZATION (NEDO) AS THE TECHNOLOGICAL DEVELOPMENT OF YTTRIUM-BASED SUPERCONDUCTING POWER EQUIPMENT.

3LP1A-02

ANALYSIS OF THE PERFORMANCE OF QUENCH PROTECTION HEATERS FOR YBCO COILS OF VERY HIGH FIELD SUPERCONDUCTING MAGNETS ***A. V. GAVRILIN****, W. D. MARKIEWICZ;* NATIONAL HIGH MAGNETIC FIELD LABORATORY - FLORIDA STATE UNIVERSITY. — VERY HIGH FIELD SUPERCONDUCTING MAGNETS ARE BEING DEVELOPED, WHICH WILL USE HIGH TEMPERATURE SUPERCONDUCTOR (HTS), YBCO COATED CONDUCTOR, INNER COILS IN A LOW

TEMPERATURE SUPERCONDUCTOR (LTS) BACKGROUND FIELD MAGNET. THE QUENCH PROTECTION OF THE YBCO COILS PRESENTS A FORMIDABLE PROBLEM. THE NATURAL QUENCH PROPAGATION RATES OF YBCO CONDUCTOR, AND HTS CONDUCTORS IN GENERAL, ARE OBSERVED TO BE VERY SLOW IN COMPARISON TO LTS CONDUCTOR QUENCH PROPAGATION RATES. METHODS OF ACTIVE QUENCH PROTECTION APPEAR TO BE NECESSARY. ONE ACTIVE QUENCH PROTECTION METHOD WOULD BE TO EMPLOY DENSELY DISTRIBUTED PROTECTION HEATERS THROUGHOUT THE WINDINGS OF THE YBCO COILS TO CREATE AN EXTENDED NORMAL ZONE IN THE EVENT OF A QUENCH. THE HIGH CRITICAL TEMPERATURE OF YBCO CONDUCTORS RESULTS IN A LARGE AMOUNT OF ENERGY REQUIRED TO QUENCH A VOLUME OF COIL. AN ANALYSIS OF HEATER PERFORMANCE IN YBCO COILS IS DONE TO DETERMINE THEIR EFFECTIVENESS IN PROMPTLY QUENCHING THE ADJACENT VOLUME OF THE WINDINGS. THE ANALYSIS IS MADE FOR TAPE WOUND AND LAYER WOUND COIL CONSTRUCTIONS.

3LP1A-03

ACTIVE PROTECTION OF AN MGB_2 TEST COIL ***D. PARK****, S. HAHN, J. BASCUÑÁN, Y. IWASA;* MASSACHUSETTS INSTITUTE OF TECHNOLOGY. — THIS PAPER DESCRIBES A STUDY, EXPERIMENTAL AND COMPUTATIONAL, OF A DETECT-AND-ACTIVATE-THE-HEATER PROTECTION TECHNIQUE, PERFORMED WITH AN MGB_2 TEST COIL OPERATED IN SEMI-PERSISTENT MODE. THE TEST COIL WITH A WINDING I.D. OF 25 CM AND WOUND WITH ~500-M LONG REACTED MGB_2 WIRE WAS OPERATED AT 4.2 K IMMERSED IN A BATH OF LIQUID HELIUM. IN THIS ACTIVE TECHNIQUE, UPON THE INITIATION OF A "HOT SPOT" OF A LENGTH ~5 CM, INDUCED BY A "QUENCH HEATER," A "PROTECTION HEATER" OF ~130-CM LONG PLANTED WITHIN THE TEST COIL IS ACTIVATED. THE NORMAL ZONE CREATED BY THE PROTECTION HEATER IS LARGE ENOUGH TO ABSORB THE ENTIRE INITIAL STORED ENERGY AND STILL REMAIN AT A TEMPERATURE NO GREATER THAN ~260 K. THE PAPER ALSO INCLUDES SIMULATION RESULTS OF THE QUENCH BEHAVIOR DURING THE ACTIVE PROTECTION IN THE TEST COIL.

THIS WORK IS SUPPORTED BY THE NATIONAL INSTITUTE OF BIOMEDICAL IMAGING AND BIOENGINEERING.

3LP1A-04

QUENCH PROPAGATION IN MAGNESIUM DIBORIDE DOUBLE-HELIX MAGNETS ***P. J. MASSON****;* ADVANCED MAGNET LAB. — QUENCH DETECTION IS CRITICAL TO THE DEVELOPMENT OF POWER APPLICATIONS OF HIGH TEMPERATURE SUPERCONDUCTIVITY (HTS). HTS CONDUCTORS EXHIBIT LOW NORMAL ZONE PROPAGATION VELOCITIES (NZPV) MAKING QUENCH DETECTION CHALLENGING. QUENCH PROPAGATION IS PART OF ANY MAGNET DESIGN AND STRONGLY DEPENDENT UPON THE MAGNET TOPOLOGY. MAGNESIUM DIBORIDE CONDUCTORS PRESENT A NZPV IN THE RANGE OF A FEW CM/S WHICH IS ORDERS OF MAGNITUDE LOWER THAN LOW TEMPERATURE SUPERCONDUCTORS. DURING A QUENCH, IT IS DESIRABLE TO SPREAD THE DISSIPATED ENERGY AS UNIFORMLY AS POSSIBLE THROUGHOUT THE WINDING IN ORDER TO LIMIT THE PEAK TEMPERATURE. DOUBLE-HELIX (DH) MAGNETS ARE DESIGNED TO FACILITATE HEAT PROPAGATION FROM LAYER TO LAYER THROUGH STRATEGICALLY LOCATED THERMAL BRIDGES. MOREOVER, SINCE THE DH WINDING TOPOLOGY IS BASED ON MODULATED HELICAL WINDING, ONE TURN DESCRIBES A LONG SINUSOIDAL TRAJECTORY IN THE MAGNET ALLOWING THE HEAT TO SPREAD BOTH IN AXIAL AND AZIMUTHAL DIRECTIONS DURING A QUENCH. THE PAPER PRESENTS THE NUMERICAL ANALYSIS OF QUENCH PROPAGATION IN A DH MAGNET WOUND WITH A COMMERCIALLY AVAILABLE MGB2 WIRE OPERATING AT 20 K. THE QUENCH IS INDUCED BY A SMALL HEATER LOCATED ON THE FIRST LAYER OF THE MAGNET CLOSE TO THE PEAK FIELD AREA. THE QUENCH DYNAMICS ALONG WITH DETECTION REQUIREMENTS ARE DERIVED FROM THE SIMULATION RESULTS AND REPORTED.

3LP1A-05

AC LOSSES IN YBCO TOROIDAL COIL FOR DC REACTOR WITH HARMONIC CURRENT OF THREE-PHASE RECTIFIER ***M. TSUDA****[1], T. HAMAJIMA[1], M. FURUSE[2], S. FUCHINO[2], N. HARADA[3], K. UEDA[3], T. NAKAJIMA[4], K. TAKENAKA[4];* [1]TOHOKU UNIVERSITY, [2]NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY, [3]YAMAGUCHI UNIVERSITY, [4]DENRYOKU COMPUTING CENTER, LTD.. — IN PLANTS AND INDUSTRIAL COMPLEXES, FURTHER ENERGY SAVING CAN BE REALIZED BY CONNECTING BETWEEN THE ENDS OF AC RADIAL DISTRIBUTION SYSTEMS BY DC CABLE AND INTERCHANGING THE POWER THAT MINIMIZES TOTAL POWER LOSSES IN THE TRANSFORMERS AND THE TRANSMISSION LINES IN THE WHOLE POWER SYSTEM. WE FABRICATED A POWER SYSTEM SIMULATOR TO VERIFY THAT THE DC INTERCONNECTION BETWEEN THE AC RADIAL DISTRIBUTION SYSTEMS IS EFFECTIVE IN REDUCING THE TOTAL POWER LOSSES IN THE TRANSFORMERS AND THE TRANSMISSION LINES. A TOROIDAL COIL COMPOSED OF YBCO DOUBLE PANCAKE COILS WAS ADOPTED AS A DC REACTOR IN THE SIMULATOR. IN THE OPERATION OF THE SIMULATOR, HARMONIC-FREQUENCY CURRENTS WITH DC-OFFSET COMPONENT WERE OBSERVED IN THE YBCO TOROIDAL COIL AND THE MAGNITUDE OF THE HARMONIC-FREQUENCY COMPONENTS DEPENDED ON THE OPERATING CURRENT. THEREFORE, WE MEASURED AC LOSSES IN THE YBCO TOROIDAL COIL AS A FUNCTION OF THE OPERATING CURRENT OF THE SIMULATOR. TO CLARIFY THE AC LOSS CHARACTERISTICS OF THE YBCO TOROIDAL COIL, WE EXPERIMENTALLY AND THEORETICALLY INVESTIGATED THE INFLUENCE OF THE MAGNITUDE OF THE HARMONIC-FREQUENCY COMPONENTS AND THE DC-OFFSET COMPONENT ON THE AC LOSSES BY USING A SHORT SAMPLE OF YBCO TAPE AND AN YBCO DOUBLE PANCAKE COIL.

3LP1A-07

EFFECTS OF THE THICKNESS OF A PZT DISC ON AE SIGNALS FROM HTS TAPES DURING QUENCHING IN A MIXED CRYOGEN COOLING SYSTEM ***K. KIM****[1], J. SONG[1], K. KIM[1], J. LEE[1], H. KIM[2], J. NA[3], T. KO[3], H. LEE[1];* [1]KOREA UNIVERSITY, KOREA, [2]KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE, KOREA, [3]YONSEI

UNIVERSITY, KOREA. — AN AE TECHNIQUE IS SUITABLE FOR DETECTING THE PRESENCE OF THERMAL AND MECHANICAL STRESSES IN A HIGH TEMPERATURE SUPERCONDUCTOR. THE AE SENSOR IS GENERALLY MANUFACTURED USING PIEZOELECTRIC CERAMICS, WHICH PRODUCE AN ELECTRICAL CHANGE WHEN A MECHANICAL STRESS IS APPLIED. THEREFORE, HIGH PERFORMANCE PIEZOELECTRIC CERAMICS ARE REQUIRED TO ENHANCE ITS SENSING PERFORMANCE. IN ORDER TO OBTAIN AE SIGNALS FROM HTS TAPES DURING QUENCHING, WE FABRICATED THE HIGH PERFORMANCE PIEZOELECTRIC CERAMIC DISCS ACCORDING TO THE FORMULA: $PB(ZR_{0.54}TI_{0.46})O_3$ + 0.2 WT% CR_2O_3 + 1.5 WT% NB_2O_5 (PZT). THIS STUDY EXAMINES THE PERFORMANCE OF THE AE SENSORS MANUFACTURED BY THESE PZT DISCS WITH VARIOUS THICKNESSES TO INVESTIGATE THE EFFECTS OF THE THICKNESS OF THE PZT DISC ON THE AE SIGNALS FROM THE YBCO COATED CONDUCTOR (CC) TAPES DURING THE REPETITIVE QUENCH TESTS IN A MIXED CRYOGEN COOLING SYSTEM.

THIS STUDY WAS SUPPORTED BY A KOSEF GRANT FUNDED BY THE KOREA GOVERNMENT (MEST 2009-0085369), AND BY A GRANT FROM THE CAST OF THE 21ST CENTURY FRONTIER R&D PROGRAM FUNDED BY THE MEST, KOREA.

3LP1A-08

THE DETECTION AND PROTECTION OF A CONDUCTION-COOLED MAGNET FOR A SUPERCONDUCTING PROPERTY MEASUREMENT SYSTEM ***S. CHOI***[1], *J. BAE*[2], *M. SOHN*[2], *C. PARK*[3], *J. LEE*[4], *K. CHOI*[5], *T. KO*[1]; [1]YONSEI UNIVERSITY, [2]KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE, [3]SEOUL NATIONAL UNIVERSITY, [4]WOOSUK UNIVERSITY, [5]KOREA POLYTECHNIC UNIVERSITY. — A SUPERCONDUCTING PROPERTY MEASUREMENT SYSTEM(SPMS) IS USED TO ACQUIRE ELECTRICAL AND THERMAL PROPERTIES OF SHORT HTS TAPE SAMPLES. THE SPMS IS COMPOSED OF A SPECIMEN HOLDER FOR MOUNTING AN HTS TAPE AND MAGNET FOR APPLYING A MAGNETIC FIELD EXTERNALLY. THE MAGNET CONSISTS OF TWO SPLIT RACETRACK WINDINGS AND IS DESIGNED TO PRODUCE MAXIMUM 3 T OF CENTER FIELD AT 20 K.THIS PAPER DESCRIBES THE QUENCH PROTECTION SYSTEM FOR AN HTS MAGNET OF THE SPMS. THE DETECTION OF ANY NORMAL ZONE MUST BE PRECEDED TO PROTECT THE HTS MAGNET. THIS IS ACHIEVED BY HAVING A CENTER VOLTAGE TAP AND VOLTAGE TAPS BETWEEN THE WINDINGS. THE VOLTAGE ACROSS THE SECTIONS OF THE WINDING IS COMPARED AND BALANCED FOR INDUCTANCE. THIS PAPER PRESENTS THE EFFECT ON THE QUENCH PROCESS OF THE NUMBER OF VOLTAGE TAPS AND THE SHUNT RESISTANCE. THE PRESENTED RESULTS IN THIS PAPER WERE VERIFIED USING FABRICATED PROTECTION CIRCUIT.

THIS WORK WAS SUPPORTED BY ELECTRIC POWER INDUSTRY TECHNOLOGY EVALUATION AND PLANNING

3LP1A-09

QUENCH AND RECOVERY CHARACTERISTICS OF PANCAKE COILS WOUND WITH GDBCO COATED CONDUCTOR BY APPLYING VARIOUS INSULATING MATERIALS ***D. YANG***[1], *Y. CHOI*[1], *J. KIM*[1], *K. KIM*[1], *J. LEE*[1], *H. KIM*[2], *H. LEE*[1]; [1]KOREA UNIVERSITY, KOREA, [2]KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE, KOREA. — THE STABILITY ISSUE OF A HIGH TEMPERATURE SUPERCONDUCTOR (HTS) MAGNET IS ONE OF THE MOST IMPORTANT FACTORS FOR THE DEVELOPMENT IN HIGH-FIELD MAGNET APPLICATIONS. ALTHOUGH MANY RESEARCHES HAVE BEEN CONDUCTED FOR THE STABILITY OF THE HTS MAGNET APPLICATIONS, THERE ARE INSUFFICIENT DATA ABOUT THE STABILITY AND NORMAL ZONE PROPAGATION CHARACTERISTICS OF THE HTS MAGNET WITH VARIOUS INSULATING MATERIALS. IN THIS STUDY, WE EXAMINED THE QUENCH/RECOVERY CHARACTERISTICS OF GDBCO COATED CONDUCTOR (CC) PANCAKE COILS, WHICH ARE INSULATED WITH VARIOUS MATERIALS SUCH AS COPPER, NOMEX AND KAPTON TAPES. THE MINIMUM QUENCH ENERGY AND QUENCH PROPAGATION VELOCITY OF GDBCO CC PANCAKE COILS ARE ALSO DISCUSSED.

THIS STUDY WAS SUPPORTED BY A KOSEF GRANT FUNDED BY THE KOREA GOVERNMENT (MEST 2009-0085369), AND THE ELECTRIC POWER INDUSTRY TECHNOLOGY EVALUATION & PLANNING.

3LP1A-10

MECHANICAL LOSS AND BOBBIN MATERIALS IN AC SUPERCONDUCTING COIL UNDER AC MAGNETIC FIELD ***T. TAKAO***[1], *T. MASUDA*[1], *K. NISHIMURA*[1], *T. TAKAGI*[1], *S. FUKUI*[2], *A. YAMANAKA*[3]; [1]SOPHIA UNIVERSITY, [2]NIIGATA UNIVERSITY, [3]TOYOBO. — WE STUDIED THE REDUCTION OF MECHANICAL LOSS WHICH AROSE FROM VIBRATION OF A SUPERCONDUCTING COIL OWING TO A PERIODICALLY VARYING ELECTROMAGNETIC FORCE. OUR APPROACH TO REDUCE THE MECHANICAL LOSS IS TO USE THE THERMAL EXPANSION/CONTRACTION PROPERTIES OF A BOBBIN MATERIAL IN THE COILS. IN OUR EARLIER WORK, SAMPLE SUPERCONDUCTORS WERE STRAIGHT AND SHORT HTS TAPES. IN THE EXPERIMENTS, AC LOSSES OCCURRING IN THE TAPES IN A DC/AC EXTERNAL MAGNETIC FIELD WITH AN AC CURRENT WERE MEASURED. ACCORDING TO THE RESULTS, MECHANICAL LOSS WAS REDUCED EFFECTIVELY WHEN THE SAMPLE-HOLDER MATERIAL HAD A NEGATIVE COEFFICIENT OF THERMAL EXPANSION. EXTENDING THE WORK, WE MEASURED MECHANICAL LOSS IN AN AC MAGNETIC FIELD FOR AC SUPERCONDUCTING COILS IN THE PAPER. EXPERIMENTAL RESULTS INDICATED THAT MECHANICAL LOSS DECREASED AS TENSION APPLIED TO THE SAMPLE TAPE INCREASED. AND WHEN A BOBBIN MATERIAL WITH A NEGATIVE COEFFICIENT OF THERMAL EXPANSION WAS USED, MECHANICAL LOSS REDUCED. THE EXPANSION BOBBIN WAS EFFECTIVE TO REDUCE THE VIBRATION. THE PAPER SHOWS DETAILS OF THE EXPERIMENTAL RESULTS, AND ALSO DISCUSSES ON THE EXPANSION/CONTRACTION PROPERTY OF THE BOBBIN AND MECHANICAL LOSS IN THE COIL.

3LP2A-01

ELECTRICAL CONTACT RESISTANCE OF MULTI-CONTACT CONNECTOR IN SEMI-RETRACTABLE CURRENT LEAD ***Y. CHOI;***

KBSI. — CURRENT LEAD IS THE KEY COMPONENT TO CARRY THE CURRENT FROM AN ELECTRICAL POWER AT ROOM TEMPERATURE TO A SUPERCONDUCTING MAGNET AT CRYOGENIC TEMPERATURE. HEAT LEAKAGE THROUGH CURRENT LEADS IS A MAJOR FACTOR IN CRYOGENIC LOAD FOR VARIOUS HIGH FIELD MAGNETS. THE SEMI-RETRACTABLE CURRENT LEAD IS ONE OF THE GOOD OPTIONS BECAUSE OF NO HEAT LEAKAGE AFTER MAGNET CHARGING. IT IS COMPOSED OF A NORMAL METAL ELEMENT AND AN HTS ELEMENT. THE NORMAL METAL ELEMENT IS DISENGAGED FROM THE HTS ELEMENT THROUGH THE MULTI-CONTACT CONNECTOR WITHOUT DISTURBANCE TO THE INSULATING VACUUM SPACE AND WITHOUT REQUIRING COMPLETE REMOVAL OF THE NORMAL METAL ELEMENT. IN THIS PAPER, ELECTRICAL CONTACT RESISTANCE OF MULTI-CONTACT CONNECTOR IS MEASURED TO CONFIRM THE FEASIBILITY OF OUR APPLICATION. THE EFFECTS OF CURRENT LEVEL AND OPERATING TEMPERATURE ON THE ELECTRICAL CONTACT RESISTANCE IN A LOCKABLE SET ARE ALSO DISCUSSED.

THIS WORK IS SUPPORTED BY THE KBSI GRANT D30110

3LP2A-02

HTS CURRENT LEADS PREPARED BY THE TFA-MOD PROCESSED YBCO TAPES ***Y. YAMADA;*** TOKAI UNIVERSITY. — HTS CURRENT LEADS HAVE BEEN PREPARED BY THE TFA-MOD PROCESSED YBCO TAPES. THE YBCO TAPE IS 5 MM IN WIDTH AND AROUND 120 MM IN OVERALL THICKNESS. THE YBCO SUPERCONDUCTING LAYER WITH 1.5 MM IS FORMED ON OXIDE BUFFERED LAYERS AND HASTELLOY SUBSTRATE TAPE. A CURRENT LEAD UNIT IS COMPOSED OF FIVE YBCO TAPES SOLDERED TO CU CAPS AT BOTH ENDS AND A GFRP BOARD. THE CRITICAL CURRENT OF FIFTY YBCO TAPES USED FOR THE CURRENT LEAD UNITS RANGES FROM 96 A TO 126 A AT 77 K.THE HTS CURRENT LEAD IS ASSEMBLED FROM TEN CURRENT LEAD UNITS IN PARALLEL. THE TRANSPORT CURRENT OF 4000 A AT 77 K WAS STABLY CARRIED WITH NO VOLTAGE GENERATION ON THE TAPES FOR TEN MINUTES. FURTHERMORE, THE TRANSPORT CURRENT OF 5000 A WAS SUCCESSFULLY APPLIED WITH VOLTAGE OF 200 MV ON SOME YBCO TAPES FOR 10 MINUTES.THE HEAT LEAKAGE OF THE HTS CURRENT LEAD WITH 150 MM IN LENGTH BETWEEN 77 K AND 4.2 K IS ESTIMATED TO BE 465 MW. THEREFORE, THE HEAT LOAD OF IT AT TRANSPORT CURRENT OF 4000 A CORRESPONDS TO 0.116 W/KA, WHICH IS ONE ORDER OF MAGNITUDE SMALLER THAN THAT (1.2 W/KA) OF CONVENTIONAL CU CURRENT LEAD. THE SMALL HEAT LOAD RESULTS FROM HIGH CURRENT PERFORMANCE AND LOW THERMAL CONDUCTIVITY IN THE PRESENT HTS CURRENT LEAD.

3LP2A-03

TEST ARRANGEMENT FOR THE W7-X HTS-CURRENT LEAD PROTOTYPE TESTING ***W. H. FIETZ****[1], S. FINK[1], M. HEIDUK[1], R. HELLER[1], C. LANGE[1], R. LIETZOW[1], T. MÖHRING[1], P. ROHR[1], M. SÜßER[1], T. RUMMEL[2];* [1]KARLSRUHE INSTITUTE OF TECHNOLOGY, [2]MAX-PLANCK-INSTITUT FÜR PLASMAPHYSIK, TEILINSTITUT GREIFSWALD. — THE KARLSRUHE INSTITUTE OF TECHNOLOGY (KIT) IS RESPONSIBLE FOR THE DESIGN, CONSTRUCTION AND TESTING OF THE HIGH TEMPERATURE SUPERCONDUCTOR (HTS) CURRENT LEADS FOR THE STELLARATOR WENDELSTEIN 7-X (W7-X) WHICH IS PRESENTLY UNDER CONSTRUCTION AT THE GREIFSWALD BRANCH OF THE MAX-PLANCK-INSTITUTE FOR PLASMA PHYSICS. BECAUSE THE W7-X CURRENT LEADS ARE MOUNTED WITH THE WARM END AT THE BOTTOM A SPECIAL TEST CRYOSTAT HAS BEEN BUILT AND IS ATTACHED TO THE B300 CRYOSTAT OF THE TOSKA FACILITY OF KIT. TWO PROTOTYPES OF THESE CURRENT LEADS ARE TESTED IN THIS CRYOSTAT UNDER W7-X RELEVANT CONDITIONS. THE TEST CONDITIONS WITH RESPECT TO CRYOGENIC, CONTROL, DATA ACQUISITION AND QUENCH DETECTION OF THE TEST SETUP FOR THE PROTOTYPE TEST AT TOSKA IS DESCRIBED.

3LP2A-04

TEST RESULTS OF THE HIGH TEMPERATURE SUPERCONDUCTOR PROTOTYPE CURRENT LEADS FOR WENDELSTEIN 7-X ***R. HELLER****[1], W. H. FIETZ[1], S. FINK[1], M. HEIDUK[1], A. KIENZLER[1], C. LANGE[1], R. LIETZOW[1], T. MÖHRING[1], P. ROHR[1], T. RUMMEL[2], T. MÖNNICH[2], K. BUSCHER[2];* [1]KARLSRUHE INSTITUTE OF TECHNOLOGY, [2]MAX PLANCK INSTITUTE FOR PLASMA PHYSICS. — THE KARLSRUHE INSTITUTE OF TECHNOLOGY IS RESPONSIBLE FOR THE DESIGN, CONSTRUCTION AND TESTING OF THE HIGH TEMPERATURE SUPERCONDUCTOR (HTS) CURRENT LEADS FOR THE STELLARATOR WENDELSTEIN 7-X (W7-X) WHICH IS PRESENTLY UNDER CONSTRUCTION AT THE GREIFSWALD BRANCH OF THE MAX-PLANCK-INSTITUTE FOR PLASMA PHYSICS. THE CURRENT LEADS ARE OF THE BINARY TYPE, THE HTS PART COVERING THE RANGE BETWEEN 4.5 K AND 60 K WHILE THE HEAT EXCHANGER COVERS THE RANGE BETWEEN 60 K AND ROOM TEMPERATURE AND BE COOLED BY 50 K HE. IN TOTAL 2 PROTOTYPE AND 14 SERIES CURRENT LEADS ARE REQUIRED WITH A NOMINAL CURRENT OF 14 KA AND A MAXIMUM CURRENT OF 18.2 KA. THE PAPER DESCRIBES THE DESIGN AND TEST RESULTS OF THE PROTOTYPE HTS CURRENT LEADS.

3LP2A-05

A STUDY ON THE STACKING METHODS OF HIGH TC SUPERCONDUCTING TAPE WITH RESPECT TO THE SHAPE OF THE COPPER TERMINAL FOR APPLICATIONS OF LARGE CURRENT ***J. JANG****, K. CHANG, Y. KIM, J. NA, S. CHOI, S. CHU, T. KO;* YONSEI UNIVERSITY. — HIGH TC SUPERCONDUCTING(HTS) TAPE IS PROMISING MATERIAL FOR LARGE CURRENT APPLICATION, FOR IT HAS ZERO RESISTANCE. HOWEVER, A SINGLE HTS TAPE HAS LIMITATION ON THE CURRENT CAPACITY DUE TO THE CRITICAL CURRENT OF A HTS TAPE. THEREFORE, STACKING OR PARALLEL STRUCTURE OF THE HTS TAPE IS INDISPENSIBLE FOR LARGE CURRENT APPLICATION. IN THIS PAPER, SEVERAL STACKING METHODS WITH RESPECT TO THE SHAPE OF THE COPPER TERMINAL ARE STUDIED AND THE OPERATING CHARACTERISTICS ARE PROVED BY EXPERIMENTAL ANALYSIS AND NUMERICAL ANALYSIS. USING THESE ANALYSIS, THE DATA OF CURRENT DISTRIBUTION AND THE CRITICAL CURRENT DECREASE OF HTS TAPE WITH RESPECT TO THE SHAPE OF THE COPPER TERMINAL CAN BE OBTAINED. BASED

ON THIS RESEARCH, THE NECESSARY STACKING NUMBER AND OPERATING CURRENT OF HTS TAPES CAN BE CALCULATED FOR LARGE CURRENT APPLICATION.

THIS RESEARCH WAS SUPPORTED BY NATIONAL R&D PROGRAM THROUGH THE NATIONAL RESEARCH FOUNDATION OF KOREA(NRF) FUNDED BY THE MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY(NO. 2009 - 0082742).

3LP2A-06

PERFORMANCE VERIFICATION TEST FOR OPTIMAL LEADS AND HITC LEADS ***C. TAYLOR****, B. WANG, H. CHEN, L. XU, B. WAHRER, M. WANG;* WANG NMR INC.. — COLD END OPTIMAL LEAD DESIGN IS GIVEN BY L/A = K2/ I AND THE OPTIMUM I2R LEADS (MINIMUM Q) ARE GIVEN BY QMIN = K1XI , WHERE K1 AND K2 ARE GIVEN BY MERCOUROFF, W. P.171, CRYOGENICS, SEPT. 1963.MOST COMMON I2R LEADS WILL HAVE UHV FEEDTHRU COPPER WITH RRR=200, AS FIRST SECTION. HOWEVER, THE SECOND SECTION WILL BE FLEXIBLE WELDING CABLE WITH RRR=30. USING NIST VALUES OF LAMBDA AND RHO, BOTH K1 AND K2 ARE EVALUATED NUMERICALLY AND GIVEN IN TABLE 1 FOR SEVERAL VALUES OF RRR AND FOR COLD END TEMPERATURE OF I2R LEAD FROM 300K TO 50K.TABLE 1RRR K2 K130 3.70E+06 4.36E-02100 3.93E+06 4.32E-02300 4.01E+06 4.31E-02BASED ON THESE DATA, WE DESIGN MICE MAGNET LEADS FOR 275A AND 50A. FOR 275A LEADS, WE USE RIGID CONDUCTOR 0.375" DIAMETERX6" LONG FOR FIRST SECTION. FOR SECOND SECTION, WE OBTAIN WELDING CABLE#2 WITH A=33.6MM2, A OPTIMAL LENGTH L=10.5", AND QMIN=12.0W FOR I=275A AND 8.1W FOR I=0. FOR 50A LEAD, WE HAVE FIRST SECTION 0.25" DIA. X 6" WITH RRR=200. SECOND SECTION IS 0.25" CABLE WITH RR=30 AND THE OPTIMAL LENGTH=9.5".WE HAVE DESIGNED AN INNOVATIVE TESTING APPARATUS WITH A CRYOCOOLER, HITC LEADS, AND A SUPERCONDUCTING LOOP TO SIMULATE SUPERCONDUCTING COILS. WE HAVE PERFORM A SERIES OF TESTS AND RESULTS AGREE VERY WELL WITH THEORY OF OPTIMAL LEADS AND WE CAN VERIFY HITC HEAT LEAK VERY EASILY. THE CRYOGENIC APPARATUS AND TEST RESULTS WILL BE PRESENTED.

3LP2A-07

CURRENT LEAD DESIGN FOR THE ACCELERATOR PROJECT FOR UPGRADE OF LHC ***J. S. BRANDT****, S. CHEBAN, S. FEHER, M. KADUCAK, F. NOBREGA, T. PETERSON;* FERMI NATIONAL ACCELERATOR LABORATORY. — THE ACCELERATOR PROJECT FOR UPGRADE OF LHC (APUL) IS A U.S. PROJECT PARTICIPATING IN AND CONTRIBUTING TO CERN'S LARGE HADRON COLLIDER (LHC) UPGRADE PROGRAM. FERMI NATIONAL ACCELERATOR LABORATORY, IN COLLABORATION WITH BROOKHAVEN NATIONAL LABORATORY, IS DEVELOPING SUB-SYSTEMS FOR AN UPGRADE OF THE LHC FINAL FOCUS MAGNET SYSTEMS. THE MOST RECENT ELECTRICAL SCHEME SPECIFIES CURRENT LEADS IN FOUR SIZES, 13KA X 4, 7KA X 2, 2.5KA X 8, AND 0.6KA X 8. ALL CURRENT LEADS ARE PLANNED TO BE CONVENTIONAL COPPER, OPERATING AT 300K AT THE TOP DOWN TO 4.7K AT THE BOTTOM WHERE THE POWER IS TRANSMITTED INTO A SUPERCONDUCTING CABLE. A CONCEPT OF MAIN AND AUXILIARY HELIUM FLOW WAS DEVELOPED THAT ALLOWS THE SUPERCONDUCTOR TO REMAIN COLD WHILE THE LEAD BODY WARMS UP TO PREVENT UPPER SECTION FROSTING. THIS AUXILIARY FLOW SUBSEQUENTLY COOLS THE THERMAL SHIELDS OF THE FEED BOX AND TRANSMISSION LINE CRYOSTATS. A THERMAL ANALYSIS OF THE MIDDLE HEAT EXCHANGE SECTION OF THE CURRENT LEAD WAS PERFORMED USING ANALYTIC AND FEA TECHNIQUES. A METHOD OF REMOTE SOLDERING WAS DEVELOPED THAT ALLOWS THE CURRENT LEADS TO BE FIELD REPLACEABLE. THE REMOTE SOLDER JOINT WAS DESIGNED TO BE MADE WITHOUT FLUX OR ADDITIONAL SOLDER, AND ABLE TO BE REMADE UP TO TEN CYCLES. A TEST FIXTURE FOR REMOTE SOLDERING THE 13 KA LEAD WAS PRODUCED. THE COOLING CONCEPT, THERMAL ANALYSES, AND TEST RESULTS FROM THE REMOTE SOLDERING FIXTURE ARE PRESENTED.

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3LP2A-08

DOUBLE PELTIER CURRENT LEAD FOR HEAT LEAK REDUCTION AT THE TERMINALS FOR SUPERCONDUCTING DIRECT CURRENT APPLICATIONS ***T. KAWAHARA****[1], T. FUJII[1], M. EMOTO[2], M. HAMABE[1], H. WATANABE[1], J. SUN[1], I. YURY[1], S. YAMAGUCHI[1];* [1]CHUBU UNIVERSITY, [2]NSTIONAL INSTITUTE FOR FUSION SCIENCE. — RECENT ENERGY PROBLEMS SHOULD BE SOLVED BY STATES OF THE ART TECHNOLOGIES SUCH AS SUPERCONDUCTIVITY. ONE OF SUPERCONDUCTING APPLICATIONS FOR ENERGY SAVING IS SUPERCONDUCTING POWER TRANSMISSION AND DISTRIBUTION (T&D). CHUBU UNIVERSITY HAS DEVELOPED 20 M-CLASS SUPERCONDUCTING DIRECT CURRENT SUPERCONDUCTING TRANSMISSION DEVICE AND RECENTLY, WE HAVE FINISHED UP THE CONSTRUCTION OF 200 M-CLASS DEVICE. FOR THESE SYSTEMS, WE HAVE USED SPECIAL CURRENT LEAD AS PELTIER CURRENT LEAD (PCL) FOR THE HEAT LEAK REDUCTION AT THE TERMINALS. AS HEAT LEAK ON PCL DEPENDS ON THE PERFORMANCE OF THERMOELECTRIC PROPERTIES AND THEN WE SHOULD SELECT SEVERAL MATERIALS THAT HAVE BETTER PARAMETERS FOR PCL. WE ESTIMATE THE HEAT LEAK ON PCL USING THERMAL BALANCE EQUATION USING MODEL PARAMETERS MEASURED FOR SEVERAL MATERIALS. AND THE BETTER COMBINATIONS OF THERMOELECTRIC MATERIALS COULD HAVE HIGHER PERFORMANCE COMPARING TO SINGLE MATERIALS. THEREFORE, WE DISCUSS ABOUT DOUBLE PCL USING TWO DIFFERENT MATERIALS FOR THE PELTIER PARTS IN PCL. FOR EXAMPLES, WHEN TWO MATERIALS HAVE MINIMUM HEAT LEAK OF 31 W/KA AND 32 W/KA, RESPECTIVELY, THE DOUBLE PCL USING THE SAME MATERIALS CAN HAVE THE HEAT LEAK BELOW 30 W/KA. THEREFORE, THE BEST COMBINATION OF THERMOELECTRIC MATERIALS IS USEFUL FOR THE MINIMIZATION OF HEAT LEAK. AND IT CAN BE USED AS HIGH PERFORMANCE SUPERCONDUCTING SYSTEMS BECAUSE OF HEAT LEAK REDUCTION AT THE TERMINALS.

3LP2A-09

THE DESIGN AND FABRICATION OF A 10 KA HTS CURRENT LEAD PROTOTYPE FOR ITER ***P. BAUER***[1]*, Y. BI*[2]*, A. DEVRED*[1]*, K. DING*[2]*, N. MITCHELL*[1]*, Y. SONG*[2]*, T. ZHOU*[2]*, G. SHEN*[2]*, X. HUANG*[2]*;* [1]ITER ORGANIZATION, [2]ASIPP. — THE ITER ORGANIZATION (IO) AND THE INSTITUTE OF PLASMA PHYSICS AT THE CHINESE ACADEMY OF SCIENCES (ASIPP) ARE JOINTLY DEVELOPING THE DESIGN OF THE 10 KA CURRENT LEADS USING HIGH TEMPERATURE SUPERCONDUCTORS (HTS) FOR THE CORRECTION COIL (CC) MAGNET SYSTEM OF THE INTERNATIONAL THERMONUCLEAR EXPERIMENTAL REACTOR, ITER. THE PROPOSED DESIGN COMBINES A CONVENTIONAL HELIUM COOLED HEAT EXCHANGER OPERATING BETWEEN 65 K AND 320 K WITH A HTS MODULE COVERING THE LOW TEMPERATURE END USING BI-2223 TAPES.THE DETAILS OF THE DESIGN AND FABRICATION EFFORT WILL BE DISCUSSED IN THIS PAPER, WITH PARTICULAR EMPHASIS OF THE ISSUES RELEVANT TO THE CURRENT LEAD SERIES PRODUCTION FOR THE ITER DEVICE, WHICH SHOULD COMMENCE SOON. THIS HTS CURRENT LEAD PROTOTYPE WILL BE TESTED IN A SPECIAL FACILITY AT ASIPP WITHIN THIS YEAR.

3LP2A-10

HEAT EXCHANGER DESIGN FOR THE 30KA GAS COOLED CURRENT LEADS IN THE ENEA 12T CICC FACILITY ***G. POLLI****, L. AFFINITO, A. DELLA CORTE;* ENEA. — HEAT EXCHANGERS CONSTITUTE ONE OF THE CRUCIAL TOPICS IN THE GAS COOLED CURRENT LEAD DESIGN. INDEED, THE PROPER BEHAVIOR OF THESE DEVICES DEPENDS LARGELY ON THE DEGREE OF EFFICIENCY IN THE HEAT EXCHANGE. THE EFFICIENCY IS PARTICULARLY IMPORTANT IN CURRENT LEADS EXCEEDING 10KA BECAUSE THE JOULE POWER PRODUCED IMPLIES THE USE OF COSTLY HELIUM REFRIGERATORS. CURRENTLY, ENEA SUPERCONDUCTIVITY DIVISION IS UPGRADING A FACILITY FOR THE CHARACTERIZATION OF SUPERCONDUCTING LONG LENGTH WOUND CONDUCTORS IN FORCED HE FLOW COOLING, AND AT THIS AIM A PAIR OF 30KA GAS COOLED CURRENT LEADS WILL BE REALIZED. THE PRELIMINARY DESIGN OF THESE LEADS, TO FIX THE BROAD PARAMETERS OF THE PROJECT, HAS BEEN ALREADY PRESENTED BY THE AUTHORS, IN THIS PAPER HOWEVER A DETAILED DESIGN OF THE HEAT EXCHANGER IS DISCUSSED. WITH REGARD TO THE HEAT EXCHANGER PART, A SCREW-LIKE SOLUTION HAS BEEN ADOPTED FOR TWO REASONS: FIRST TO GUARANTEE THAT HELIUM WOULD WET ALL THE SURFACES OF THE HEAT EXCHANGER AND THUS LIMITING POSSIBLE SHORT-PATH THAT COULD OCCUR IN BRAIDED SOLUTIONS, THEN TO GUARANTEE A PROPER INSULATION WITH THE ENVIRONMENT BY CREATING A COUNTER SCREW THAT SEALS THE HEAT EXCHANGER.

3LP2A-11

4 KA BINARY LEADS WITH REBCO COATED CONDUCTOR ***H. W. WEIJERS****, G. M. MILLER, P. D. NOYES;* NHMFL. — THE SERIES CONNECTED HYBRID MAGNET UNDER DEVELOPMENT FOR USE AT THE NHMFL REQUIRES 20 KA HTS LEADS. THESE LEADS ARE PLANNED WITH SELF-DEMAND LIQUID NITROGEN COOLING FOR THE RESISTIVE SECTION AND RARE-EARTH-BCO COATED CONDUCTOR IN THE HTS SECTION. AS PART OF THE DEVELOPMENT PROCESS OF SUCH LEADS, A SUB-SCALE 4 KA LEAD PAIR WAS DESIGNED, BUILT AND TESTED. DESIGN ASPECTS AND TEST RESULTS FOR THE SUB-SCALE LEADS ARE PRESENTED AS WELL AS THE IMPLICATIONS FOR THE 20 KA LEAD DESIGN.

3LP2B-01

PROGRESS ON THE DEVELOPMENT OF A 5 T HTS INSERT MAGNET FOR GHZ CLASS NMR APPLICATIONS ***Y. CHOI***[1]*, D. KIM*[1]*, S. HAHN*[2]*;* [1]KOREA BASIC SCIENCE INSTITUTE, [2]FRANCIS BITTER MAGNET LABORATORY. — THE KOREA BASIC SCIENCE INSTITUTE (KBSI) HAS INITIATED THE DEVELOPMENT OF A 5 T HTS INSERT MAGNET SYSTEM. THE OBJECTIVE OF THIS PROGRAM IS THE DESIGN AND FABRICATION OF HTS INSERT MAGNET FOR GHZ CLASS LTS/HTS NMR APPLICATIONS. COMPACT AND EFFICIENT HTS MAGNET SYSTEM IS DESIGNED TO BE INSERTED INTO 15 T CONDUCTION-COOLED SUPERCONDUCTING MAGNET WITH 100 MM ROOM-TEMPERATURE BORE. IN THIS PAPER, THE STATUS OF THE HTS INSERT MAGNET DEVELOPMENT IN KBSI IS PRESENTED. THE DESIGN ISSUES OF THE 5 T HTS INSERT MAGNET INCLUDING 2G HTS CONDUCTOR PROPERTIES WITH ADDITIONAL REINFORCEMENT AND INSULATION, COIL CONFIGURATION WITH SUPPORTING STRUCTURES, MAGNETIC WINDING AND BENDING STRESS-STRAIN, DETECT AND ACTIVATE PROTECTION, AND SPATIAL AND TEMPORAL FIELD PERFORMANCE ARE DISCUSSED. IN ADDITION, THE DESIGN OF CRYOSTAT FOR 5 T HTS INSERT MAGNET IS PRESENTED.

3LP2B-02

THE CONSTRUCTION AND TESTING OF HTS COILS FOR 10T SOLENOID ***Y. SHIROYANAGI****, W. SAMPSON, A. GHOSH, R. GUPTA;* BROOKHAVEN NATIONAL LABORATORY. — DOUBLE PANCAKE COILS ARE BEING FABRICATED USING SECOND GENERATION (2G) HIGH TEMPERATURE SUPERCONDUCTOR (HTS) MANUFACTURED BY SUPERPOWER FOR A PROTOTYPE 10T SOLENOID. THIS IS A PART OF A SBIR (SMALL BUSINESS INNOVATIVE RESEARCH) AWARD TO PARTICLE BEAM LASERS, INC. (PBL) WITH BROOKHAVEN NATIONAL LABORATORY (BNL) BEING A RESEARCH PARTNER TO BUILD AND TEST THE SOLENOID. EACH HALF PANCAKE IS MADE FROM TWO LENGTHS OF TAPE, SO THAT THE TOTAL LENGTH OF CONDUCTOR IN EACH COIL IS 100M. THE INNER DIAMETER OF THE COIL IS ~100MM AND THE OUTER DIAMETER, 162MM. FOR INTER-TURN INSULATION, A 0.0254MM THICK STAINLESS STEEL TAPE WAS CO-WOUND WITH THE CONDUCTOR. DURING THE TESTING OF THE COILS AT CRYOGENIC TEMPERATURES, THE VOLTAGE DEVELOPED ACROSS EACH COIL WAS MEASURED AS A FUNCTION OF CURRENT AT TEMPERATURES BETWEEN ~77K AND ~4.2K. IRREVERSIBLE DEGRADATION OF THE COIL PERFORMANCE DUE TO THERMAL SHOCK WAS OBSERVED. THE DEFECTS COULD BE LOCATED BY MEASURING THE VOLTAGE DISTRIBUTION IN THE COIL. THE DETAILED RESULTS AND THE IMPROVEMENTS REQUIRED IN ORDER TO ACHIEVE THE GOAL OF 10T WILL BE DISCUSSED.

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3LP2B-04

ELECTRO-THERMAL SIMULATION AND STABILITY OF TRAPPED FIELD IN MULTI-LAYER YBCO PLATES ***P. J. MASSON;*** ADVANCED MAGNET LAB. — TRAPPED FLUX MAGNETS (TFM) ARE VERY ATTRACTIVE FOR APPLICATION TO POWER DEVICES AS THEY CAN TRAP FLUX DENSITIES OF MORE THAN 10 T AT REASONABLE OPERATING TEMPERATURE. THE MAJOR LIMITATION OF FLUX TRAPPING CAPABILITIES OF BULK YBCO STEMS FROM MECHANICAL PROBLEMS. INDEED, LORENZ FORCES CAN BECOME VERY IMPORTANT WHEN MAGNETIC ENERGY STORED INCREASES. IN ORDER TO IMPROVE FLUX TRAPPING IN TFMS, MECHANICAL REINFORCEMENT CAN BE DONE USING EPOXY IMPREGNATED FIBER GLASS CLOTH AND UP TO 17 T HAS BEEN TRAPPED AT 29 K. HOWEVER, DUE TO THE CERAMIC NATURE OF YBCO, IT REMAINS STRUCTURALLY WEAK AND CAN VERY LIKELY FAIL IF ELECTRO-THERMAL INSTABILITIES OCCUR. WE PROPOSE TO STUDY A DIFFERENT KIND OF TFMS BASED ON A MULTI-LAYER CONFIGURATION THAT COULD BE ACHIEVED BY STACKING DISKS MADE OF COATED CONDUCTORS. THE MULTI-LAYER CONFIGURATION WOULD BRING A MUCH BETTER STRESS DISTRIBUTION AND SHOULD LEAD TO MORE STABLE FLUX TRAPPING. EVEN THOUGH PACKING FACTOR REMAINS AN ISSUE FOR STACKED COATED CONDUCTORS, IT IS EXPECTED THAT YBCO CAN BE DEPOSITED ADVANTAGEOUSLY IN MULTIPLE LAYER CONFIGURATION ESPECIALLY FOR THIS SPECIFIC APPLICATION. USING COMSOL MULTIPHYSICS FEA SOFTWARE, WE PRESENT ELECTRO-THERMAL-STRUCTURAL ANALYSIS COMPARING FLUX TRAPPING IN YBCO BULK PLATES AND MULTI-LAYERS PLATES FOR DIFFERENT FLUX TRAPPING METHODS AS WELL AS THEIR RESPONSE TO THERMAL DISTURBANCES.

3LP2B-05

PERFORMANCES OF HTS COILS IN HIGH MAGNETIC FIELDS AND VARIABLE TEMPERATURES ***F. DEBRAY***[1]*, X. CHAUD*[1]*, F. HATANIAN*[1]*, E. MOSSANG*[1]*, P. TIXADOR*[2]*, J. REY*[3]*, H. KITAGUCHI*[4]*;* [1]LABORATOIRE NATIONAL DES CHAMPS MAGNETIQUES INTENSES LNCMI, CNRS, FRANCE, [2]G2ELAB/INSTITUT NÉEL, CNRS/GRENOBLE-INP/UJF, FRANCE, [3]CEA-DSM-IRFU-SACM, FRANCE, [4]SUPERCONDUCTING MATERIALS CENTER, NATIONAL INSTITUTE FOR MATERIALS SCIENCE (NIMS), 1-2-1 SENGEN, TSUKUBA 305-0031, JAPAN. — HIGH TEMPERATURE SUPERCONDUCTORS (HTS) ARE NOW WIDELY USED ON MANY APPLICATIONS. THE RECENT PROGRESS IN TRANSPORT AND MECHANICAL PROPERTIES OF CONDUCTORS OF THESE MATERIALS ENABLES THEIR APPLICATION AS INSERT COILS FOR HIGH FIELD GENERATION. INSERT SOLENOIDS HAVE BEEN MADE AT CNRS GRENOBLE, FRANCE, USING YBA2CU3O7-X (YBCO) COATED CONDUCTORS. A SOLENOID LAYER-WINDING COIL USING (BI,PB)2SR2CA2CU3OX (BI-2223) WAS FABRICATED IN NIMS TSUKUBA, JAPAN.[1]THESE SMALL HTS COILS (LESS THAN 130 MM DIAMETER) ARE TESTED UP IN EXTERNAL MAGNETIC FIELDS UP TO 19 T, AND IN TEMPERATURE RANGES FROM 4.2 TO 80 K IN ORDER TO DEMONSTRATE THEIR FEASIBILITY OF HTS CONDUCTORS FOR HIGH MAGNETIC FIELD GENERATION, AND THEIR USE AT HIGH TEMPERATURE.[1] H. KITAGUCHI ET AL., SUPERCOND. SCI. TECHNOL. 22, 045005, 2009

3LP2B-06

DEVELOPMENT OF $YBA_2CU_3O_{7-\Delta}$ COATED CONDUCTOR COIL TECHNOLOGY FOR HEP HIGH FIELD MAGNETS *E. BARZI,* ***A. BARTALESI****, V. LOMBARDO, M. LAMM, D. TURRIONI, A. V. ZLOBIN;* FERMILAB. — THE FINAL BEAM COOLING STAGES OF A MUON COLLIDER MAY REQUIRE DC SOLENOID MAGNETS WITH MAGNETIC FIELDS OF 40-50 T. IN THIS PAPER WE PRESENT PROGRESS IN COIL TECHNOLOGY DEVELOPMENT USING COMMERCIALLY AVAILABLE $YBA_2CU_3O_{7-\Delta}$ COATED CONDUCTOR. THIS DEVELOPMENT INCLUDED THIN SMALL COILS USED FOR TEMPERATURE DEPENDENCE STUDIES IN A 49 MM VARIABLE TEMPERATURE INSERT AND LARGER ONES TO FIT A 14 T, 77 MM BORE MAGNET. THE LATTER INCLUDE ALSO DOUBLE PANCAKES TESTED IN LIQUID HELIUM UP TO 14 T WITHIN A MODULAR INSERT TEST FACILITY (ITF). TECHNOLOGICAL ASPECTS COVERED IN THE DEVELOPMENT INCLUDE TURN TO TURN INSULATION, COIL IMPREGNATION AND COIL MANUFACTURING AND TESTING. IN ORDER TO WIND THICKER COILS, A DEDICATED WINDING FIXTURE HAS BEEN SPECIFICALLY DESIGNED FOR THE CO-WINDING OF CONDUCTOR AND INSULATION. TEST RESULTS OF DOUBLE PANCAKE COILS OPERATED IN LIQUID NITROGEN AND LIQUID HELIUM ARE PRESENTED AND COMPARED WITH THE PERFORMANCE OF VIRGIN $YBA_2CU_3O_{7-\Delta}$ TAPE.

3LP2C-01

MAGNETIC FIELD MEASUREMENTS OF AN HTS RETROFIT SYNCHROTRON DIPOLE ***J. F. MURATORE***[1]*, J. ESCALLIER*[1]*, G. GANETIS*[1]*, A. GHOSH*[1]*, R. GUPTA*[1]*, P. HE*[1]*, A. JAIN*[1]*, P. JOSHI*[1]*, P. WANDERER*[1]*, M. CHRISTIAN*[2]*, M. FEE*[2]*;* [1]BROOKHAVEN NATIONAL LABORATORY, [2]HTS-110 LTD, NEW ZEALAND. — A COPPER COIL DIPOLE MAGNET FROM THE NATIONAL SYNCHROTRON LIGHT SOURCE (NSLS) AT BROOKHAVEN NATIONAL LABORATORY (BNL) HAS BEEN RETROFITTED BY HTS-110 LTD WITH COILS MADE FROM BI-2223 WIRE AND A SELF-CONTAINED CRYOGENIC COOLING SYSTEM, WHILE KEEPING THE MAGNET'S ORIGINAL IRON YOKE. THIS MODIFIED BENDING DIPOLE, WHICH IS THE FIRST SUCH KNOWN RETROFIT HTS-BASED ACCELERATOR MAGNET, PROVIDES THE BENEFITS OF A COMPACT COIL DESIGN TO ACCOMMODATE SPACE-LIMITED EXPERIMENTAL ISSUES AND A SIGNIFICANT REDUCTION IN POWER COSTS COMPARED TO THE PREVIOUS COPPER MAGNET. IN ORDER TO VALIDATE THIS MODIFIED DESIGN FOR USE IN THE SYNCHROTRON, A DETAILED MAGNETIC FIELD MAP HAS BEEN MEASURED USING A MULTIPLE-HALL PROBE ASSEMBLY AND TRANSPORTER SYSTEM. THE RESULTS ARE DISCUSSED IN THIS PAPER, ALONG WITH THE PERFORMANCE OF THE CLOSED CIRCUIT CRYOGENICS SYSTEM IN KEEPING THE COILS BELOW 45K.

3LP2C-02

FABRICATION AND TEST OF HELICAL SOLENOID SHORT MODEL BASED ON YBCO TAPE ***M. YU***[1]*, M. L. LOPES*[1]*, V.*

LOMBARDO[1], M. A. TARTAGLIA[1], A. V. ZLOBIN[1], E. BARZI[1], N. ANDREEV[1], V. S. KASHIKHIN[1], M. J. LAMM[1], R. P. JOHNSON[2], M. TURENNE[2], S. KAHN[2]; [1]FERMILAB, [2]MUONS INC.. — THE HELICAL COOLING CHANNEL (HCC) IS A NEW TECHNIQUE PROPOSED FOR SIX-DIMENSIONAL (6D) COOLING OF MUON BEAMS. IT IS BASED ON A CONTINUOUS ABSORBER INSIDE SUPERCONDUCTING MAGNETS THAT PROVIDE SUPERIMPOSED SOLENOID, HELICAL DIPOLE, AND HELICAL GRADIENT FIELD COMPONENTS. THE HCC FOR MUON COLLIDER AND SOME OTHER APPLICATIONS IS USUALLY DIVIDED INTO SEVERAL SECTIONS EACH WITH PROGRESSIVELY STRONGER FIELDS, SMALLER APERTURE, AND SHORTER HELIX PERIOD TO ACHIEVE THE OPTIMAL MUON COOLING RATE. THE LEVEL OF MAGNETIC FIELD IN THE HCC HIGH-FIELD SECTIONS SUGGESTS USING A HYBRID COIL STRUCTURE WITH HIGH TEMPERATURE SUPERCONDUCTORS (HTS) IN THE INNERMOST COIL LAYERS AND TRADITIONAL LOW TEMPERATURE SUPERCONDUCTORS (LTS) IN THE OUTER COIL LAYERS. THE DEVELOPMENT OF THE CONCEPTS AND ENGINEERING DESIGNS OF HYBRID HELICAL SOLENOIDS BASED ON ADVANCED SUPERCONDUCTOR TECHNOLOGIES, WITH SPECIAL EMPHASIS ON THE USE OF HTS FOR HIGH FIELDS AT LOW TEMPERATURE IS THE KEY STEP TOWARDS A PRACTICAL HCC. THIS PAPER IS FOCUSING ON DEVELOPING THE DESIGN AND FABRICATION TECHNOLOGY OF HTS HELICAL SOLENOID SHORT MODEL USING 12-MM WIDE YBCO TAPE. BOTH SINGLE DOUBLE-PANCAKE COIL AND FOUR-COIL HELICAL MODEL WERE FABRICATED AND TESTED, AND THE RESULTS WERE COMPARED AND DISCUSSED.

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3LP2C-03

EVALUATION OF PULSED-FIELD MAGNETIZATION ON A SUPERCONDUCTING BULK MAGNET SYSTEM USING A 13 K REFRIGERATOR ***K. YOKOYAMA[1]**, T. OKA[2], K. NOTO[3];* [1]ASHIKAGA INSTITUTE OF TECHNOLOGY, [2]NIIGATA UNIVERSITY, [3]IWATE UNIVERSITY. — WE DEVELOPED A SMALL-SUPERCONDUCTING BULK MAGNET SYSTEM USING A 13 K REFRIGERATOR. THE INDUSTRIAL APPLICATIONS OF BULK MAGNETS DEMAND THE MINIATURIZATION OF THE MAGNET APPARATUS AS WELL AS THE ENHANCEMENT OF THE MAGNETIC FIELD. A GIFFORD-MCMAHON CYCLE HELIUM REFRIGERATOR WITH THE ULTIMATE TEMPERATURE OF 13 K AT THE 2ND STAGE WAS ADOPTED, AND A GDBA2CU3O7-X BULK MATERIAL OF 60 MM DIAMETER AND 20 MM THICKNESS REINFORCED BY A STAINLESS STEEL RING WAS LOCATED ON A COLD STAGE. THE TOTAL LENGTH OF THE MAGNETIC POLE WAS 570 MM INCLUDING THE REFRIGERATOR, THEREFORE, THE SYSTEM COULD EASILY BE MANAGED. WHEN A MAGNETIZING TEST ON THE ULTIMATE TEMPERATURE OF 14.5 K WAS CARRIED OUT, THE TRAPPED FIELD REACHED 2.76 T AT AN APPLIED FIELD OF 7.74 T. IN THIS PAPER, WE EVALUATE THE MAGNETIZATION PERFORMANCE WHEN CHANGING THE INITIAL TEMPERATURE OF BULK MATERIAL AND THE AMPLITUDE OF APPLIED-FIELD, TO IMPROVE THE TRAPPED FIELD. WE SUCCEED THE TRAPPED FIELD OF OVER 3 T.

3LP2C-04

DESIGN OF A HTS MAGNET FOR THE STUDY OF RESONANT X-RAY SCATTERING *Y. T. YU[1], S. D. CHEN[2], Z. W. HUANG[3], J. C. JAN[4],* ***C. S. HWANG[4]**, I. G. CHEN[5], C. H. DU[6];* [1]GRADUATE PROGRAM FOR SCIENCE AND TECHNOLOGY OF ACCELERATOR LIGHT SOURCE, NATIONAL CHIAO-TUNG UNIVERSITY,TAIWAN, [2]DEPARTMENT OF ELECTORPHYSICS COLLEGE OF SCIENCE, NATIONAL CHIAO-TUNG UNIVERSITY,TAIWAN, [3]DEPARTMENT OF PHYSICS, NATIONAL TSING HUA UNIVERSITY HSINCHU 30043, TAIWAN, [4]NATIONAL SYNCHROTRON RADIATION RESEARCH CENTER, [5]DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING, NATIONAL CHENG KUNG UNIVERSITY,TAIWAN, [6]DEPARTMENT OF PHYSICS, TAMKANG UNIVERSITY,TAIWAN. — FOR MATERIAL RESEARCH, THE CHARACTERISTICS OF NOVEL MATERIALS ARE ESPECIALLY AFFECTED BY A CHANGING ENVIRONMENT. A SPECIAL MAGNET WITH A POWERFUL MAGNETIC FIELD WILL THEREFORE BE DEVELOPED FOR A RESONANT X-RAY SCATTERING EXPERIMENTAL STATION TO STUDY THE FEATURES OF MATERIALS. THE SPECIAL MAGNET WILL BE DEVELOPED WITH HIGH-TEMPERATURE SUPERCONDUCTOR (HTS) BULKS; THESE $BA_2CU_3O_7$ BULKS WILL BE MAGNETIZED WITH A HTS COIL MAGNET THAT WILL BE FABRICATED FROM 2G HTS WIRE. THE HTS (RE)BCO WILL BE SELECTED FOR THE COIL CONSTRUCTION OF THE HTS COIL MAGNET. THE HTS BULK MAGNET AND THE HTS COIL MAGNET WILL BE ASSEMBLED ON THE SAME MOVABLE SYSTEM. THE HTS BULK MAGNET WILL PROVIDE OVER 3 T WITH A MAGNET GAP 50 MM THAT CAN ACCOMMODATE THE VACUUM CHAMBER OF THE EXPERIMENTAL STATION. THE HTS BULK AND THE HTS COIL MAGNETS WILL BE COOLED TO 68 K WITH A CRYOCOOLER; THE HTS COIL MAGNET IS SEPARABLE FROM THE HTS BULK MAGNET AFTER THE FIELD IS TRAPPED. IN THIS REPORT WE DESCRIBE THE OVERALL DESIGN OF THE MAGNETIC CIRCUIT OF THE HTS BULK AND THE HTS COIL MAGNETS, AND THE COOLING ALGORITHM OF THE WHOLE MAGNETS SYSTEM.

THIS WORK WAS SUPPORTED BY THE NATIONAL SCIENCE COUNCIL OF TAIWAN.

3LP2C-05

EXPERIMENTAL TEST AND NUMERICAL ANALYSIS TO ESTIMATE FOR PERMISSIBLE TRANSPORT CURRENT CONSIDERING PROTECTION OF HIGH-TC SUPERCONDUCTING TAPES IN ADIABATIC CONDITION ***Y. KIM[1]**, D. PARK[2], K. CHANG[1], M. AHN[3], T. KO[1];* [1]YONSEI UNIVERSITY, [2]MESSACHUSETTS INSTITUTE OF TECHNOLOGY, [3]KUNSAN NATIONAL UNIVERSITY. — IN RECENT YEARS, HIGH-TC SUPERCONDUCTING (HTS) TAPE SHOWS GOOD PROSPECTS AS A CONDUCTOR OF HIGH FIELD MAGNET. THIS CONDUCTOR HAS MORE CURRENT CARRYING CAPABILITY IN HIGH MAGNETIC FIELD AND ALSO HAS MORE STABILITY IN CRYOGENIC ENVIRONMENT THAN LOW TEMPERATURE SUPERCONDUCTING (LTS) WIRES. BUT THE HTS TAPE HAS

SLOWER NORMAL ZONE PROPAGATION (NZP) VELOCITY WHICH LEADS DIFFICULTIES IN PROTECTION OF MAGNET BECAUSE THE LOW NZP VELOCITY CAN EASILY INDUCE LOCAL HEAT ACCUMULATION WHICH RESULTS IN EXCESSIVE TEMPERATURE INCREMENT AND PERMANENT DAMAGE TO THE MAGNET. THIS PAPER PRESENTS EXPERIMENTAL TEST AND NUMERICAL ANALYSIS ABOUT PERMISSIBLE TRANSPORT CURRENT FOR HTS TAPES WHILE AN UNEXPECTED NORMAL ZONE IS PRODUCED. THE SAMPLES WHICH CONTAINS STACK OF HTS TAPES WERE FABRICATED AND NI-CR HEATER WAS INSERTED TO INITIATE NORMAL ZONE. FROM THE EXPERIMENTAL RESULTS, AN ANALYTICAL MODEL WAS ALSO FABRICATED TO PREDICT TRANSIENT TEMPERATURE TRACES. IN THIS PAPER, WE DERIVED PERMISSIBLE TRANSPORT CURRENT CONSIDERING MAGNET PROTECTION AND EVALUATED A POSSIBILITY THAT THIS PERMISSIBLE TRANSPORT CURRENT COULD BE APPLICABLE TO THE REAL HTS MAGNET APPLICATIONS FROM THESE EXPERIMENTAL TESTS AND NUMERICAL ANALYSIS.

THIS RESEARCH WAS SUPPORTED BY NATIONAL RESEARCH LAB. PROGRAM THROUGH THE KOREA SCIENCE AND ENGINEERING FOUNDATION FUNDED BY THE MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY (R0A-2007-000-20063-0).

3LP2C-06

SMES DESIGN USING HTS RIBBONS ***J. G. REY***[1]*, P. TIXADOR*[2]*, T. LACREVISSE*[1]*, M. BRUCHON*[1]*, J. GHELLER*[1]*, O. LOUCHARD*[1]*, O. LOUCHARD*[1]*;* [1]CEA, [2]UJF GRENOBLE 1. — **SMES DESIGN USING HTS RIBBONS**SMES DEVICES ARE AN ATTRACTIVE SOLUTION FOR PULSED CURRENT SOURCES. THE SPECIFIC STORED ENERGY IS MODERATE THEREFORE IT HAS TO BE IMPROVED. HTS MATERIALS OFFER OPPORTUNITIES IN TERMS OF CURRENT CARRYING CAPABILITIES AS WELL AS MECHANICAL STRENGTH.THE SPECIFIC MAGNETIC STORAGE CAPABILITY IS PRESENTED AS A FUNCTION OF THE ASPECT RATIO OF SOLENOID. OPTIMIZATION IS DISCUSSED WITH RESPECT TO THE CHOICE OF SUPERCONDUCTING TAPES TO BE USED AS CONDUCTORS AND OPERATING TEMPERATURE.

3LP3A-02

MGB_2 SUPERCONDUCTIVE INSERTS: MANUFACTS BETWEEN BULK AND WIRES ***G. GIUNCHI****;* EDISON SPA. — A NEW SERIE OF SUPERCONDUCTIVE MANUFACTS IS PRESENTED. WITH THE AIM TO GROWTH HTS MATERIAL INSIDE GROOVED SUBSTRATES, IT HAS BEEN DISCOVERED THAT THE MGB_2 MATERIAL CAN BE USED IN A VERY CONVENIENT AND VERSATILE WAY FOR THIS KIND OF MANUFACTS. APPLYING THE WELL ESTABLISHED LIQUID MG INFILTRATION TECHNOLOGY, TO PRODUCE MGB_2, WE PREPARE LARGE PLATES, CYLINDERS, BARS, DECORATED BY DIFFERENT SHAPES OF SUPERCONDUCTIVE INSERTS MADE BY MGB_2 STRIPS. THE SUBSTRATE MATERIAL OF THE INSERT CAN BE VARIED ACCORDING TO THE NEEDS. THE SUPERCONDUCTIVE INSERTS IN METALLIC SUBSTRATES (SIMS) SHOW A MECHANICAL ROBUSTNESS VERY USEFUL FOR BRITTLE CERAMIC LIKE HTS SUPERCONDUCTORS. THE SUPERCONDUCTING BEHAVIOUR OF THE MGB_2-SIMS ACCOUNTS FOR THE ADVANTAGES OF THE BULKS AND OF THE WIRES MANUFACTS TOGETHER.THE SUPERCONDUCTING CHARACTERISTICS OF THE SIMS HAVE BEEN CHECKED BY TRANSPORT AND MAGNETIZATION MEASUREMENTS, AND THE CRITICAL CURRENT DENSITY HAS THE VALUES TYPICAL OF THE WELL SINTERED MGB_2 BULK MANUFACTS. THE FIRST OUTSTANDING APPLICATIONS OF SIMS CAN BE MAGNETIC SHIELDS, CURRENT LEADS AND SUPERCONDUCTING PERMANENT MAGNETS.

EDISON SPA ACKNOWLEDGES THE CNR-IENI LABORATORY IN LECCO , FOR ITS HELP IN THE MATERIALS MANUFACTURING

3LP3A-03

FABRICATE MGB_2 BULKS WITH DIFFERENT MASS DENSITY ***S. ZHOU****, R. ZENG, L. LU, S. DOU;* UNIVERSITY OF WOLLONGONG. — **FABRICATE MGB_2 BULKS WITH DIFFERENT MASS DENSITY**A DIRECT MG-DIFFUSION METHOD WAS USED TO MAKE MGB_2 BULKS OF DIFFERENT MASS DENSITY. CRYSTALLINE B POWDERS WERE MIXED WITH DIFFERENT AMOUNT OF MG POWDERS IN THE FORMULA OF $MG_{1-X}B_2$ WHERE X IS 1, 0.75, 0.5, 0.25, AND 0. AFTER THEY WERE MADE INTO PELLETS, THE PELLETS WERE LOADED INTO IRON TUBES. THE TUBES WERE FILLED WITH THE CORRESPONDING AMOUNT OF MG POWDERS IN THE FORMULA OF MG: ($MG_{1-X}B_2$) =X:1, SO THE MG POWDER CAN JUST ADD UP TO THE FORMULA OF MGB_2 AFTER THE REACTION EVENTUALLY. THE SAMPLES WERE SINTERED AT 850°C FOR 1 TO 10 HRS, WHERE A FLOW OF HIGH PURITY ARGON GAS WAS MAINTAINED, AND THEN COOLED TO ROOM TEMPERATURE BY NATURAL COOLING.IT WAS FOUND THAT THE CONNECTIVITY WAS SIGNIFICANTLY IMPROVED, SINCE THE EFFECTIVE AREA (A_F) INCREASED FROM 0.135 (CONVENTIONAL IN-SITU) TO 0.42 (DIFFUSION), HENCE THE SELF-FIELD CRITICAL CURRENT DENSITY, J_C, IS SIGNIFICANTLY IMPROVED COMPARED WITH CONVENTIONAL POROUS MGB_2 BULKS MADE BY THE IN-SITU METHOD. BOTH *A*- AND *C*-AXIS LATTICE PARAMETERS OF DIFFUSION SAMPLES ARE LARGER THAN THOSE OF THE IN-SITU SAMPLES, AND THE T_C OF THE DIFFUSION SAMPLES IS HIGHER THAN FOR THE IN-SITU SAMPLES.THE J_C OF DIFFUSION SAMPLES WAS SIGNIFICANTLY IMPROVED OVER THE WHOLE TEMPERATURE AND FIELD RANGE. SAMPLES REACTED AT 850 °C FOR 10 HRS EXHIBITED J_C OF 1.2 MA/CM^2 AT 20 K IN SELF-FIELD

3LP3A-04

A NOVEL DESIGNING OF THE THERMALLY ACTUATED MAGNETISATION FLUXPUMP FOR HIGH TEMPERATURE SUPERCONDUCTING BULKS ***Y. YAN***[1]*, C. HSU*[1]*, Z. HONG*[1]*, Y. MURATA*[2]*, W. YUAN*[1]*, W. XIAN*[1]*, T. COOMBS*[1]*;* [1]SUPERCONDUCTIVITY GROUP, ENGINEERING DEPARTMENT, UNIVERISITY OF CAMBRIDGE, [2]HITACHI, LTD, JAPAN. — HIGH TEMPERATURE SUPERCONDUCTORS, SUCH AS THE MELT-PROCESSED YBCO BULKS, HAVE GREAT ADVANTAGES ON TRAPPING STRONG MAGNETIC FIELDS IN LIQUID NITROGEN. TO ENABLE THEM TO FUNCTION WELL, THERE ARE SOME TRADITIONAL WAYS OF MAGNETISATION, IN WHICH THE YBCO BULKS ARE MAGNETISED INSTANTLY UNDER A VERY STRONG SOURCE OF MAGNETIC FIELD. THESE WAYS CONSUME GREAT

AMOUNTS OF POWER TO MAKE THE SUPERCONDUCTORS TRAP AS MUCH FIELD AS POSSIBLE. HOWEVER, THERMALLY ACTUATED MAGNETISATION (TAM) FLUXPUMP HAS BEEN PROVED A PERFECT SUBSTITUTION FOR THESE EXPENSIVE METHODS BY USING JUST NORMAL PERMANENT MAGNETS AS THE FIELD SOURCE. IN THIS WAY, THE FIELD IS FORMED GRADUALLY OVER MANY PULSES. UNLIKE OTHER FLUXPUMPS, THE TAM WILL NOT MAKE THE SUPERCONDUCTOR NORMAL DURING THE PROCESS OF MAGNETISATION. IN FORMER EXPERIMENTS, THE INTERMEDIA MATERIALS INCLUDE PRUSSIAN BLUE, NDFEB AND GADOLINIUM. IN THE NEW EXPERIMENT SYSTEM, OTHER MATERIALS, SUCH AS DYSPROSIUM AND FERRITE CORES, ARE USED TO GET BETTER PERFORMANCES. THIS PAPER WILL DEMONSTRATE THE NEW DESIGNING OF THE TAM FLUXPUMP AND THE PROPERTY OF THE NEWLY ADOPTED MATERIALS. BECAUSE THE FERRITE CORES THAT WE MADE ACCORDING TO CERTAIN RECIPES HAVE LARGER GRADIENTS IN THE PERMEABILITY-TEMPERATURE CURVE, THE THERMAL WAVES TRAVELLING INWARDS WILL GIVE MORE EFFECTIVE MAGNETIC WAVES AT THE CURIE POINT, LEADING TO A STRONGER ACCUMULATION OF THE FIELD TRAPPED BY THE YBCO BULK.

3LP3A-05

METHODS OF PATTERNING MAGNETIC FIELDS USING BULK SUPERCONDUCTORS ***T. A. COOMBS****, Z. HONG, Y. YAN;* CAMBRIDGE UNIVERSITY. — HIGH TEMPERATURE SUPERCONDUCTORS ARE ABLE TO CARRY VERY HIGH CURRENT DENSITIES, AND THEREBY SUSTAIN VERY HIGH MAGNETIC FIELDS. THERE ARE MANY PROJECTS WHICH USE THE FIRST PROPERTY AND THESE HAVE CONCENTRATED ON POWER GENERATION, TRANSMISSION AND UTILIZATION, HOWEVER THERE ARE RELATIVELY FEW WHICH ARE CURRENTLY EXPLOITING THE ABILITY TO SUSTAIN HIGH MAGNETIC FIELDS. THERE ARE TWO MAIN REASONS FOR THIS: HIGH FIELD WOUND MAGNETS CAN AND HAVE BEEN MADE FROM BOTH BSCCO AND YBCO BUT CURRENTLY THEIR COST IS MUCH HIGHER THAN THE ALTERNATIVE PROVIDED BY LOW TC MATERIALS SUCH AS NB3SN AND NBTI. AN ALTERNATIVE FORM OF THE MATERIAL IS THE BULK FORM WHICH CAN BE MAGNETISED TO HIGH FIELDS AND USING FLUX PUMPING THIS CAN BE DONE IN SITU. THIS PAPER EXPLORES SOME OF THE APPLICATIONS OF BULK SUPERCONDUCTORS AND DESCRIBES METHODS OF PRODUCING FIELD PATTERNS INCLUDIN THE HIGHLY UNIFORM MAGNETIC FIELDS REQUIRED FOR MRI AND THE SINUSOIDAL FIELDS REQUIRED FOR PERMANENT MAGNET MOTORS AND GENERATORS.

3LP3A-06

MICROSTRUCTURE AND PROPERTIES OF SINGLE GRAINS OF Y-BA-CU-O CONTAINING Y-2411(M) AND Y_2O_3 ***Y. SHI****, A. DENNIS, S. PATHAK, D. CARDWELL;* UNIVERSITY OF CAMBRIDGE. — Y-BA-CU-O (YBCO) SINGLE GRAINS HAVE THE POTENTIAL TO GENERATE LARGE TRAPPED MAGNETIC FIELDS FOR ENGINEERING APPLICATIONS, AND RESEARCH ON THE PROCESSING AND PROPERTIES OF THIS MATERIAL HAS ATTRACTED INTEREST WORLD-WIDE OVER THE PAST 20 YEARS. IN PARTICULAR, THE INTRODUCTION OF FLUX PINNING CENTRES TO THE LARGE GRAIN MICROSTRUCTURE TO IMPROVE ITS CURRENT DENSITY J_C, AND HENCE TRAPPED FIELD, HAS BEEN INVESTIGATED EXTENSIVELY. $Y_2BA_4CUMO_X$ [Y-2411(M)], WHERE M = NB, TA, MO, W, RU, ZR, BI AND AG, HAS BEEN DISCOVERED RECENTLY TO FORM VERY EFFECTIVE FLUX PINNING CENTRES DUE PRIMARILY TO ITS ABILITY TO FORM NANO-SIZE INCLUSIONS IN THE SUPERCONDUCTING PHASE MATRIX. HOWEVER, THE ADDITION OF THE Y-2411(M) PHASE TO THE PRECURSOR COMPOSITION COMPLICATES THE MELT-PROCESSING OF SINGLE GRAINS. THE ADDITION OF Y_2O_3 TO THE PRECURSOR COMPOSITION, HOWEVER, BROADENS THE GROWTH WINDOW OF SINGLE YBCO GRAINS CONTAINING Y-2411 (M). WE REPORT AN INVESTIGATION OF THE MICROSTRUCTURES AND SUPERCONDUCTING PROPERTIES OF SINGLE GRAINS OF THIS COMPOSITION GROWN BY TOP SEEDED MELT GROWTH (TSMG).

3LP3A-07

MAGNETIZATION NONLINEARITY OF YBA2CU3O7-X ABOVE THE SUPERCONDUCTING TRANSITION TEMPERATURE ***N. D. KUZMICHEV****[1], V. V. SLAVKIN[2], E. A. TISHCHENKO[3];* [1]MACHINE-BUILDING INSTITUTE, [2]SARANSK COOPERATIVE INSTITUTE, RUSSIAN UNIVERSITY OF COOPERATION, [3]KAPITZA INSTITUTE OF PHYSICAL PROBLEMS. — **MAGNETIZATION NONLINEARITY OF YBA CU O 2 3 7-X** **ABOVE THE SUPERCONDUCTING TRANSITION TEMPERATURE**V. V. SLAVKIN[A], N. D. KUZ'MICHEV[B] AND E. A. TISHCHENKO[D] [A] SARANSK COOPERATIVE INSTITUTE, RUSSIAN UNIVERSITY OF COOPERATION, SARANSK, 430027 RUSSIA[B] OGAREV MORDOVIAN STATE UNIVERSITY, SARANSK, 430000 RUSSIA[D] KAPITZA INSTITUTE OF PHYSICAL PROBLEMS, MOSCOW, 119991 RUSSIAE-MAIL: KUZMICHEVND@RAMBLER.RUTEMPERATURE DEPENDENCES OF THE MAGNETIZATION HARMONICS OF $YBA_2CU_3O_{7-X}$ MONODOMAIN SAMPLES ARE STUDIED EXPERIMENTALLY AT TEMPERATURES OF 77 - 120 K. IT IS FOUND THAT NONLINEARITY OF MAGNETIZATION OF $YBA_2CU_3O_{7-X}$ (HIGHER HARMONICS GENERATION) IS OBSERVED UP TO TEMPERATURES T = 103 - 112 K, WHICH ARE MUCH HIGHER THAN THE SUPERCONDUCTING TRANSITION TEMPERATURE OF THIS COMPOUND. AT THE SAME TEMPERATURES, THE TEMPERATURE DEPENDENCE OF RESISTIVITY BEGINS TO DEVIATE FROM LINEARITY. THE OBSERVED SINGULARITY OF THE MAGNETIZATION OF $YBA_2CU_3O_{7-X}$ IS ASSOCIATED WITH THE EMERGENCE OF A PSEUDOGAP STATE IN THIS COMPOUND.

3LP3A-08

EVALUATION OF STABILITY IN ACTIVE MAGNETIC LEVITATION USING SPHERICAL HTS BULK FOR INERTIAL NUCLEAR FUSION ***T. WANG****, H. UEDA, K. AGATSUMA, A. ISHIYAMA;* WASEDA UNIVERSITY. — WE HAVE BEEN DEVELOPING AN ACTIVE MAGNETIC LEVITATION SYSTEM, WHICH IS COMPOSED OF A FIELD-COOLED SPHERE-SHAPED HIGH-TEMPERATURE SUPERCONDUCTING BULK (HTS BULK) AND VERTICALLY PILED RING-SHAPED ELECTROMAGNETS. WE SUPPOSE THAT THIS ACTIVE MAGNETIC LEVITATION SYSTEM CAN BE APPLIED TO INERTIAL NUCLEAR FUSION. IN INERTIAL NUCLEAR FUSION, ONE OF THE MOST IMPORTANT ISSUES IS TO ACHIEVE HIGH-

ACCURACY POSITION CONTROL OF THE FUSION FUEL, WHICH CONSISTS OF DEUTERIUM AND TRITIUM IN ORDER TO EVENLY ILLUMINATE THE ENTIRE SURFACE OF THE TARGET. THEREFORE, ACTIVE MAGNETIC LEVITATION IS APPLIED TO THE STABLE LEVITATION AND ACCURATE POSITION CONTROL OF A SPHERE-SHAPED SUPERCONDUCTING CAPSULE CONTAINING NUCLEAR FUSION FUEL. IN THIS STUDY, WE DESIGNED AND CONSTRUCTED A POSITION CONTROL SYSTEM IN ORDER TO ACHIEVE THE STABLE LEVITATION OF A SPHERE-SHAPED HTS BULK BY USING THE NUMERICAL SIMULATION BASED ON 3-D HYBRID FINITE ELEMENT AND BOUNDARY ELEMENT ANALYSIS. THEN, WE CARRIED OUT THE EXPERIMENTS ON THE EVALUATION OF LEVITATION CHARACTERISTICS OF A SPHERE-SHAPED HTS BULK WITH A DIAMETER OF 5 MM IN THE CONSTRUCTED SYSTEM.

3LP3A-09

EVALUATION OF HYSTERESIS LOSS OF A QMG COIL MAGNET FOR PULSED CURRENT ***M. TSUCHIMOTO****;* HOKKAIDO INSTITUTE OF TECHNOLOGY. — A QMG COIL MAGNET IS AN APPLICATION OF AN OXIDE BULK HIGH T_C SUPERCONDUCTOR (HTS) FOR A HIGH FIELD APPLICATION. THE QMG IS A HIGH J_C BULK MATERIAL, WHICH CONSISTS OF SINGLE CRYSTALLINE 123 WITH FINELY DISPERSED 211. THE QMG COIL WITH 8 TURNS IS MADE FROM A SLICE OF AG DOPED GD-BA-CU-O QMG BY USING PRECISE MACHINING TECHNIQUES. THE MAGNET IS MADE FROM 6 LAYERS AND 11 TURNS OF THE QMG COIL. INNER AND OUTER DIAMETERS OF THE COIL ARE 13.0MM AND 74.0MM. THE WIDTH AND THE THICKNESS OF ONE TURN ARE 2.3MM AND 1.0MM, AND THE GAP BETWEEN EACH TURN IS 0.5MM. THE HYSTERESIS LOSS OF EXPERIMENTAL RESULT IN 54 K IS NUMERICALLY ANALYZED WITH AN AXISYMMETRIC MODEL, WHERE THE SUPERCONDUCTIVE CHARACTERISTIC IS EVALUATED WITH CRITICAL STATE MODEL. THE APPLIED CURRENT IS LINEARLY INCREASED FROM ZERO TO 700 A IN 0.5 S, AND KEEP CONSTANT 1.0 S, THEN LINEARLY DECREASED FROM 700 A TO ZERO IN THE EXPERIMENT. DIFFERENCES OF THE HYSTERESIS LOSS AMONG THE INCREASING, THE DECREASING AND THE REPULSED CASES ARE DISCUSSED WITH FIELD PROFILE AND CURRENT DISTRIBUTIONS.

3LP3A-10

MAGNETIC SHIELDING CHARACTERISTICS OF ARRAYED AND STACKED BULK SUPERCONDUCTORSFOR HIGHER FIELD APPLICATIONS ***Y. TERAO****[1], M. SEKINO[1], H. OHSAKI[1], H. TESHIMA[2], M. MORITA[2];* [1]THE UNIVERSITY OF TOKYO, [2]NIPPON STEEL CORPORATION. — HIGH PERFORMANCE (RE)BACUO BULK SUPERCONDUCTORS ARE AVAILABLE NOW, AND THE CRITICAL CURRENT DENSITY HAS REACHED 10^9 A/M^2 EVEN AT 77 K AND 3 T. BULK SUPERCONDUCTORS CAN BE USED AS STRONG MAGNETIC FLUX SOURCES AND MAGNETIC SHIELDING MATERIALS AT LOW TEMPERATURES. FOR LARGE-AREA MAGNETIC SHIELDING, MULTIPLE BULK SUPERCONDUCTORS ARE ARRANGED SIDE BY SIDE AND STACKED IN LAYERS. AT LOWER TEMPERATURES THE CRITICAL CURRENT DENSITY INCREASES AND MAGNETIC SHIELDING PROPERTIES BECOMES MUCH BETTER. BUT MAGNETIC FIELD PENETRATION NEAR THE BOUNDARIES OF EACH BULK SUPERCONDUCTOR COMPONENT INFLUENCES OVERALL MAGNETIC SHIELDING CHARACTERISTICS. MAGNETIC SHIELD EXPERIMENTS ARE PERFORMED USING A SIMPLE CYLINDRICAL BULK AND MULTIPLE SQUARE BULK SUPERCONDUCTORS PLACED IN A BORE OF A SUPERCONDUCTING COIL. FEM ANALYSIS BASED ON A CRITICAL STATE MODEL OF SUPERCONDUCTOR IS ALSO CARRIED OUT TO COMPARE ITS RESULTS WITH THE EXPERIMENTAL ONES AND TO BUILD AN ANALYSIS MODEL OF LARGE-AREA MAGNETIC SHIELD USING MULTIPLE BULK SUPERCONDUCTORS. MAIN TARGETS OF SUCH LARGE-AREA MAGNETIC SHIELDING ARE MAGNETIC FIELD SHAPING FOR HIGHER FIELD APPLICATIONS.

3LP3A-11

CONCENTRIC SLITTING OF A RING-SHAPED BULK SUPERCONDUCTOR FOR A REDUCTION IN CIRCUMFERENTIAL INHOMOGENEITY OF THE TRAPPED MAGNETIC FIELD ***M. SEKINO****, H. YASUDA, H. OHSAKI;* THE UNIVERSITY OF TOKYO. — MAGNETIC FIELD TRAPPED IN A SUPERCONDUCTING BULK MAGNET HAS NON-NEGLIGIBLE INHOMOGENEITY RESULTING FROM NON-UNIFORM SUPERCONDUCTING PROPERTIES. COUNTERACTING THE INHOMOGENEITY IS ONE OF THE CHALLENGING PROBLEMS IN APPLICATIONS OF BULK MAGNETS TO NMR. IN THIS STUDY, WE FABRICATED A BULK MAGNET COMPOSED OF FOUR PIECES OF CONCENTRICALLY ARRANGED BULK SUPERCONDUCTORS WITH DIFFERENT DIAMETERS, FOR TRAPPING A FIELD WITH REDUCED CIRCUMFERENTIAL INHOMOGENEITY. A GDBACUO SUPERCONDUCTOR, 22 MM IN INNER DIAMETER AND 60 MM IN OUTER DIAMETER, WAS SLICED WITH A THICKNESS OF 2 MM. THREE EQUALLY-SPACED CONCENTRIC SLITS WERE FORMED USING A SANDBLAST MACHINE. THE MAGNETS WERE COOLED WITH LIQUID NITROGEN IN AN EXTERNAL FIELD OF 600 MT. THE Z-COMPONENT OF TRAPPED FIELD WAS MEASURED ALONG CIRCULAR TRAJECTORIES. THE MAXIMUM INTENSITY OF TRAPPED FIELD WAS ABOVE 200 MT. THE MAGNET WITH SLITS EXHIBITED SMALLER INHOMOGENEITIES OF FIELDS COMPARED WITH AN EQUAL-SIZED ONE WITHOUT SLIT. ON A TRAJECTORY 30 MM IN DIAMETER, THE FIELD INHOMOGENEITIES OF MAGNETS WITH AND WITHOUT SLITS WERE 7 % AND 11 %, RESPECTIVELY. ON A 13-MM TRAJECTORY, THE SLITS RESULTED IN THE REDUCTION OF INHOMOGENEITY FROM 0.9 % TO 0.3 %. THE RESULTS SUGGEST THAT THE SLITS SUPPRESS DISTORTIONS IN LOOP PATHWAYS OF SUPERCONDUCTING CURRENTS.

3LP3B-01

SUPERCONDUCTING MAGNET WITH FOR 400 MHZ NMR ***Q. WANG****;* INSTITUTE OF ELECTRICAL ENGINEERING, CHINESE ACADEMY OF SCIENCES. — A SUPERCONDUCTING MAGNET WITH THE CENTER FIELD OF 9.4 T IS DESIGNED AND FABRICATED FOR THE 400MHZ THE NUCLEAR MAGNETIC RESONANCE. THE SUPERCONDUCTING COIL WITH NBTIWIRE IS COOLED BY RE-CONDENSED LIQUID HELIUM WITH THE CLEAR-BORE OF 54 MM. THE PULSED TUBE REFRIGERATOR WITH SEPARATED VALVE IS EMPLOYED TO COOL THE MAGNET SYSTEM. THE SUPERCONDUCTING MAGNET HAS AN ACTIVE

SHIELD WITH HIGH PURE COPPER SHIELD TO PROTECT. THE PAPER WILL PRESENT THE ELECTROMAGNETIC DESIGN, AND FABRICATED IN DETAILED.

3LP3B-02

EVALUATION OF THE SCREENING CURRENT IN A 1.3 GHZ NMR MAGNET USING REBCO ***A. OTSUKA***[1]*, Y. YANAGISAWA*[2]*, T. KIYOSHI*[3]*, H. NAKAGOME*[2]*, H. MAEDA*[4]*, M. TAKEDA*[5]*;* [1]JAPAN SUPERCONDUCTOR TECHNOLOGY INC., [2]CHIBA UNIVERSITY, [3]NATIONAL INSTITUTE FOR MATERIALS SCIENCE, [4]RIKEN, [5]KOBE UNIVERSITY. — NMR MAGNETS USING HIGH-T_C SUPERCONDUCTORS (HTS) ARE CURRENTLY DESIGNED TO GENERATE HIGH FIELDS EXCEEDING 25 T BY SEVERAL ORGANIZATIONS. IN THE DESIGNS, THE HTS ARE USED FOR THE INNER COILS, AND THE OUTER COILS CONSIST OF NBTI AND NB_3SN WIRES. THE REBCO WIRE WITH HASTELLOY SUBSTRATE HAS EXCELLENT CRITICAL CURRENT PERFORMANCE OVER WIDE RANGE OF MAGNETIC FIELDS AND TOLERATES HIGH TENSILE STRESS UP TO 700 MPA. WE SHOWED THE CONCEPTUAL DESIGNS OF A 1.3 GHZ (30.5 T) NMR MAGNET UNDER THE HOOP STRESS CONDITION OF 500 MPA. ALL OF THEIR MAIN COILS WERE ASSUMED TO USE REBCO WIRES. THE DESIGNS SUGGEST THE POSSIBILITY TO REALIZE MUCH MORE COMPACT AND LIGHT-WEIGHT MAGNETS THAN THE CONVENTIONAL MAGNETS WITH LTS AND HTS. ON THE OTHER HAND, THE PROBLEM OF SCREENING CURRENT INDUCED BY THE PERPENDICULAR FIELD REMAINS TO BE SOLVED. IN THIS STUDY, WE EVALUATE NUMERICALLY THE AMOUNT OF THE MAGNETIC FIELD GENERATED BY THE SCREENING CURRENT IN REBCO COILS. COMPENSATION COILS FOR IMPROVING FIELD HOMOGENEITY WERE FOUND TO REDUCE THE SHIELDING CURRENT BY SEVERAL PERCENT. THE IMPROVED COIL ARRANGEMENT IS REPORTED CONSIDERING THE SHIELDING CURRENT EFFECT.

THIS WORK HAS BEEN SUPPORTED BY S-INNOVATION, JST.

3LP3B-03

THE OPTIMIZATIONS OF THE THICKNESS OF A HTS BULK AND THE GAP LENGTH BETWEEN STACKED HTS BULK FOR COMPACT NMR MAGNETS USING HTS BULK ANNULI ***M. IMAI***[1]*, S. KIM*[1]*, R. TAKANO*[1]*, J. JOO*[1]*, S. HAHN*[2]*;* [1]OKAYAMA UNIVERSITY, [2]FRANCIS BITTER MAGNET LABORATORY, MASSACHUSETTS INSTITUTE OF TECHNOLOGY. — THE PERFORMANCE OF HIGH TEMPERATURE SUPERCONDUCTING (HTS) BULKS SUCH AS A CRITICAL CURRENT DENSITY, SIZE AND MECHANICAL STRENGTH HAS BEEN IMPROVED, AND VARIOUS APPLICATIONS WITH HTS BULKS SUCH AS MOTORS, BEARINGS AND FLYWHEELS ARE BEING INVESTIGATED BY MANY RESEARCH GROUPS; COMPACT NUCLEAR MAGNETIC RESONANCE (NMR) MAGNET IS ONE OF THE NEW APPLICATIONS AFTER A TECHNIQUE TO ENHANCE MAXIMUM TRAPPED FIELD OF AN HTS BULK MORE THAN 11.7 T, 500 MHZ 1H NMR FREQUENCY, HAS BEEN DEVELOPED. THIS NEW COMPACT NMR MAGNET OUT OF THE HTS BULKS IS FAR LESS EXPENSIVE THAN THOSE CONVENTIONAL NMR MAGNETS AND EXPECTED TO BE WIDELY USED IN FOOD AND DRUG INDUSTRY. IN DESIGN AND MANUFACTURE OF THOSE COMPACT NMR MAGNETS, THE ISSUES OF SPATIAL HOMOGENEITY AND TEMPORAL STABILITY OF TRAPPED MAGNETIC FIELDS IN HTS BULK ANNULI ARE VERY IMPORTANT. ON THE OTHER HAND, THE MOUNT OF WHOLE PRODUCT OF THE HTS BULKS IS ALSO VERY IMPORTANT ISSUE FROM ECONOMICAL REASON. IN THIS PAPER, THE OPTIMIZED THICKNESS OF A HTS BULK AND THE GAP LENGTH BETWEEN STACKED HTS BULKS WERE INVESTIGATED EXPERIMENTALLY AND ANALYTICALLY. THE IMPROVED SPATIAL HOMOGENEITY AND STRENGTH OF GENERATED MAGNETIC FIELD BY COMPACT MAGNET STACKED HTS BULK ANNULI WILL BE PRESENTED.

3LP3B-04

DESIGN OF AXIAL SHIM COILS FOR NMR ***Q. WANG****, Z. NI;* INSTITUTE OF ELECTRICAL ENGINEERING, CHINESE ACADEMY OF SCIENCES. — AN EFFICIENT DESIGN METHOD OF AXIAL SUPERCONDUCTING SHIM COILS FOR MRI AND NMR IS PRESENTED. THE AXIAL SUPERCONDUCTING SHIM COILS ARE DESIGNED TO CORRECT MAGNETIC FIELD HOMOGENEITY COMPENSATE FOR THE INEVITABLE ENGINEERING TOLERANCES. IN ORDER TO SIMPLIFY THE DESIGN COMPLEXITY OF SHIM COILS AND ALSO REDUCE THE DIFFICULTY OF ENGINEERING, THREE PAIRS OF SOLENOIDS IN SERIES ARE DESIGNED TO ELIMINATE ALL OF THE LOWER SIX ORDERS OF SPHERICAL HARMONICS (Z1, Z2, Z3, Z4, Z5, AND Z6) FOR ONE TIME. COMPUTER SEARCH METHOD IS EMPLOYED TO OPTIMIZE POSITIONS OF THE SHIM COILS. DETAILS OF THE DESIGN METHOD AND CALCULATION RESULTS ARE PRESENTED.

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3LP3B-05

AN OPTIMAL CONFIGURATION DESIGN OF SUPERCONDUCTING MAGNETS WITH MAGNETIC SHIELDING FOR NMR ***K. YOSHIZAWA****, S. NOGUCHI, H. IGARASHI;* HOKKAIDO UNIVERSITY. — IN THIS STUDY, AN OPTIMAL DESIGN METHOD OF THE SUPERCONDUCTING MAGNETS FOR NMR WHICH GENERATES HIGH MAGNETIC FIELD WITH HIGH HOMOGENEITY IS DESCRIBED. THE MAGNETS WOUND WITH HIGH TEMPERATURE SUPERCONDUCTING (HTS) TAPES NEED MAGNETIC SHIELDING, WHICH DON'T DETERIORATE THE B-J CHARACTERISTIC OF THE HTS TAPES, TO PROTECT THE ENVIRONMENT AND TO REDUCE THE INFLUENCE OF THE STRAY MAGNETIC FIELD. THEREFORE, IT IS REQUIRED TO DEVELOP THE OPTIMIZATION METHOD OF THE CONFIGURATION OF THE SUPERCONDUCTING MAGNETS WITH THE MAGNETIC SHIELDING. THE IRON MAGNETIC SHIELDS ARE EXPOSED TO SO HIGH FIELD THAT THE SATURATION OF IRON HAS TO BE TAKEN INTO ACCOUNT. SO FAR THE DESIGN EXAMPLE OF THE MAGNETS WITH THE IRON MAGNETIC SHIELD EXPOSED TO OVER 2 T ISN'T REPORTED. RECENTLY, IT WAS REPORTED THAT THE NONLINEAR MAGNETIC CHARACTERISTICS OF IRON WERE MEASURED AT HIGH MAGNETIC FIELDS OVER 2 T. THE MEASURED MAGNETIC CHARACTERISTICS OF IRON ARE TAKEN INTO ACCOUNT TO OPTIMIZE THE CONFIGURATION OF THE SUPERCONDUCTING

MAGNETS GENERATING THE HIGH MAGNETIC FIELD. THE HYBRID FINITE ELEMENT AND BOUNDARY ELEMENT METHOD IS EMPLOYED AS THE FIELD COMPUTATION METHOD. THE AIM OF THIS STUDY IS TO MINIMIZE THE WINDING VOLUME OF THE SUPERCONDUCTING MAGNET WITH THE MAGNETIC SHIELDING FOR NMR.

3LP3B-06

A 1.1 GHZ LTS/HTS NMR MAGNET - PROGRESS REPORT ***J. BASCUNAN****, S. HAHN, D. PARK, Y. IWASA;* MIT - FBML. — THE 1.1 GHZ LTS/HTS NMR MAGNET IS THE FINAL PHASE, BEFORE EMBARKING IN WHAT STARTED AS A 3-PHASE PROGRAM IN 2000, NAMELY THE COMPLETION OF A HIGH RESOLUTION 1.3 GHZ LTS/HTS MAGNET. HERE WE PRESENT DETAILS OF THE 600 MHZ HTS INSERT (H600) DOUBLE-PANCAKE (DP) WINDINGS, TO BE OPERATED IN THE BORE OF A 500 MHZ LTS MAGNET, THUS ACHIEVING A FINAL FREQUENCY OF 1.1 GHZ. ULTIMATELY, THE H600 WILL BE COUPLED TO A 700 MHZ LTS MAGNET TO COMPLETE THE FINAL FREQUENCY OF 1.3 GHZ. THE HTS INSERT IS COMPOSED OF TWO CONCENTRIC STACKS OF DOUBLE PANCAKES, ONE WOUND WITH HIGH STRENGTH BSCCO-2223 TAPE, THE OTHER WITH YBCO COATED CONDUCTOR. DETAILS INCLUDE CONDUCTOR AND COIL PARAMETERS, WINDING PROCEDURE, DPS MECHANICAL SUPPORT AND INTEGRATION TO THE BACKGROUND 500 MHZ LTS MAGNET. TEST RESULTS OF INDIVIDUAL DPS IN LN2 ARE ALSO PRESENTED.

WORK SUPPORTED BY NCRR, NIBIB AND NIGMS

3LP3B-07

A NOVEL HIGH PRECISION PROCEDURE FOR COIL MAGNETIC DESIGN ***A. CAPELLUTO****, D. DAMIANI, R. MARABOTTO, M. MODICA, D. NARDELLI;* ASG SUPERCONDUCTORS. — THE MARKET OF HIGH HOMEGENEITY SUPERCONDUCTIVE MAGNETS REQUIRES OPTIMIZED AD-HOC SOLUTIONS, ESPECIALLY USING INNOVATIVE MATERIALS LIKE MGB2.THIS PAPER PRESENTS A NEW PROCEDURE FOR THE FAST DESIGN OF IRONLESS MAGNETS, CHARACTERIZED BY RESTRICTIVE PROJECT SPECIFICATIONS. AVAILABLE USUAL PROCEDURES ARE BASED ON APPROXIMATED TECHINQUES FOR MAGNETIC FIELD CALCULATION.THE PROPOSED PROCEDURE IS BASED ON A VERY FAST SEMI-ANALYTIC CALULATION OF MAGNETIC FIELD PRODUCED BY RECTANGULAR CROSS SECTION CONDUCTORS, LINKED TO A HYBRID STOCHASTIC-DETERMINISTIC ALGORITHM, PURPOSE-MADE TO FIND COIL CONFIGURATIONS.A TEST WAS PERFORMED ASKING THE CODE TO DESIGN THE MAGNET CONFIGURATION FOR A OPEN SKY MRI MAGNET EQUIPED WITH MGB2 COILS.THE RESULTS WERE VERIFIED BY A COMMERCIAL RELIABLE SOFTWARE FOR MAGNETIC CALCULATION.

3LP3B-08

THE CRYOGENICS OF A THERMOSIPHON-COOLED HTS MRI MAGNET - EXPERIMENTAL RESULTS AND PERFORMANCE LIMITS ***W. STAUTNER****, M. XU, E. T. LASKARIS, E. BUDESHEIM, G. CONTE, X. HUANG, K. AMM;* GE GLOBAL RESEARCH. — THE TEAM AT GE GLOBAL RESEARCH PRESENTS EXPERIMENTAL RESULTS OF A HIGH-TEMPERATURE SUPERCONDUCTING (HTS) LIMB SIZE MAGNETIC RESONANCE IMAGING (MRI) SCANNER USING SUMITOMO'S DI-BSCCO TAPE CONDUCTOR, UNDER AN NIH RESEARCH GRANT. THERMOSIPHON BEHAVIOR IS INVESTIGATED FOR DIFFERENT MRI OPERATING MODES, CONFIRMING THE CRYOGENIC ROBUSTNESS OF THIS COOLING APPROACH AND ITS PERFORMANCE LIMITS. THE MAGNET IS INDIRECTLY COOLED USING COOLING TUBES WITH LIQUID NEON FILLING. A COMMERCIALLY AVAILABLE SINGLE-STAGE CRYOCOOLER RELIQUEFIES BOIL OFF IN A SMALL 2.5-LITER NEON TANK.

NIH GRANT

3LP3B-09

RESEARCH ON STABILITY OF MGB_2 SUPERCONDUCTING MAGNET FOR MRI ***D. ZHANG****;* INSTITUTE OF ELECTRICAL ENGINEERING, CHINESE ACADEMY OF SCIENCES. — RESEARCH ON STABILITY OF MGB_2 SUPERCONDUCTING MAGNET FOR MRID. ZHANG, Z.K. WANG, S.T. DAI, J.Y. ZHANG, N.H. SONG, X.H. LI, F.Y. ZHANG, X.J. DU, M. QIU, Z.F. ZHANG, T.B. HUANG, Z.Q. ZHU, X. XU, W.W. ZHOU, G.M. ZHANG, L.Y. XIAO, L.Z. LIN*KEY LABORATORY OF APPLIED SUPERCONDUCTIVITY, CHINESE ACADEMY OF SCIENCES; INSTITUTE OF ELECTRICAL ENGINEERING, CHINESE ACADEMY OF SCIENCES, BEIJING 100190, CHINAABSTRACT*_MAGNESIUM DIBORIDE (MGB_2) SHOWS A WIDE APPLICATION PROSPECT IN THE FIELD OF LOW FIELD DC APPLICATION FOR ITS RELATIVELY SIMPLE STRUCTURE AND RATHER HIGHER CRITICAL TEMPERATURE THAN LTS. WITH THE DEVELOPMENT OF MGB_2 COMPOSITE SUPERCONDUCTOR MANUFACTURING TECHNOLOGY AND CRYOGENIC TECHNOLOGY, DEVELOPING CONDUCTION COOLED SUPERCONDUCTING MRI SYSTEM WITH MGB_2 COMPOSITE SUPERCONDUCTOR IS BECOMING INCREASINGLY FEASIBLE. AN MGB_2 SUPERCONDUCTING MAGNET FOR MRI IS DEVELOPED TO INVESTIGATE THE FUNDAMENTAL SCIENTIFIC PROBLEM OF THE MRI MAIN MAGNET. THE SUPERCONDUCTING MAGNET IS FABRICATED AND TESTED. THE CENTRAL MAGNETIC FIELD OF THE SUPERCONDUCTING MAGNET REACHES 1.0T WHEN THE CURRENT OF THE MGB_2 MAGNET IS 290A. IN THIS PAPER, THE MAIN MAGNET FOR MRI WITH MGB_2 COMPOSITE SUPERCONDUCTOR IS ANALYZED AND PROPOSED, INCLUDING MAGNET TEST RESULTS, STABILITY OF MAGNET, INFLUENCING FACTOR OF STABILITY AND QUENCH PROTECTION.*INDEX TERMS*_MAGNET, MGB_2, MRI, STABILITY, SUPERCONDUCTING

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3LP3B-10

HTS LIMB MRI MAGNET BUILD AND TEST ***M. XU****, W. STAUTNER, G. CONTE, E. BUDESHEIM, E. T. LASKARIS, X. HUANG, K. AMM;* GE GLOBAL RESEARCH CENTER. — ABSTRACT FOR SUBMISSION TO 2010 APPLIED SUPERCONDUCTIVITY CONFERENCEHTS LIMB MRI MAGNET

BUILD AND TESTMINFENG XU, WOLFGANG STAUTNER, GENE CONTE, ERIC BUDESHEIM, EVANGELOS T. LASKARIS, XIANRUI HUANG, AND KATHLEEN AMMABSTRACT: A LIMB SIZE MRI MAGNET WAS WOUND WITH DI-BSCCO HTS TAPE AND CRYOSTAT WAS BUILT USING THERMOSIPHON TECHNOLOGY FOR COOLING. THE COILS WERE SOLENOIDAL AND LAYER-WOUND. TESTING OF THE COILS AT LIQUID NITROGEN (LN2) BEFORE CRYOSTAT BUILD REVEALED ISSUES ASSOCIATED WITH UN-REINFORCED BSCCO TAPES DURING WINDING, CURING, AND COOLING. MAGNET TESTING IN THE CRYOSTAT WILL BE CARRIED OUT IN TWO STEPS. FIRST, THE COOLING TUBES WILL BE FILLED WITH NITROGEN GAS AND COOLED TO LN2 TEMPERATURE (77K). MAGNET RAMP WILL BE ATTEMPTED AT A LOWER CURRENT LEVEL. THEN THE TUBES WILL BE FILLED WITH NEON GAS, AND COOLED TO ~27K. THE MAGNET IS EXPECTED TO REACH 1.5T AT A FULL OPERATING CURRENT OF 120A. THIS PAPER WILL BE FOCUSED ON THE ELECTROMAGNETIC ASPECT OF THE MAGNET. THE MAGNET DESIGN AND TEST RESULTS AT DIFFERENT TEMPERATURES WILL BE DISCUSSED IN MORE DETAILS.

3LP3C-01

DEVELOPMENT AND TESTING OF BI-2212 INSERT COILS FOR RESEARCH AND HIGH HOMOGENEITY MAGNET APPLICATIONS ***Z. MELHEM***[1]*, S. CHAPPELL*[1]*, P. GHOSHAL*[1]*, A. TWIN*[1]*, S. HONG*[2]*, Y. HUANG*[2]*, H. MIAO*[2]*, M. MEINESZ*[2]*, Y. YANG*[3]*, J. SIMKIN*[4]*;* [1]OXFORD INSTRUMENTS NANONSCIENCE, [2]OXFORD SUPERCONDUCTING TECHNOLOGY, [3]SOUTHAMPTON UNIVERSITY, [4]VECTOR FIELDS SOFTWARE. — FAMILY OF BI-2212 TEST COILS HAVE BEEN DESIGNED AND DEVELOPED USING THE HIGH TEMPERATURE SUPERCONDUCTOR (HTS) BI-2212 ROUND WIRES. INSERT COILS HAVE BEEN MANUFACTURED WITH DIFFERENT SIZE CONFIGURATIONS INCLUDING VARIATION OF COIL LENGTH AS WELL AS NUMBER OF LAYERS. THE FABRICATED COILS ARE INTEGRATED INTO A WIDE BORE LTS SUPERCONDUCTING 20T MAGNET AND TESTED SUCCESSFULLY AT 4.2K AS WELL AS AT DIFFERENT LOW AND HIGH BACKGROUND FIELD VALUES. COILS RESPONSE AND PERFORMANCE AND THE CORRESPONDING QUENCH BEHAVIOUR AT DIFFERENT OPERATING CONDITIONS WERE MEASURED AND ANALYSED. THIS PAPER WE REPORT ON OUR PROGRESS ON THE DEVELOPMENT OF INSERT COILS USING BI-2212 HTS COILS AND THEIR INTEGRATION INTO HIGH FIELD MAGNETS AND HIGH HOMOGENEITY APPLICATIONS FABRICATED FROM LTS SUPERCONDUCTOR MATERIALS. ***INDEX TERMS_*** **BI-2212 ROUND WIRE, HIGH TEMPERATURE SUPERCONDUCTORS, SUPERCONDUCTING MAGNETS, WIND AND REACT COILS, QUENCH ANALYSIS,**

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3LP3C-02

NO-INSULATION DOUBLE-PANCAKE WINDING FOR A 600 MHZ HTS INSERT IN A 1.3 GHZ LTS/HTS NMR MAGNET ***S. HAHN****, D. PARK, J. BASCUÑÁN, Y. IWASA;* MASSACHUSETTS INSTITUTE OF TECHNOLOGY. — IN 2008, WE STARTED THE 3RD PHASE OF A 3-PHASE PROGRAM OF WHICH THE ULTIMATE GOAL IS TO DESIGN, BUILD, AND OPERATE A 1.3 GHZ LTS/HTS NMR MAGNET (600 MHZ HTS INSERT PLUS 700 MHZ LTS BACKGROUND MAGNET.) WITH THE DESIGN OF A 600 MHZ HTS INSERT (H600) COMPLETED, WE HAVE BEGUN WINDING A TOTAL OF 112 DOUBLE-PANCAKE (DP) COILS. AS REPORTED PREVIOUSLY, THE TENSILE STRAIN OF THE 600 MHZ HTS INSERT UNDER A 700 MHZ BACKGROUND FIELD MAY EXCEED 0.4 %, THE SAFE TENSILE LIMIT OF HTS CONDUCTOR, IF SOFT ORGANIC MATERIAL, FOR EXAMPLE NOMEX OR KAPTON, IS USED AS A TURN-TO-TURN INSULATOR. TO KEEP THE TENSILE STRESS LEVEL LOW ENOUGH AND THUS PREVENT COIL MECHANICAL DAMAGE (< 300 MPA), WE HAVE DECIDED TO DISCARD THE ORGANIC INSULATION AND USE INSTEAD, AS MECHANICAL REINFORCEMENT, AN UNINSULATED STAINLESS STEEL STRIP, CO-WOUND WITH THE CONDUCTOR. THIS PAPER PRESENTS EXPERIMENTAL AND ANALYTICAL RESULTS PERFORMED ON TEST DOUBLE-PANCAKE COILS, CO-WOUND WITH AN UNINSULATED STAINLESS STEEL STRIP. KEY TECHNICAL ISSUES FOR AN UNINSULATED COIL INCLUDE: 1) CHARGING/DISCHARGING TIME CONSTANT; 2) QUENCH CHARACTERISTICS AND DETECTION; 3) CURRENT RE-DISTRIBUTION IN ACTIVE PROTECTION.

THIS WORK IS SUPPORTED BY THE NATIONAL CENTER FOR RESEARCH RESOURCES, THE NATIONAL INSTITUTE OF BIOMEDICAL IMAGING AND BIOENGINEERING, AND THE NATIONAL INSTITUTE OF GENERAL MEDICAL SCIENCES.

3LP3C-03

EXPERIMENTAL DEMONSTRATION OF PERIOD LENGTH SWITCHING FOR SUPERCONDUCTING INSERTION DEVICES ***A. GRAU***[1]*, T. BAUMBACH*[1]*, S. CASALBUONI*[1]*, S. GERSTL*[1]*, M. HAGELSTEIN*[1]*, D. SAEZ DE JAUREGUI*[1]*, C. BOFFO*[2]*, W. WALTER*[2]*;* [1]INSTITUTE OF SYNCHROTRON RADIATION, KARLSRUHE INSTITUTE OF TECHNOLOGY, [2]BABCOCK NOELL GMBH. — ONE OF THE ADVANTAGES OF SUPERCONDUCTING INSERTION DEVICES (IDS) WITH RESPECT TO PERMANENT MAGNET IDS IS THE POSSIBILITY TO ENLARGE THE SPECTRAL RANGE BY CHANGING THE PERIOD LENGTH BY REVERSING THE DIRECTION OF THE CURRENT IN A PART OF THE WINDINGS.IN THIS CONTRIBUTION WE REPORT THE FIRST EXPERIMENTAL TEST OF THIS PRINCIPLE DEMONSTRATED ON A 70MM NBTI MOCK-UP COIL DESIGNED AND BUILT BY BABCOCK-NOELL (BNG) WITH PERIOD TRIPLING, ALLOWING TO SWITCH BETWEEN A 15MM PERIOD LENGTH UNDULATOR AND A 45MM WIGGLER.

3LP3C-04

DISTRIBUTIONS OF SCREENING CURRENTS INDUCED ON COATED CONDUCTORS ***A. MIYAZOE***[1]*, M. SEKINO*[1]*, T. KIYOSHI*[2]*, H. OHSAKI*[1]*;* [1]THE UNIVERSITY OF TOKYO, [2]NATIONAL INSTITUTE FOR MATERIALS SCIENCE. — MAGNETIC FIELDS PERPENDICULAR TO A TAPE PLANE OF A COATED CONDUCTOR (CC) INDUCE SCREENING CURRENTS ON THE SUPERCONDUCTING LAYER. IN A HIGH-FIELD NMR MAGNET INCLUDING COILS WOUND WITH CCS, THE SCREENING CURRENTS MAY BE A CRITICAL ISSUE IN DESIGN AND

CONSTRUCTION OF SUPERCONDUCTING MAGNETS BECAUSE OF ITS INFLUENCE ON INTENSITY, DISTRIBUTION AND STABILITY OF THE MAGNETIC FIELDS. IN ORDER TO DESIGN THE COILS, EVALUATION OF SCREENING CURRENT DISTRIBUTION IS VERY IMPORTANT. WE HAVE MEASURED DISTRIBUTIONS OF SCREENING CURRENT INDUCED FIELDS (SCFS) ON SHORT AND STRAIGHT CCS AND COILS, AND THE DISTRIBUTIONS OF SCREENING CURRENTS. THEIR DEPENDENCES ON THE EXTERNAL CURRENTS (I_E) AND MAGNETIC FIELDS (B_{EX}) WERE INVESTIGATED. A SCF AT A POSITION 0.9 MM ABOVE THE CENTER OF TAPE PLANE OF A 4 MM-WIDE CC WAS OVER 30 MT AT 4.2 K, I_E = 0 A AND B_{EX} = 1.0 T. AS THE CURRENTS FLOWING ON CCS BECOME LARGE, SCFS BECOME SMALLER. SCFS BECOME LARGER FROM B_{EX} = 0 T TO ABOUT 0.2 T AND SMALLER UNDER B_{EX} > 0.2 T. THE DISTRIBUTIONS OF SCFS UNDER B_{EX} > 0.2 T DECREASE LINEARLY FROM A POSITION 0.9 MM ABOVE THE CENTER TO 0.9 MM ABOVE THE EDGE OF TAPE. THE DISTRIBUTIONS OF SCREENING CURRENTS ARE DISCUSSED.

3LP3C-06

INITIAL COOLDOWN CHARACTERISTIC OF CONDUCTION-COOLED HIGH FIELD MAGNET SYSTEM ***Y. CHOI****;* KBSI. — COOLDOWN TIME IS ONE OF THE MAJOR FACTORS IN THE CONDUCTION-COOLED SUPERCONDUCTING MAGNET SYSTEM. COOLDOWN TIME MEANS A TIME COOLING A SUPERCONDUCTING MAGNET FROM A ROOM TEMPERATURE TO CRYOGENIC TEMPERATURE WITHIN A STIPULATED AMOUNT OF TIME. THE ESTIMATION OF COOLDOWN TIME SEEKS THE ELAPSED TIME TO COOL THE SUPERCONDUCTING MAGNET BY CRYOCOOLER DURING INITIAL COOLDOWN PROCESS. THIS PROCEDURE INCLUDES THE MODELING OF PROPERTIES OF LOW TEMPERATURE SUPERCONDUCTOR, THE DIMENSIONS OF SUPERCONDUCTING MAGNET, THE CRYOGENIC LOADS, THE THERMAL LINK BETWEEN MAGNET AND CRYOCOOLER, AND THE AVAILABLE REFRIGERATING CAPACITY OF CRYOCOOLER. THIS METHOD IS APPLIED TO THE 3 T NBTI SUPERCONDUCTING MAGNET COOLED BY A TWO-STAGE GM CRYOCOOLER. THE EFFECTS OF MAGNETIC FIELD, SIZE OF MAGNET AND THERMAL SWITCH ON THE INITIAL COOLDOWN ARE ALSO DISCUSSED.

THIS WORK IS SUPPORTED BY THE KBSI GRANT D30110

3LP3C-07

FABRICATION OF A 10 TESLA CRYOFREE SUPERCONDUCTING MAGNET ***L. YAN****;* INSTITUTE OF ELECTRICAL ENGINEERING, CHINESE ACADEMY OF SCIENCES. — A SUPERCONDUCTING MAGNET WITH THE CENTER OF 10 T AND THE WARM BORE SIZE OF 100MM WAS DESIGNED AND FABRICATED. THE MAGNET FABRICATED BY NBTI AND NB_3SN CAN BE ROTATED WITH A SUPPORT FRAME TO BE OPERATED WITH EITHER HORIZONTAL OR VERTICAL POSITION. A PAIR OF BI-2223 HIGH TEMPERATURE SUPERCONDUCTING CURRENT LEADS WAS EMPLOYED TO REDUCE HEAT LEAKAGE INTO 4.2 K LEVEL. THE MAGNET SYSTEM HAS ⍰742 MM OUTSIDE DIAMETER, 558 MM HEIGHT AND 230 KG WEIGHT. THE SUPERCONDUCTING MAGNET WAS COOLED AND TESTED DIRECTLY THROUGH CRYOCOOLER. IT IS REACHED TO OPERATING CURRENT OF 120 A WITHOUT TRAINING EFFECT TO BE OBSERVED DURING CHARGE OF THE MAGNET. IT SHOWS THAT THE TRAINING EFFECT IN THE MAGNET DIRECTLY COOL-DOWN BY CRYOCOOLER AND INTER-WINDING SUPPORT STRUCTURE IN MAGNET CAN BE REMARKABLY IMPROVED. THE SUPERCONDUCTING MAGNET WAS STABLY OPERATING MORE THAN TWO MONTHS CONTINUOUSLY IN FULL FIELD. IN THE PAPER, THE DETAILED FABRICATED AND USED FOR SEPARATOR EXPERIMENTAL ARE REPORTED.

3LP3D-01

DEVELOPMENT OF AN MGB_2 COIL WOUND WITH A PARALLEL CONDUCTOR COMPOSED OF TWO TAPES WITH INSULATION ***A. KAWAGOE****[1], K. MATSUSHIMA[1], Y. YOSHIDOME[1], Y. HAEYAMA[1], S. KAWABATA[1], F. SUMIYOSHI[1], N. YANAGI[2], T. MITO[2], M. KIUCHI[3], S. E. OTABE[3], T. MATSUSHITA[3], M. TAKAHASHI[4], T. WAKUDA[4];* [1]KAGOSHIMA UNIVERSITY, [2]NATIONAL INSTITUTE FOR FUSION SCIENCE, [3]KYUSHU INSTITUTE OF TECHNOLOGY, [4]HITACHI RESEARCH LABORATORY, HITACHI, LTD.. — THE MGB_2 COIL WOUND WITH A PARALLEL CONDUCTOR COMPOSED OF TWO MGB_2 TAPES WITH INSULATION HAS BEEN DEVELOPED. THE TAPE IS OBTAINED BY THE ROLLING PROCESS FROM THE ROUND WIRE WHICH IS FABRICATED BY IN-SITU METHOD. THE PERFORMANCES OF TAPES, SUCH AS CRITICAL CURRENT DENSITY AND AC LOSSES, ARE HIGHER THAN THAT OF ROUND WIRES IN CASE THAT THE TRANSVERSE MAGNETIC FIELDS ARE APPLIED TO THE TAPE IN DIRECTION OF THE PARALLEL TO THE FLAT FACE OF THE TAPE. WE PROPOSED AS A CANDIDATE OF APPLYING THE TAPE TO A CONDUCTOR WITH LARGE CURRENT CAPACITY THAT THE PARALLEL CONDUCTOR IS COMPOSED OF INSULATED TAPES. WE FABRICATED A TAPE WITH ASPECT RATIO OF TWO FROM A ROUND WIRE WITH DIAMETER OF 0.8 MM AS A STRAND FOR THE CONDUCTOR. THE COIL IS COMPOSED OF TWO COILS THAT ARE JOINTED EACH OTHER IN SERIES. AT THE JOINT, TWO STRANDS ARE TRANSPOSED TO BE IDENTICAL THE INDUCTANCES OF TWO STRANDS. THE INNER AND OUTER DIAMETERS OF THE COIL ARE 65 MM AND 104 MM, RESPECTIVELY. THE TOTAL TURN NUMBER IS 540 TURN. THE HEIGHT OF THE COIL IS 53 MM. THE MAGNETIC FLUX DENSITY AT THE CENTER IN THE COIL IS 1.31 T WHEN THE TRANSPORT CURRENT IS 200 A. IN THIS PAPER, THE DESIGN AND THE TEST RESULTS OF THE MGB_2 COIL WOUND WITH THE CONDUCTOR ARE SHOWN AND THE CRITICAL CURRENT PROPERTIES AND AC LOSS PROPERTIES OF THE COIL ARE DISCUSSED.

THIS WORK IS PERFORMED WITH THE SUPPORT AND UNDER THE AUSPICES OF THE NIFS COLLABORATION RESEARCH PROGRAM.（NIFS07KOBA019）

3LP3D-02

A SMALL 1.5 T PERSISTENT CURRENT OPERATING TEST MAGNET USING MGB_2 WIRE WITH HIGH J_C JOINTS ***X. LI****, Z. GAO, D. ZHANG, Y. MA, J. ZHANG, S. DAI, D. XIA, L. LIN, L. XIAO;* INSTITUTE OF ELECTRICAL ENGINEERING, CHINESE ACADEMY OF SCIENCES. — A SMALL PERSISTENT CURRENT (PC)

OPERATING MAGNET WITH BORE DIAMETER OF 30 MM WAS DESIGN AND DEVELOPED BASED ON MULTI- AND MONO-FILAMENT MGB_2 WIRES. A COIL WAS FIRSTLY DESIGNED AND WINDED, THEN TWO HIGH J_C JOINTS WERE FABRICATED AT THE BOTH ENDS OF THE COIL, CONNECTING IT TO A SPECIAL DESIGNED SUPERCONDUCTING SWITCH. THE COIL ITSELF AND THE PC MAGNET WERE TESTED IN BOTH LIQUID HE AND CONDUCTION COOLING CONDITIONS FOR DEMONSTRATION OF THE POSSIBILITY OF HIGH FIELD AND HIGH TEMPERATURE OPERATIONS. THE RESULTS SHOW A PROMISING FUTURE IN THE DEVELOPMENT OF LARGE SCALE MGB_2 MAGNETS, SUCH AS CHEAP MAGNETIC RESONANCE IMAGING SYSTEMS.INDEX TERMS: JOINTS; MGB_2; PC OPERATION; MAGNET.

THIS WORK IS PARTIALLY SUPPORTED BY THE NSFC OF CHINA, GRANT NOS. 50507019 AND 50677067.

3LP3D-04

FABRICATION OF SUBSCALE Y-BA-CU-O RACE-TRACK COILS ***X. WANG****, S. CASPI, D. W. CHENG, D. R. DIETDERICH, H. FELICE, P. FERRACIN, A. GODEKE, J. M. JOSEPH, J. LIZARAZO, S. O. PRESTEMON, G. SABBI;* LAWRENCE BERKELEY NATIONAL LABORATORY. — WE REPORT THE FABRICATION TECHNOLOGY OF SUBSCALE INSERT COILS BASED ON YBA2CU3O7-Δ COATED CONDUCTORS FOR ACCELERATOR APPLICATIONS. THE COILS ARE CONSIDERED TO BE TESTED AS INSERTS IN HD1, A NB3SN HIGH-FIELD DIPOLE MAGNET DEVELOPED AT LAWRENCE BERKELEY NATIONAL LABORATORY. THE RACE-TRACK SHAPED COILS HAVE TWO LAYERS AND ARE WOUND AROUND STAINLESS STEEL ISLANDS. AS THE COILS WILL EXPERIENCE HIGH LORENTZ LOAD WHEN OPERATING IN HIGH BACKGROUND FIELD, MECHANICAL STRUCTURE AND IMPREGNATION TECHNIQUES THAT ARE COMPATIBLE WITH THE CONDUCTOR PERFORMANCE ARE INVESTIGATED. SELF-FIELD PERFORMANCE OF THE COILS AT 77 K AND 4.2 K, INDICATING THE QUALITY OF THE FABRICATION TECHNOLOGY, ARE PRESENTED AND DISCUSSED. IN-FIELD COIL PERFORMANCE PREDICTIONS BASED ON SHORT-SAMPLE IN-FIELD MEASUREMENTS ARE ALSO DISCUSSED, WHICH SHOWS THE POTENTIAL OF YBCO INSERTS TO ENABLE A HIGHER FIELD BEYOND THAT BASED ON THE NB-BASED ACCELERATOR TECHNOLOGY.

THIS WORK WAS SUPPORTED BY THE DIRECTOR, OFFICE OF SCIENCE, HIGH ENERGY PHYSICS, U.S. DEPARTMENT OF ENERGY UNDER CONTRACT NO. DE-AC02-05CH11231.

3LP3D-06

THE SMC DIPOLE: TECHNICAL ASPECTS OF COIL WINDING, INSTRUMENTATION AND MAGNET ASSEMBLY ***J. C. PEREZ****[1], M. BAJKO[1], M. GUINCHARD[1], F. REGIS[1], P. MANIL[2], S. CANFER[3], G. ELLWOOD[3];* [1]CERN, [2]CEA, [3]STFC. — THE SHORT MODEL COIL (SMC) ASSEMBLY HAS BEEN DESIGNED AS TEST BENCH FOR SHORT RACETRACK COILS WOUND WITH NB3SN CABLE. THE MECHANICAL STRUCTURE COMPRISES AN IRON YOKE SURROUNDED BY A 20 MM THICK ALUMINUM SHELL, AND INCLUDES FOUR LOADING PADS THAT TRANSMIT THE REQUIRED PRE-COMPRESSION FROM THE OUTER SHELL INTO THE TWO COILS. THE OUTER SHELL IS PRE-TENSIONED WITH PRESSURIZED BLADDERS AND TWO 30 MM DIAMETER ALUMINUM BARS PROVIDE THE AXIAL LOADING AT THE COIL ENDS. THE OUTER SHELL, AXIAL BARS, AND THE COILS ARE INSTRUMENTED WITH STRAIN GAUGES, WHICH ALLOW PRECISE MONITORING OF THE LOADING CONDITIONS DURING THE ASSEMBLY AND AT CRYOGENIC TEMPERATURE DURING THE MAGNET TEST.THE FIRST SMC ASSEMBLY HAS BEEN COMPLETED AND THE COLD TEST CAMPAIGN OF THE FIRST COIL SUCCESSFULLY CARRIED OUT AS A EUROPEAN COLLABORATION BETWEEN CEA (FR), CERN (CH) AND STFC (UK) AND WITH THE TECHNICAL SUPPORT FROM LBNL. THIS PAPER DESCRIBES THE MAIN FEATURES OF THE SMC ASSEMBLY, THE EXPERIENCE FROM THE DUMMY ASSEMBLIES, AND THE FABRICATION OF THE FIRST COILS. THE TEST RESULTS OF THE FIRST COLD TEST ARE DISCUSSED AND THE MAIN CHARACTERISTICS OF THE PLANNED COIL VARIANTS ARE GIVEN.

3LP3D-07

CONSTRUCTION OF TAMU3 - A 13 TESLA MODEL DIPOLE TO EVALUATE STRESS-MANAGEMENT IN HIGH FIELD DIPOLE WINDINGS ***A. D. MCINTURFF****, R. BLACKBURN, N. DIACZENKO, T. ELLIOTT, T. HOLIK, A. JAISLE, P. MCINTYRE, A. SATTAROV;* TEXAS A&M UNIVERSITY. — THE TEXAS A&M UNIVERSITY ACCELERATOR RESEARCH LAB HAS BUILT A SUCCESSION OF MODEL DIPOLES TO DEVELOP AND EVALUATE STRESS MANAGEMENT IN THE COILS OF HIGH FIELD MAGNETS. THE LATEST SUCH MAGNET IS NOW BEING BUILT USING HIGH-PERFORMANCE TIN-RICH MULTI-FILAMENT NB_3SN/CU COMPOSITE STRAND IN ITS CABLES AND SILANE-SIZED ULTRA-THIN S-GLASS INSULATION FABRIC. FIVE COIL MODULES ARE UNDER CONSTRUCTION. THE FIRST PAIR OF MODULES WILL BE ASSEMBLED AS TAMU3, A 13 TESLA DIPOLE THAT WILL PROVIDE A DEFINITIVE STUDY OF STRESS MANAGEMENT IN THE WINDINGS. A SECOND PAIR WILL BE ASSEMBLED AS TAMU4, A 4X3 CM^2 APERTURE ACCELERATOR PROTOTYPE DIPOLE. DETAILS OF TOOLING AND FABRICATION WILL BE PRESENTED; PLANS FOR TESTING WILL BE DISCUSSED.

THIS WORK SUPPORTED BY DIRECTOR, OFFICE OF SCIENCE, HIGH ENERGY PHYSICS, U.S. DEPT. OF ENERGY UNDER CONTRACT DE-FG02-06ER41405

3LP3E-03

QUENCH PROPAGATION ANALYSIS AND PROTECTION DESIGN OF A 7T SUPERCONDUCTING MAGNET FOR ANIMAL MRI J. CHEN[1], X. JIANG[1], D. ZHENG[2], G. CHAI[3]; [1]DEPARTMENT OF ELECTRICAL ENGINEERING, TSINGHUA UNIVERSITY, BEIJING, CHINA, [2]INSTITUTE OF PHYSICS, CHINESE ACADEMY OF SCIENCES, BEIJING, [3]HANGZHOU INNOVATION PARK OF BIOPHAMAR, HANGZHOU — **QUENCH PROPAGATION ANALYSIS AND PROTECTION DESIGN OF A 7T SUPERCONDUCTING MAGNET FOR ANIMAL MRI**THIS PAPER PRESENTS QUENCH PROPAGATION ANALYSIS AND PROTECTION DESIGN OF A 7T SUPERCONDUCTING MAGNET FOR ANIMAL MRI. A 3D QUENCH SIMULATION PROGRAM IS DEVELOPED BASED ON A THERMAL-ELECTROMAGNETIC

COUPLED CALCULATION BY THE FINITE ELEMENT METHOD. FIELD AND TEMPERATURE DEPENDENCE OF THERMAL AND ELECTROMAGNETIC CHARACTERISTICS OF THE MAGNET MATERIALS ARE TAKEN INTO ACCOUNT INCLUDING THE THERMAL CONDUCTIVITIES, THE SPECIFIC HEATS, THE CRITICAL CURRENTS OF THE NBTI WIRES AND THE RESISTIVITY OF THE COPPER MATRIX. THE NON-LINEAR CALCULATION IS OPTIMIZED SO THAT THE COMPUTATION TIME IS REASONABLE. AS THE RESULTS, QUENCH PROPAGATION ALONG THE AZIMUTHAL, RADIAL AND AXIAL DIRECTIONS, TIME-DEPENDENT TEMPERATURE AND VOLTAGE DISTRIBUTION ARE OBTAINED. QUENCH PROTECTION CIRCUITS ARE DESIGNED AND THE QUENCH SIMULATION WITH THE PROTECTION CIRCUITS INTERACTING IS PERFORMED TO VALIDATE THE PROTECTION. THE FINAL RESULTS INDICATE THAT THE TEMPERATURE RISE AND THE INTER-LAYER VOLTAGE OF THE PROTECTED MAGNET ARE TOLERABLE.

3LP3E-05

STUDY ON THE MECHANICAL INSTABILITY OF THE MICE COUPLING MAGNETS *H. PAN[1], **L. WANG**[2], H. WU[1], X. GUO[1], S. ZHENG[1], M. GREEN[3];* [1]INSTITUTE OF CRYOGENICS AND SUPERCONDUCTIVITY TECHNOLOGY, HIT, HARBIN150080, CHINA, [2]SHANGHAI INSTITUTE OF APPLIED PHYSICS, SHANGHAI 201204, CHINA, [3]LAWRENCE BERKELEY LABORATORY, BERKELEY CA 94720, USA. — THE SUPERCONDUCTING COUPLING SOLENOID MAGNET IS ONE OF THE KEY EQUIPMENT IN THE MUON IONIZATION COOLING EXPERIMENT (MICE). THE COIL HAS AN INNER RADIUS OF 750 MM, LENGTH OF 281 MM AND THICKNESS OF 104 MM AT ROOM TEMPERATURE. THE PEAK INDUCTION IN THE COIL IS ABOUT 7.4 T WITH A FULL CURRENT OF 210 A. THE MECHANICAL DISTURBANCES WHICH MIGHT CAUSE THE INSTABILITY OF THE IMPREGNATED SUPERCONDUCTING MAGNET INVOLVE THE FRICTIONAL MOTION BETWEEN CONDUCTORS AND THE CRACKING OF IMPREGNATED MATERIALS. IN THIS PAPER, THE MECHANICAL INSTABILITY OF THE SUPERCONDUCTING COUPLING MAGNET WAS STUDIED. THIS PAPER PRESENTS THE NUMERICAL CALCULATION RESULTS OF THE MINIMUM QUENCH ENERGY (MQE) OF THE COUPLING MAGNET, AS WELL AS THE DISSIPATED STRAIN ENERGY IN THE STRESS CONCENTRATION REGION WHEN THE EPOXY CRACKING AND THE FRICTIONAL ENERGY CAUSED BY "STICK-SLIP" OF THE CONDUCTOR BASED ON THE BENDING THEORY OF BEAM HAPPEN. SLIP PLANES ARE USED IN THE COUPLING COIL AND THE FRICTIONAL ENERGY DUE TO "SLOW SLIP" AT THE INTERFACE OF THE SLIP PLANES WAS ALSO INVESTIGATED. THE DISSIPATED ENERGY WAS COMPARED WITH MQE, AND THE RESULTS SHOW THAT THE CRACKING OF EPOXY RESIN IN THE REGION OF SHEAR STRESS CONCENTRATION IS THE MAIN FACTOR FOR PREMATURE QUENCH OF THE COIL.

THIS WORK IS SUPPORTED BY FUNDS OF THE CRYOGENICS AND SUPERCONDUCTING TECHNOLOGY INNOVATION PROJECT UNDER THE "985-2" PLAN OF THE HIT. THIS WORK IS ALSO SUPPORTED BY THE OFFICE OF SCIENCE, US-DOE UNDER DOE CONTRACT DE-AC02-05CH11231.

3LP3E-06

MEASUREMENTS OF AC LOSS AND INTERSTRAND CONTACT RESISTANCE IN NB3SN RUTHERFORD CABLES WITH MGO AND S-GLASS CORES ***E. W. COLLINGS**[1], M. D. SUMPTION[1], D. R. DIETDERICH[2], A. A. NIJHUIS[3];* [1]THE OHIO STATE UNIVERSITY, [2]THE SUPERCONDUCTING MAGNET GROUP, LAWRENCE BERKELEY NATIONAL LABORATORY (LBNL), [3]LOW TEMPERATURE DIVISION, FACULTY OF APPLIED PHYSICS, UNIVERSITY OF TWENTE, ENSCHEDE, NL. — INTERSTRAND CONTACT RESISTANCE WAS MEASURED VIA TWO TECHNIQUES FOR NB3SN CABLES WITH CORES OF EITHER MGO OR S-GLASS. THE BASIC CABLE WAS MADE FROM 0.8 MM OD NB3SN STRAND MANUFACTURED BY OST. THE CABLE HAD 35 STRANDS, WITH A CABLE PITCH OF NOMINALLY 102 MM AND 4BR LUBRICANT. THE CABLE THICKNESS RANGED FROM 1.434 MM TO 1.534 MM, AND THE WIDTH FROM 14.8 TO 15.1 MM AND KEYSTONE ANGLE OF ~0.7 DEG. CORES WERE THEN INSERTED INTO THIS BASE CABLE TO GENERATE VARIANTS. TWO NOMINALLY SIMILAR MGO VARIANTS WERE MADE, AND TWO NOMINALLY SIMILAR S-GLASS VARIANTS WERE ALSO MADE. A CONTROL VERSION, WITH NO CORE, WAS MADE. IN PREPARATION FOR MEASUREMENT, THE CABLES WERE WRAPPED WITH S-GLASS TAPE IMPREGNATED WITH A CERAMIC BINDER (APPLIED BEFORE REACTION HT). THE HT/PRESSURIZATION SEQUENCE OF THE CABLES WAS MADE TO MIMIC AS CLOSELY AS POSSIBLE THE EXPECTED (LARP) ACCELERATOR MAGNET-FABRICATION SCHEDULES. IN THE FIRST MEASUREMENT TYPE, CALORIMETRIC AND MAGNETIC MEASUREMENTS OF AC LOSS WERE MADE AT 4.2 K, FOR FREQUENCIES UP TO 90 MILLIHZ AND FIELD AMPLITUDES OF +- 400 MT. VALUES FOR THE INTERSTRAND CONTRACT RESISTANCE, ICR, WERE EXTRACTED USING THE STANDARD LOSS EXPRESSIONS. SECONDLY, DIRECT I-V MEASUREMENTS WERE MADE OF THE CABLE CONTACTS. THESE VALUES WERE COMPARED TO THOSE MEASURED BY EXTRACTION FROM THE LOSS. COVERAGE FRACTIONS WERE THEN ESTIMATED FOR THE MGO AND S-GLASS CORES.

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3LP3E-08

OVERCOMING THE MAGNETO-THERMAL INSTABILITY OF HIGH JC NB3SN WIRES BY CONTROLLING THE CURRENT DISTRIBUTION ***B. BORDINI**, L. ROSSI, C. SCHEUERLEIN, E. TAKALA;* CERN. — SUPERCONDUCTING MAGNETS BASED ON HIGH J_C NB_3SN CONDUCTOR APPEAR TO BE, MORE AND MORE, INDISPENSIBLE DEVICES FOR THE LHC LUMINOSITY UPGRADE. FOR THIS REASON, CERN IS INTENSIFYING ITS RESEARCH ON NB_3SN STRANDS AND CABLES. PUSHING THE CRITICAL CURRENT DENSITY OF NB_3SN WIRES TOWARDS HIGHER AND HIGHER VALUES MAY GENERATE MAGNETO-THERMAL INSTABILITIES THAT CAN DRASTICALLY REDUCE THE CONDUCTOR PERFORMANCE. IN ORDER TO STUDY THE MECHANISMS THAT CAUSE MAGNETO-THERMAL INSTABILITIES AND TO IMPROVE THE CONDUCTOR STABILITY, A SPECIAL JOINT BETWEEN THE STRAND SAMPLE AND THE

CURRENT LEADS IN THE CRITICAL AND STABILITY CURRENT MEASUREMENT SET-UP, WAS PREPARED AT CERN TO FORCE A MORE EVEN DISTRIBUTION OF THE TRANSPORT CURRENT WITHIN THE STRAND. SEVERAL NB_3SN 0.8 MM RRP SAMPLES, USING SPECIAL JOINT CONFIGURATIONS, WERE TESTED SHOWING A SIGNIFICANT IMPROVEMENT OF THE CONDUCTOR STABILITY AS EXPECTED BY OUR THEORY. IN THIS PAPER THE SAMPLE PREPARATION AND THE EXPERIMENTAL RESULTS ARE PRESENTED TOGETHER WITH A FINITE ELEMENT MODEL THAT SHOWS HOW THE TRANSPORT CURRENT DISTRIBUTION IS CHANGING BY USING THE NEW JOINT CONFIGURATION.

3LP3E-09

ANALYSIS OF TRANSVERSE RESISTANCE MEASUREMENTS IN NB_3SN SUPERCONDUCTING WIRES ***M. BRESCHI***[1]*, V. CORATO*[2]*, A. DELLA CORTE*[2]*, C. FIAMOZZI ZIGNANI*[2]*, L. MUZZI*[2]*, P. RIBANI*[3]*;* [1]UNIVERSITY OF BOLOGNA -DEPARTMENT OF ELECTRICAL ENGINEERING, [2]ENEA, FRASCATI, ITALY, [3]UNIVERSITY OF BOLOGNA. — THE OVERALL ARCHITECTURE AND MANUFACTURING TECHNOLOGY OF NB_3SN STRANDS CAN SIGNIFICANTLY AFFECT THEIR THERMAL STABILITY TOWARDS EXTERNAL ENERGY DISTURBANCES. THE BRONZE OF THE MATRIX IN THE FILAMENTARY REGION OF INTERNAL TIN STRANDS, WITH ITS LOW THERMAL AND ELECTRICAL CONDUCTIVITY, CAN HINDER THE FLOW OF HEAT AND CURRENT FROM THE SUPERCONDUCTING FILAMENTS TO THE COPPER STABILIZER DURING THE FIRST PHASES OF A QUENCH. THIS PHENOMENON IS ANALYZED HERE BY MEANS OF A NUMERICAL MODEL, WITH A DETAILED DESCRIPTION OF HEAT EXCHANGE WITH POOL BOILING HELIUM, AS ALREADY VALIDATED BY COMPARISON WITH A WIDE EXPERIMENTAL DATABASE. THE NUMERICAL MODEL IS APPLIED IN THIS WORK TO A 3D ANALYSIS OF THERMAL STABILITY OF WIRES REALIZED WITH DIFFERENT CONFIGURATIONS. THE TEMPERATURE DEPENDENT TRANSVERSE ELECTRICAL RESISTANCES AMONG THE SUB-ELEMENTS HAVE BEEN DIRECTLY MEASURED WITH A NEW METHODOLOGY DEVELOPED AT ENEA FRASCATI. THE TRANSVERSE THERMAL CONDUCTANCE BETWEEN SUB-ELEMENTS IS COMPUTED BY MEANS OF A 2D NUMERICAL MODEL OF THE WIRE CROSS SECTION. FINALLY, THE 3D NUMERICAL MODEL OF QUENCH PROPAGATION IS APPLIED TO COMPARE THE THERMAL STABILITY OF TYPICAL NB_3SN STRANDS FOR FUSION APPLICATION WITH EITHER A DISTRIBUTED TA-NB DIFFUSION BARRIER DESIGN, OR WITH A SINGLE TA DIFFUSION BARRIER BETWEEN THE FILAMENTARY REGION AND THE STABILIZING COPPER SHELL.

3LP3E-10

STABILITY TEST RIG FOR EPOXY-IMPREGNATED SUPERCONDUCTING COILS ***A. WU****, Y. ZHAO, J. LI, X. HUANG, C. YANG, S. MINE, P. THOMPSON, M. XU, K. AMM, J. PAN, L. CHE;* GE GLOBAL RESEARCH. — A TEST RIG IS DEVELOPED FOR STABILITY TEST OF EPOXY-IMPREGNATED SUPERCONDUCTING COILS WITH CONDUCTIVE/ CONVECTIVE COOLING. THE TEST RIG CONSISTS OF FOUR SUB-SYSTEMS, VACUUM AND CRYOGENIC SYSTEM, TEST INSERT COILS, DATA ACQUISITION SYSTEM, ELECTRICAL AND QUENCH PROTECTION SYSTEM. IN EACH TEST, A PAIR OF IDENTICAL EPOXY-IMPREGNATED COILS ARE INDIVIDUALLY BONDED WITH COOLING TUBES, WHICH ARE CONNECTED WITH A CONVECTIVE CRYOGENIC COOLING SYSTEM. THESE TWO COILS ARE INSTALLED IN THE TEST RIG WITH ADJUSTABLE SUPPORTING BARS TO SEPARATE THE TWO COILS FOR SIMULATING THE EQUIVALENT PEAK FIELD AND STRESSES DURING NORMAL OPERATION. THE CRYOGENIC SYSTEM IS COMPOSED OF A VACUUM DEWAR, AN ALUMINUM THERMAL SHIELD, AND A LIQUID-HELIUM COOLING LOOP. THE THERMAL SHIELD WAS SPLIT TO MINIMIZE THE EDDY CURRENT FORCES. THIS TEST RIG ALLOWS DIFFERENT COIL PAIR DISTANCES BY USING FLEXIBLE BELLOWS WITHIN THE LIQUID HELIUM COOLING CIRCUIT. A PAIR OF COPPER/HTS LEADS WAS SPECIALLY DESIGNED TO APPLY THE RAMP CURRENT. A PAIR OF NBTI SUPERCONDUCTING COILS HAVE BEEN TESTED IN THIS TEST RIG TO VALIDATE THE WHOLE TEST SYSTEM. THE STABILITY OF COILS HAS BEEN EVALUATED BASED ON MAXIMUM CURRENT APPLIED AT SELF-PRODUCED FIELD.

3LP3F-01

USING OF SUPERCONDUCTING DEVICES OPERATING TOGETHER TO ENSURE THE DYNAMICAL STABILITY OF AN ELECTRIC POWER SYSTEM ***S. KOPYLOV****, N. BALASHOV, S. IVANOV, A. VESELOVSKY, V. ZHEMERIKIN;* JOINT INSTITUTION FOR HIGH TEMPERATURES, RAS. — AMONG THE SUPERCONDUCTING POWER DEVICES DEVELOPED TO THE PRESENT TIME FIRST OF ALL SHOULD BE SELECTED SUPERCONDUCTING MAGNETIC ENERGY STORAGE (SMES) AND SUPERCONDUCTING FAULT CURRENT LIMITERS (SFCL) SINCE THEY HAVE THE BEST TEST RESULTS BY THE OPERATION IN REAL ELECTRIC POWER SYSTEMS.THIS INVESTIGATION IS AIMED TO THE DEVELOPMENT OF SUPERCONDUCTING MAGNETIC SYSTEMS OF BOTH THESE DEVICES OPERATING IN A POWER SYSTEM TOGETHER WHAT FACILITATES THE SOLUTION OF TWO TASKS. THE FIRST ONE IS TO ASSURE THE DYNAMIC OF AN ELECTRIC POWER NETWORK ITSELF BY THE JOINT OPERATION OF SMES AND SFCL. THE SECOND ONE IS TO PROVIDE AN UNINTERRUPTED POWER SUPPLY TOGETHER WITH SAME ASSURANCE OF THE STABLE OPERATION FOR A POWER SYSTEM WITH THE SYNCHRONOUS LOAD, E.G., FOR REFINERIES, THE MAIN POWER CONSUMERS OF WHICH ARE SYNCHRONOUS MOTORS OPERATING IN PARALLEL.UNDER A FAULT EVENT WHICH DISTURBS THE NORMAL OPERATION WE UNDERSTAND HERE THE SUDDEN SHORT-CIRCUIT LEADING TO THE DISCONNECTING OF THE DAMAGED POWER TRANSMISSION LINE.

THIS WORK WAS SUPPORTED BY THE RUSSIAN FOUNDATION FOR BASIC RESEARCH.

3LP3F-02

TECHNO-ECONOMIC EVALUATION OF HYBRID ENERGY STORAGE TECHNOLOGIES FOR A SOLAR-WIND GENERATION SYSTEM ***L. REN****, Y. TANG, J. SHI, J. LI;* HUAZHONG UNIVERSITY OF SCIENCE AND TECHNOLOGY. — WITH ENERGY STORAGE AND GRID POWER QUALITY BECOMING INCREASINGLY IMPORTANT, MANY COUNTRIES ARE PLACING GREATER EMPHASIS ON CLEAN RENEWABLE SOURCES. IN 2010,

HUAZHONG UNIVERSITY OF SCIENCE AND TECHNOLOGY IS PLANNING TO ESTABLISH A HYBRID SOLAR-WIND GENERATION DYNAMIC SIMULATION LABORATORY. ENERGY STORAGE TECHNOLOGIES WILL BE VITAL TO THIS SYSTEM FOR LOAD LEVELING, POWER QUALITY CONTROL AND STABLE OUTPUT. IN THIS PAPER, THE TECHNICAL FEASIBILITY OF ENERGY STORAGE TECHNOLOGIES FOR RENEWABLE INTERMITTENT SOURCES LIKE WIND AND SOLAR GENERATION IS ANALYZED. FURTHERMORE, THE DIFFERENT COMBINATION MODES OF ENERGY STORAGE TECHNOLOGIES ARE PROPOSED. THE INVOLVED ENERGY STORAGE TECHNOLOGIES INCLUDE SUPERCONDUCTING MAGNETIC ENERGY STORAGE (SMES), FLYWHEELS (FWS), ELECTROCHEMICAL SUPERCAPACITORS (SCS) AND REDOX FLOW BATTERIES (RFBS). BASED ON THAT, THE ECONOMIC ANALYSIS OF HYBRID ENERGY STORAGE TECHNOLOGIES IS CONDUCTED.

THIS WORK WAS SUPPORTED IN PART BY KEY PROJECT OF NATIONAL NATURAL SCIENCE FOUNDATION OF CHINA UNDER GRANT 50937002 AND NATIONAL BASIC RESEARCH PROGRAM OF CHINA-973 PROGRAM UNDER GRANT 2009CB219702.

3LP3F-03

STUDY ON WIND-TURBINE GENERATOR SYSTEM SIZING CONSIDERING OVERCURRENT RELAY COORDINATION WITH SFCL *H. LEE, G. SON,* ***J. PARK****;* YONSEI UNIVERSITY. — THIS PAPER DESCRIBES THE STUDY TO ANALYZE THE EFFECT OF THE SUPERCONDUCTING FAULT CURRENT LIMITER (SFCL) ON OPTIMAL SIZING OF THE WIND-TURBINE GENERATOR SYSTEM (WTGS), WHICH IS A REPRESENTATIVE RENEWABLE ENERGY SOURCE. WHEN THE WTGS IS CONNECTED TO A RADIAL DISTRIBUTION SYSTEM, IT INCREASES THE LEVEL OF FAULT CURRENT DURING A CONTINGENCY. THEN, THIS INCREASED FAULT CURRENT CAN REDUCE THE COORDINATION TIME INTERVALS (CTIS) BETWEEN THE MULTIPLE OVERCURRENT RELAYS, WHICH ARE THE IMPORTANT FACTOR IN DETERMINING THE OPTIMAL SIZE OF THE WTGS. MOREOVER, ITS MAXIMUM CAPACITY ARE ALSO RESTRICTED BY THE ASSOCIATED FAULT CURRENT LEVEL AND CTIS IN A POWER SYSTEM.HOWEVER, THE SFCL CAN LIMIT THE FAULT CURRENT IN THE EXISTENCE OF WTGS, AND THUS RESTORE THE ORIGINAL RELAY COORDINATION. CONSEQUENTLY, THIS PROVIDES A CHANCE TO INCREASE THE MAXIMUM CAPACITY OF WTGS. THE CASE STUDY IS CARRIED OUT TO VERIFY THAT THE SFCL CAN BE PREFERABLY APPLIED IN DETERMINING THE OPTIMAL SIZE OF WTGS UNDER THE TIGHTLY CONSTRAINED CONDITIONS RESULTING FROM THE REQUIRED PROTECTIVE RELAY COORDINATION PROBLEMS.

THIS WORK WAS SUPPORTED BY MANPOWER DEVELOPMENT PROGRAM FOR ENERGY & RESOURCES OF MKE WITH YONSEI ELECTRIC POWER RESEARCH CENTER (YEPRC) AT YONSEI UNIVERSITY, SEOUL, KOREA.

3LP3F-04

ANALYSIS OF UNBALANCED THREE-PHASE CURRENT DISTRIBUTION IN HTS POWER CABLE ***J. KIM****[1], J. KIM[2], M. PARK[2], I. YU[2];* [1]CENTER FOR ADVANCED POWER SYSTEMS, [2]CHANGWON NATIONAL UNIVERSITY. — A THREE-PHASE POWER SYSTEM IS CALLED BALANCED OR SYMMETRICAL IF THE THREE-PHASE CURRENTS HAVE THE SAME AMPLITUDE AND ARE PHASE SHIFTED BY 120 DEGREE WITH RESPECT TO EACH OTHER. IF EITHER OR BOTH OF THESE CONDITIONS ARE NOT MET, THE SYSTEM IS CALLED UNBALANCED OR ASYMMETRICAL. AN IMPORTANT PROPERTY OF A THREE-PHASE BALANCED POWER SYSTEM IS THAT THE PHASOR SUM OF THE THREE LINE OR PHASE VOLTAGE IS ZERO, AND THE PHASOR SUM OF THE THREE LINE OR PHASE CURRENT IS ZERO. WHEN THE THREE LOAD IMPEDANCES ARE NOT EQUAL TO ONE ANOTHER, THE PHASOR SUMS AND THE NEUTRAL CURRENT ARE NOT ZERO, AND THE LOAD IS, THEREFORE, UNBALANCED.THE UNBALANCE OF THE CURRENTS FLOW THE HTS POWER CABLE CAUSED BY ASYMMETRICAL FAULT, HARMONICS AND UNBALANCED LOAD. THAT PROBLEM CAUSES ADDITIONAL LOSS AND LEAKAGE FIELD IN THE HTS POWER CABLE, AND DETERIORATES THE ELECTRIC POWER QUALITY AND STABILITY.THIS PAPER PRESENTS AN ANALYSIS UNBALANCED THREE-PHASE CURRENT DISTRIBUTION IN HTS POWER CABLE CAUSED BY UNBALANCED LOAD CONDITION AND GROUNDING METHODS USING PSCAD/EMTDC. THE RESULTS OBTAINED THROUGH THE ANALYSIS WOULD PROVIDE IMPORTANT DATA FOR THE DESIGN OF HTS POWER CABLES AND VALID INFORMATION FOR THEIR INSTALLATION IN POWER SYSTEM.

3LP3F-05

STOCHASTIC METHOD FOR THE OPERATION OF POWER SYSTEMS WITH WIND GENERATORS AND SUPERCONDUCTING MAGNETIC ENERGY STORAGE (SMES) ***J. LEE****, J. KIM, S. JOO;* KOREA UNIVERSITY. — VARIOUS ENERGY STORAGE SYSTEMS HAVE BEEN ADOPTED IN POWER SYSTEMS FOR ECONOMIC AND RELIABILITY REASONS. IN ORDER TO MAINTAIN THE RELIABILITY OF POWER SYSTEMS, RESERVE POWER NEEDS TO BE SCHEDULED AGAINST POSSIBLE GENERATION UNIT OUTAGES. THE VARIATION OF WIND POWER OUTPUTS ALSO REQUIRES THE ADDITIONAL RESERVE POWER IN ADDITION TO THE RESERVE FOR THE POSSIBLE GENERATION UNIT OUTAGES. THE SUPERCONDUCTING MAGNETIC ENERGY STORAGE (SMES) HAS A POTENTIAL FOR PROVIDING THE EXTRA POWER TO MEET THE RESERVE REQUIREMENTS IN POWER SYSTEMS WITH WIND POWER GENERATORS. THIS PAPER PRESENTS A STOCHASTIC METHOD FOR THE OPTIMAL OPERATION OF POWER SYSTEMS WITH VOLATILE WIND GENERATION AND SMES. NUMERICAL SIMULATION RESULTS ARE PRESENTED TO DEMONSTRATE THE EFFECTIVENESS OF THE PROPOSED METHOD.

THIS WORK WAS SUPPORTED BY THE NATIONAL RESEARCH FOUNDATION OF KOREA (NRF) GRANT FUNDED BY THE KOREA GOVERNMENT (MEST) (2009-0077634).

3LP3F-06

HIGH-TEMPERATURE SUPERCONDUCTING ENERGY STORAGE SYSTEMS FOR WIND FARMS AND ITS INTEGRATION WITH SMART GRID ***E. LEE****;* HARVARD UNIVERSITY. — THIS PAPER PROVIDES AN INTEGRATIVE MULTI-DISCIPLINARY

FRAMEWORK FOR ACHIEVING THE EFFECTIVE UTILIZATION OF INTERMITTENT DISTRIBUTED ENERGY RESOURCES IN THE POWER GRID. THE EFFORT IS ORGANIZED AROUND A UTILITY-CENTRIC SYSTEMS-LEVEL APPROACH WHERE THE DESIGN OF THE ENERGY STORAGE IS DRIVEN BOTH BY THE OPERATIONAL NEEDS OF THE POWER GRID AS WELL AS THE OPERATIONAL CONSTRAINTS OF WIND GENERATION SYSTEMS. THE EFFORT IS FOCUSED ON ANSWERING BASIC SCIENCE RESEARCH QUESTIONS IN HIGH-TEMPERATURE SUPERCONDUCTING MATERIALS, MOTIVATED BY THE DESIGN REQUIREMENTS FOR HTS FLYWHEEL ENERGY STORAGE SYSTEMS, WHOSE OPERATIONAL REQUIREMENTS ARE DETERMINED BY THE INTERMITTENCY OF WIND POWER AND THE STABILITY AND SECURITY OF THE POWER GRID. HTS-MAGNET FLYWHEEL ENERGY STORAGE SYSTEMS HAVE THE POTENTIAL (ENERGY DENSITY, CHARGE AND DISCHARGE CHARACTERISTICS) TO MITIGATE THE ADVERSE AFFECTS OF INTERMITTENCY OF WIND POWER IN THE SUPPLY OF ELECTRICAL ENERGY TO THE GRID. ADVANCES IN MATERIALS RESEARCH AND ENGINEERING DESIGN, IN CONJUNCTION WITH REAL-TIME DISTRIBUTED CONTROL OF HTS FLYWHEEL ENERGY STORAGE SYSTEMS AND GRID-TIE INTERFACE WILL PROVIDE A TRANSFORMATIONAL APPROACH TO ENERGY STORAGE AND RETRIEVAL LEADING THE WAY TOWARD INCREASING THE CAPACITY FACTOR OF WIND FARMS, ENHANCING THEIR EFFECTIVENESS IN PEAK LOAD SHAVING PEAK THROUGH STABILITY AUGMENTATION.

3LP3F-08

IMPACTS OF SUPERCONDUCTING CABLES ON THE DYNAMIC RESPONSE OF CURRENT TRANSFORMERS AND PROTECTIVE RELAYING DEVICES ***B. K. JOHNSON***[1]*, N. FISCHER*[2]*, Y. XIA*[1]*;* [1]UNIVERSITY OF IDAHO, [2]SCHWEITZER ENGINEERING LABORATORIES. — REPLACING CONVENTIONAL AC TRANSMISSION LINES WITH SUPERCONDUCTING CABLES PROVIDES PERFORMANCE ADVANTAGES SINCE SUPERCONDUCTING CABLES HAVE LOWER SERIES INDUCTANCE AND VERY LOW AC RESISTANCE. HOWEVER, THE VERY LOW RESISTANCE WILL ALSO HAVE AN IMPACT ON THE DYNAMIC RESPONSE OF CURRENT TRANSFORMERS (CTS) AND ON THE RESPONSE OF PROTECTIVE RELAYS THAT PROCESS THEIR CURRENT MEASUREMENTS. WHENEVER A SHORT CIRCUIT OCCURS ON AN AC POWER SYSTEM THE RESULTING CURRENT WILL HAVE BOTH FUNDAMENTAL FREQUENCY AC RESPONSE AND A DECAYING DC OFFSET. THE AMPLITUDE OF THE DC OFFSET IS DEPENDENT ON THE POINT ON THE AC VOLTAGE WAVE WHERE THE FAULT OCCURS, WHICH IS RANDOM. THE RATE OF THIS DECAY DEPENDS ON THE R-L TIME CONSTANT OF THE AC CIRCUIT INVOLVED IN THE CURRENT PATH. A LARGER TIME CONSTANT INCREASES THE ODDS THAT A CT WILL ENTER SATURATION. SUPERCONDUCTING CABLES WILL INCREASE THE R-L TIME CONSTANT, AND POTENTIALLY INCREASE THE SEVERITY OF CT SATURATION, CREATING ERROR IN THE SECONDARY CURRENT USED BY THE PROTECTIVE RELAYS. FOR MANY PROTECTION FUNCTIONS THIS ERROR WILL DELAY THE PROTECTIVE ACTION, BUT IN A FEW CASES IT MAY CAUSE CIRCUIT BREAKERS TO TRIP IN ERROR. THIS PAPER WILL MODEL A SAMPLE SYSTEM WITH DIFFERING LEVELS OF PENETRATION OF SUPERCONDUCTING CABLES AND LOOK AT THE IMPACT OF THE SUPERCONDUCTING CABLES ON THE DYNAMIC CT RESPONSE AND ON DIFFERENT PROTECTIVE RELAY FUNCTIONS AND DISCUSS POTENTIAL SOLUTIONS.

3LP3G-01

PARAMETER OPTIMIZATION OF SFCL WITH WIND-TURBINE GENERATION SYSTEM CONSIDERING ITS PROTECTIVE COORDINATION *W. PARK, B. SUNG,* ***J. PARK****;* YONSEI UNIVERSITY. — THIS PAPER DESCRIBES A STUDY TO DETERMINE THE OPTIMAL RESISTANCE OF A SUPERCONDUCTING FAULT CURRENT LIMITER (SFCL) CONNECTED TO THE WIND-TURBINE GENERATION SYSTEM (WTGS) IN SERIES CONSIDERING ITS PROTECTIVE COORDINATION. THE CONNECTION OF THE WTGS TO AN ELECTRIC POWER GRID MAY HAVE THE SERIOUS EFFECTS ON THE STABILITY AND RELIABILITY OF OVERALL SYSTEM DURING A CONTINGENCY DUE TO THE INCREASE OF FAULT CURRENTS. MOREOVER, IT CAUSES TO MALFUNCTION THE EXISTING COORDINATION OF THE PROTECTIVE DEVICES SUCH AS THE OVERCURRENT RELAYS (OCRS). TO DEAL WITH THIS PROBLEM, THE SFCL IS APPLIED TO REDUCE THE LEVEL OF FAULT CURRENT INCREASED BY THE CONNECTION OF WTGS. THEN, TO DETERMINE ITS OPTIMAL PARAMETER, THE PROTECTIVE COORDINATION BETWEEN THE EXISTING MULTIPLE OCRS IS STUDIED BASED ON THE COMPUTATION OF FAULT CURRENT BY USING THE EQUIVALENT VOLTAGE SOURCE METHOD.THE EFFECTIVENESS OF THE OPTIMAL RESISTANCE FOR THE SFCL IS EVALUATED BY THE TIME-DOMAIN SIMULATION THROUGH THE POWER SYSTEMS COMPUTER AIDED DESIGN/ELECTROMAGNETIC TRANSIENTS INCLUDING DC (PSCAD/EMTDC®) SOFTWARE. THE RESULTS SHOW THAT THE PROTECTIVE COORDINATION IS WELL MAINTAINED WITHOUT CHANGING THE PREVIOUS SETTINGS OF EXISTING OCRS BY APPLYING THE SFCL WITH ITS OPTIMAL PARAMETER. THEREFORE, THE SYSTEM CAN KEEP ITS SUITABLE RELIABILITY EVEN WHEN THE LEVEL OF FAULT CURRENT IS INCREASED BY CONNECTING THE WTGS TO THE POWER SYSTEM.

THIS WORK WAS SUPPORTED BY MANPOWER DEVELOPMENT PROGRAM FOR ENERGY & RESOURCES OF MKE WITH YONSEI ELECTRIC POWER RESEARCH CENTER (YEPRC) AT YONSEI UNIVERSITY, SEOUL, KOREA.

3LP3G-02

FAULT CURRENT CONSTRAINED DECENTRALIZED OPTIMAL POWER FLOW INCORPORATING SUPERCONDUCTING FAULT CURRENT LIMITER (SFCL) ***G. MOON****, Y. WI, K. LEE, S. JOO;* KOREA UNIVERSITY. — THE ADDITION OF NEW GENERATION CAPACITY INCREASES THE FAULT CURRENT LEVELS IN POWER SYSTEMS. FAULT CURRENT CONSTRAINTS ARE IMPOSED ON NEW GENERATION AND TRANSMISSION CAPACITY ADDITIONS. THE SUPERCONDUCTING FAULT CURRENT LIMITER (SFCL) HAS A POTENTIAL AS A SPECIAL PROTECTION DEVICE TO LIMIT THE FAULT CURRENT IN THE EVENT OF A FAULT IN POWER SYSTEMS. INSTALLATIONS OF SFCLS CAN ALTER FAULT CURRENT LEVELS IN POWER SYSTEMS, THEREBY INFLUENCING THE POWER SYSTEM PLANNING. THIS PAPER PRESENTS FAULT CURRENT CONSTRAINED DECENTRALIZED OPTIMAL POWER

FLOW (OPF) FOR POWER SYSTEM PLANNING INCORPORATING THE SFCL. THE NUMERICAL SIMULATION RESULTS ARE PRESENTED TO SHOW THE EFFECTIVENESS OF THE PROPOSED METHOD.

3LP3G-03

ASSESSMENT OF THE IMPACT OF SFCL ON VOLTAGE SAGS IN POWER DISTRIBUTION SYSTEM ***J. MOON***[1]*, S. YUN*[2]*, S. LIM*[3]*, J. KIM*[3]*;* [1]CHUNGJU NATIONAL UNIVERSITY, [2]KOREA ELECTRIC POWER RESEARCH INSTITUTE, [3]SOONGSIL UNIVERSITY. — THIS PAPER ASSESSES AND ANALYZES THE EFFECTS OF SUPERCONDUCTING FAULT CURRENT LIMITER (SFCL) INSTALLED IN POWER DISTRIBUTION SYSTEM ON VOLTAGE SAGS. MANY VOLTAGE SAGS IN A TYPICAL POWER DISTRIBUTION SYSTEM COME FROM VOLTAGE DROP ACCORDING TO FAULT CURRENT INCREASED BY FAULTS OF POWER SYSTEM. IF SFCL IS INSTALLED IN POWER DISTRIBUTION SYSTEM, THE FAULT CURRENT DECREASES BASED ON LOCATION AND IMPEDANCE VALUE OF SFCL AND ULTIMATELY VOLTAGE SAGS ARE IMPROVED. THUS, IN THIS PAPER, IMPROVEMENT OF VOLTAGE SAG IS ANALYZED ACCORDING TO THE LOCATION AND IMPEDANCE VALUE OF SFCL USING INFORMATION OF TECHNOLOGY INDUSTRY COUNCIL(ITIC) CURVE. FIRST OF ALL, RESISTOR-TYPE SFCL IS MODELED USING PSCAD/EMTDC TO REPRESENT THE QUENCH AND RECOVERY CHARACTERISTICS BASED ON THE EXPERIMENTAL RESULTS. NEXT, TYPICAL POWER DISTRIBUTION SYSTEM OF KOREA IS MODELED. FINALLY, WHEN THE SFCL IS INSTALLED IN VARIOUS LOCATIONS SUCH AS THE STARTING POINT OF FEEDERS, THE MIDDLE POINT OF BUS, AND THE SECONDARY SIDE OF MAIN TRANSFORMER(MTR) AT SUBSTATION, IMPROVEMENT OF VOLTAGE SAG IS EVALUATED USING SOME SAG EVALUATION METHODS WHEN A FAULT OCCUR. AS A RESULT, VOLTAGE SAG IS MORE IMPROVED IN CASE THAT SFCL IS INSTALLED IN THE STARTING POINT OF FEEDER THAN FEEDER END, THE IMPEDANCE OF SFCL IS LARGER THAN SMALL, AND THE TYPE OF SFCL IS RESISTANCE THAN REACTANCE.

THIS WORK HAS BEEN SUPPORTED BY KESRI(R-2008-38), WHICH IS FUNDED BY MKE(MINISTRY OF KNOWLEDGE ECONOMY)

3LP3G-04

FEASIBILITY ANALYSIS OF THE POSITIONING OF SUPERCONDUCTING FAULT CURRENT LIMITERS FOR THE SMART GRID APPLICATION USING SIMULINK AND SIMPOWERSYSTEMS ***U. A. KHAN****, J. K. SEONG, S. H. LEE, B. W. LEE;* HANYANG UNIVERSITY. — ONE OF THE MOST IMPORTANT TOPICS REGARDING THE APPLICATION OF SUPERCONDUCTING FAULT CURRENT LIMITERS(SFCL) IN FUTURE SMART GRID IS RELATED TO ITS EFFECT ON THE RENEWABLE ENERGY RESOURCES CONNECTED WITH THE GRID AT DISTRIBUTION LEVEL. HOWEVER, A SHORTAGE OF RESEARCH CONCERNING POSITIONING OF SFCL IN SMART GRID IS FELT. IN THIS WORK, A GENERALIZED SFCL MODEL WAS DESIGNED BY INTEGRATING SIMULINK AND SIMPOWERSYSTEM BLOCKS IN MATLAB. THE DESIGNED FCL MODEL COULD BE USED IN DETERMINING THE IMPEDANCE LEVEL OF SFCL ACCORDING TO THE FAULT-CURRENT-LIMITATION REQUIREMENTS OF A PARTICULAR SMART GRID. MOREOVER, A COMPLETE POWER NETWORK INCLUDING GENERATION, TRANSMISSION AND DISTRIBUTION WAS ALSO MODELED TO DETERMINE THE PERFORMANCE OF SFCL IN SMART GRID. THE DISTRIBUTION NETWORK OF THE MODEL HAS A WIND TURBINE ATTACHED TO IT FORMING A MICRO GRID. THREE PHASE FAULTS HAVE BEEN SIMULATED AT VARIOUS LOCATIONS ALONG WITH PLACING FCL MODELS AT KEY POINTS OF THE DISTRIBUTION GRID. IT WAS OBSERVED THAT DISTRIBUTION GRID HAVING DISTRIBUTED GENERATION SOURCES ATTACHED TO IT MUST NOT HAVE A SINGLE FCL LOCATED AT THE SUBSTATION LEVEL AS IT CAN CAUSE ABNORMAL FAULT CURRENT GENERATION FROM THE RENEWABLE POWER SOURCES. DIFFERENT HTS FCL LOCATION ARRANGEMENTS HAVE BEEN SIMULATED AND THE RESULTS HAVE BEEN COMPARED. CONSEQUENTLY, THE BEST ARRANGEMENT OF HTS FCL LOCATION IN SMART GRID HAS BEEN PROPOSED.

THIS WORK WAS SUPPORTED BY THE RESEARCH FUND OF HANYANG UNIVERSITY(HY-2008-T)

3LP3G-05

OPTIMAL PLACEMENT OF SUPERCONDUCTING FAULT CURRENT LIMITERS IN THE DISTRIBUTION POWER SYSTEM USING DESIGN OF EXPERIMENT METHOD ***S. B. RHEE***[1]*, B. W. LEE*[2]*;* [1]SUNGKYONKWAN UNIVERSITY, [2]HANYANG UNIVERSITY. — THIS PAPER PRESENTS A NEW METHODOLOGY TO EVALUATE IN AN OPTIMAL PLACEMENT CONFIGURATION OF SUPERCONDUCTING FAULT CURRENT LIMITERS (SFCLS) IN DISTRIBUTION POWER SYSTEMS. THE PROPOSED ALGORITHM IS BASED ON HEURISTIC SEARCH MANNER WITH DESIGN OF EXPERIMENT (DOE) METHOD. SOME COMPUTATIONAL ASPECTS RELATED WITH THE IMPLEMENTATION OF THE PROPOSED ALGORITHM IN TYPICAL DISTRIBUTION NETWORKS ARE ALSO DISCUSSED. OPTIMAL PLACEMENT OF SFCLS COULD BE DETERMINED BY SENSITIVITY ANALYSIS OF THE POWER FLOW EQUATIONS. THE SIZING METHOD FOR A SET OF LOADING CONDITIONS, GENERATION PENETRATION LEVEL AND POWER FACTOR IS FORMULATED AS A SECURITY CONSTRAINED OPTIMIZATION PROBLEM. THE INFORMATION ON OPTIMAL SITES OF SFCLS SHOULD BE USED FURTHER TO OPTIMIZE SYSTEM RELIABILITY ACCESSED VIA RELIABILITY INDICES CALCULATION. THE DESCRIPTION OF THE PROPOSED ALGORITHM WAS CARRIED OUT USING A SAMPLE TEST SYSTEM OF KOREA AND THE RESULTS OBTAINED WITH A TYPICAL CONFIGURATION OF A TEST SYSTEM ARE PRESENTED AND DISCUSSED.

3LP3G-06

A TECHNICAL FEASIBILITY STUDY ON HTS CABLE AND SFCL FIELD DEMONSTRATION IN SOUTH KOREA ***B. YANG***[1]*, Y. WON*[1]*, J. CHOI*[1]*, C. JUNG*[1]*, S. LEE*[2]*, J. YOON*[2]*;* [1]KEPCO, [2]KERI. — UNTIL NOW SOME COUNTRIES INCLUDING SOUTH KOREA HAVE MADE BIG PROGRESS AND MANY EFFORTS IN THE DEVELOPMENT OF HTS POWER EQUIPMENTS, ESPECIALLY HTS

CABLE AND SFCL SYSTEMS ARE THE STRONGEST CANDIDATES AMONG THEM FROM THE VIEWPOINT OF APPLYING TO REAL GRID.IN SOUTH KOREA, HTS CABLE AND SFCL HAVE BEEN INSTALLED IN TEST FIELDS AND TESTED SUCCESSFULLY. IN ORDER TO MEET PRACTICAL REQUIREMENTS AND BE FEASIBLE IN REAL GRID, DEMONSTRATION PROJECT FOR HTS CABLE AND SFCL SYSTEMS, CALLED GENI PROJECT HAS BEEN INITIATED TO INSTALL 23KV HTS CABLE AND SFCL SYSTEMS IN A UTILITY NETWORK IN KOREA SINCE 2008.THIS PROJECT SAYS A TECHNICAL FEASIBILITY STUDY FOR APPLYING A 23KV 50MVA 3-PHASE CABLE SYSTEM AND TWO 23KV 630A/3KA SFCL SYSTEMS INTO ICHEON SUBSTATION, REAL GRID, BY USING MODELING AND SIMULATION OF HTS CABLE AND SFCL.

THIS RESEARCH WAS SUPPORTED BY A GRANT FROM KOREA INSTITUTE OF ENERGY TECHNOLOGY EVALUATION AND PLANNING FUNDED BY THE MINISTRY OF KNOWLEDGE ECONOMY, REPUBLIC OF KOREA

3LP3G-07

ANALYSIS ON PROTECTION COORDINATION OF HYBRID SFCL WITH PROTECTIVE DEVICES IN A POWER DISTRIBUTION SYSTEM ***S. LIM****, J. KIM, I. YOU, J. KIM, M. KIM, S. WANG;* SOONGSIL UNIVERSITY. — IN CASE THAT THE FAULT HAPPENS IN THE POWER SYSTEM WITH THE HYBRID SUPERCONDUCTING FAULT CURRENT LIMITER (SFCL), THE FAULT CURRENT CAN BE LIMITED BY THE HYBRID SFCL AND, IF THE FAULT CONTINUES, CAN BE INTERRUPTED BY THE CIRCUIT BREAKER (CB) AFTER SEVERAL CYCLES. HOWEVER, SINCE THE FAULT CURRENT IS DECREASED BY THE CURRENT LIMITING RESISTOR (CLR) COMPRISING THE HYBRID SFCL, THE TRIP SIGNAL OF THE OVER CURRENT RELAY (OCR) FOR THE INTERRUPTION OF THE CB CAN BE DELAYED AND THE DELAYED OPERATION OF THE OCR CAN RESULT IN THE FAILURE OF THE PROTECTION COORDINATION WITH THE BACKUP PROTECTIVE DEVICE AS WELL. THEREFORE, THE CLR IN THE HYBRID SFCL IS REQUIRED TO BE DESIGNED WITHIN THE LIMITED RESISTANCE AMPLITUDE TO KEEP THE PROTECTION COORDINATION WITH THE CONVENTIONAL PROTECTIVE DEVICES. IN THIS PAPER, THE PROTECTION COORDINATION OF THE HYBRID SFCL WITH THE PROTECTIVE DEVICES WILL BE ANALYZED THROUGH THE EXPERIMENTS. THROUGH THE ANALYSIS ON THE EXPERIMENTAL RESULTS, THE VARIOUS COMPONENTS COMPRISING THE HYBRID SFCL AS WELL AS THE CLR WILL BE SHOWN TO AFFECT THE PROTECTION COORDINATION OF THE HYBRID SFCL WITH THE PROTECTIVE DEVICES AND THE METHOD TO KEEP THE PROTECTION COORDINATION BETWEEN THE HYBRID SFCL AND THE PROTECTIVE DEVICES WILL BE DISCUSSED.

THIS WORK HAS BEEN SUPPORTED BY KESRI(R-2008-38), WHICH IS FUNDED BY MKE(MINISTRY OF KNOWLEDGE ECONOMY)

3LP3G-08

STUDY ON PROTECTION COORDINATION OF SUPERCONDUCTING FAULT CURRENT LIMITER APPLIED INTO KEPCO GRID *J. KIM[1], **S. LIM**[1], J. KIM[1], O. HYUN[2];* [1]SOONGSIL UNIVERSITY, [2]KOREA ELECTRIC POWER RESEARCH INSTITUTE. — IN THIS PAPER, THE EFFECTS ON THE PROTECTION COORDINATION OF A SUPERCONDUCTING FAULT CURRENT LIMITER (SFCL) WITH THE PROTECTION DEVICES WAS REPORTED. THE SFCL IS EXPECTED TO BE AN EFFECTIVE SOLUTION TO REDUCE THE FAULT CURRENT. HOWEVER, THE FAULT CURRENT IS LIMITED BECAUSE THE SFCL GENERATE THE IMPEDANCE INSTANTLY AFTER THE FAULT HAPPENS AND IF THE FAULT CONTINUES, THE INTERRUPTION TIME OF THE PROTECTION DEVICES, WHICH GENERALLY HAS REVERSE TIME-CURRENT CHARACTERISTIC IN THE DISTRIBUTION POWER SYSTEM, IS DELAYED BY THE IMPEDANCE OF THE SFCL.TO INVESTIGATE THE OPERATION TEST OF THE SFCL AND TO RESEARCH THE SEVERAL TECHNICAL PROBLEMS SUCH AS PROTECTION COORDINATION WITH CONVENTIONAL PROTECTION DEVICES, THE SFCL HAS BEEN TESTED IN THE GO-CHANG POWER TEST FIELD, KOREA. IN ORDER TO SOLVE THE PROTECTION COORDINATION, THE OPERATION CHARACTERISTICS OF THE CONVENTIONAL PROTECTION DEVICES WITH THE SFCL ARE ANALYZED FROM THE CASE STUDIES ON THE RE-CONFIGURATION OF THE LINES AND SWITCHES IN THE GO-CHANG POWER TEST FIELD. THE METHOD FOR THE OPERATION OF THE PROTECTION COORDINATION WITH THE SFCL IS PROPOSED AND CONFIRMED THROUGH THE SIMULATIONS BETWEEN THE SFCL AND THE PROTECTION DEVICE.

3LP3H-01

A NOVEL DUAL-FCL CONNECTION FOR NEWLY-ADDED DISTRIBUTED GENERATIONS CONNECTED WITH THE UTILITIES ***Y. ZHANG****, R. DOUGAL;* UNIVERSITY OF SOUTH CAROLINA. — A NOVEL DUAL-FCL CONNECTION IS PROPOSED FOR CONNECTING NEWLY-ADDED DISTRIBUTED GENERATIONS (DGS) WITH THE UTILITIES. THE OPERATION AND CONTROL SCHEME OF THIS CONNECTION ARE INTRODUCED AND ANALYZED. ONLY ONE COOLING SYSTEM IS REQUIRED TO REDUCE THE COMPLEXITY AND VOLUME OF DEVICES. THE DUAL-FCL CONNECTION CAN NOT ONLY MINIMIZE FAULT CURRENT CONTRIBUTIONS FROM THE DGS TO AVOID DISTURBING THE PROTECTION RELAY SCHEMES OF THE UTILITIES, BUT CAN ALSO IMPROVE THE SYNCHRONISM BETWEEN DGS AND THE UTILITIES. THESE EFFECTS ARE VALIDATED BY SIMULATIONS OF A 36 MW, 4.16 KV TURBINE GENERATOR CONNECTED TO AN INFINITE SYSTEM. THIS DUAL-FCL CONNECTION REDUCES FAULT CURRENT CONTRIBUTION BY 97% (FROM 41 KA TO 1 KA), AND MAINTAINS THE CIRCUIT BREAKERS ON DUTY WHEN A THREE-PHASE FAULT OCCURS AT THE BUS CONNECTED TO DG. OTHERWISE, WHEN A THREE-PHASE FAULT OCCURS IN THE INFINITE SYSTEM, THIS CONNECTION LIMITS FAULT CURRENT CONTRIBUTION OF DG FROM 4.8 KA TO 0.4 KA, AND FREQUENCY OSCILLATION OF DG FROM 0.14 HZ TO 0.01 HZ. THE POWER CONTINUITY IN THE LOCAL NETWORK IS IMPROVED, DUE TO THE VOLTAGE SAG AT THE BUS CONNECTED TO DG IS REDUCED BY 96% (FROM 851 V TO 32 V) DURING AND AFTER SERIOUS SHORT-CIRCUIT FAULTS.

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3LP3H-02

OPTIMAL DESIGN SPECIFICATION OF 22.9KV HTS FCL APPLIED IN REAL KOREAN POWER SYSTEM ***J. YOON;*** KERI. — ABSTRACT: FROM THIS YEAR 2010, KEPCO DECIDED TO APPLY THE HTS FCL AND CABLE IN REAL SUBSTATION. THIS IS THE FIRST EXHIBITION CASE AND STARTING POINT OF THE HTS EQUIPMENT IN SOUTH KOREA, EVEN THOUGH THIS IS NOT GENERAL COMMERCIALIZATION. FOR SUCCESSFUL APPLYING ON THIS COMMERCIALIZATION STARTING, IT IS QUITE IMPORTANT TO DESIGN THE HTS FCL SPECIFICATION CONSIDERING CURRENT STATUS OF THE KOREAN POWER SYSTEM, FOR EXAMPLE THE EXISTENCE OF NGR (NEUTRAL GROUNDING REACTOR), 3-WINDING LOW % IMPEDANCE AND SO ON. THIS PAPER EVALUATES THE NECESSARY AND SUFFICIENT DESIGN SPECIFICATIONS OF THE 22.9KV HTS FCL TO FULFILL THE REAL POWER SYSTEM CONDITIONS. IT IS INVESTIGATED TO THE DETAILED DESIGN CRITERIA, SHORT CIRCUIT CAPACITY, FCL IMPEDANCE, PROTECTION SCHEME, FAULT LIMITING TYPE AND OTHER DESIGN PARAMETERS CONSIDERING THE REAL STATUS OF ICHEON SUBSTATION WHICH WILL BE APPLIED THE HTS FCL.

THE AUTHORS WOULD LIKE TO EXPRESS THEIR GRATITUDE WITH SPECIAL THANKS TO THE CENTER FOR APPLIED SUPERCONDUCTIVITY TECHNOLOGY IN KOREA FOR THEIR FINANCIAL SUPPORT AND COOPERATION

3LP3H-03

PROTECTIVE RELAY TESTS OF HYBRID SFCLS IN A KOREAN DISTRIBUTION POWER SYSTEM USING RTDS ***S. LEE[1], J. YOON[1], B. LEE[2];*** [1]KERI (KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE), [2]KOREA UNIVERSITY. — THE PROTECTIVE RELAY SYSTEM IS ONE OF IMPORTANT TECHNICAL ISSUES IN POWER SYSTEMS APPLYING SUPERCONDUCTING FAULT CURRENT LIMITER (SFCL). WE USED REAL TIME DIGITAL SIMULATOR (RTDS) TO STUDY ACCURATELY THE INTERACTION OF THE PROTECTION SYSTEM WITH POWER SYSTEMS. RTDS MODELING OF SFCL IS NECESSARY FOR DETAILED PROTECTIVE RELAY TESTS. IN THIS PAPER, WE DEVELOPED AN ANALYSIS MODEL USING RTDS FOR STUDYING THE TRANSIENT BEHAVIOR OF 22.9KV SFCL AND CARRIED OUT CLOSED-LOOP TESTING OF PROTECTIVE RELAYS IN A DISTRIBUTION POWER SYSTEM WITH THE DEVELOPED SFCL MODEL. THE SFCL MODEL HAS THE OPERATION MECHANISM OF 22.9KV HYBRID SFCL UNDER DEVELOPMENT BY LSIS (LS INDUSTRIAL SYSTEMS CO., LTD.) AND KEPRI (KOREA ELECTRIC POWER RESEARCH INSTITUTE) IN KOREA. THE PARAMETERS OF THE MODEL ARE BASED ON THE TEST DATA OF REAL SFCL. POWER SYSTEM PLANNERS AND OPERATORS CAN SOLVE PROBLEMS EXPECTED IN THE APPLICATION OF SFCL TO POWER SYSTEMS USING PROTECTIVE RELAY TESTING RESULTS.

THIS RESEARCH WAS SUPPORTED BY A GRANT FROM GENI PROJECT FUNDED BY KEPCO AND MINISTRY OF KNOWLEDGE ECONOMY, REPUBLIC OF KOREA.

3LP3H-04

EVALUATION OF THE IMPACT OF SUPERCONDUCTING FAULT CURRENT LIMITERS ON POWER SYSTEM NETWORK PROTECTIONS USING A RTS-PHIL METHODOLOGY ***M. M. DIONE****, F. SIROIS;*** ECOLE POLYTECHNIQUE DE MONTREAL. — PLANNING THE INTEGRATION OF A SUPERCONDUCTING FAULT CURRENT LIMITER (SFCL) IN AN ELECTRIC POWER NETWORK MAINLY CONSISTS IN PREDICTING THE CURRENT LIMITING CHARACTERISTICS IN ANY FAULT CONDITION, IN ORDER TO SET THE PROTECTION RELAYS ACCORDINGLY. DUE TO THE VERY NON LINEAR BEHAVIOR OF THE SFCL, MODIFICATIONS TO THE SETTINGS OF EXISTING PROTECTION RELAYS ARE EXPECTED. TO EXPLORE THE POTENTIAL CHANGES, WE USED A REAL-TIME SIMULATION (RTS) METHODOLOGY WITH POWER-HARDWARE-IN-THE-LOOP (PHIL) CAPABILITIES (I.E. CIRCUIT SIMULATOR COUPLED WITH POWER AMPLIFIERS FOR DRIVING EXTERNAL PHYSICAL POWER DEVICES). THE RTS-PHIL IS A POWERFUL APPROACH THAT ALLOWS INCORPORATING THE ACTUAL TRANSIENT REACTION OF THE HARDWARE UNDER STUDY WITHOUT THE NEED FOR DEVELOPING A COMPLICATED NUMERICAL MODEL, WHILE THE POWER SYSTEM CIRCUIT, SIMPLER IN NATURE, CAN BE PURELY SIMULATED. WITHIN THE SCOPE OF THIS PROJECT, THE RESPONSE OF A COMMERCIAL PROTECTION RELAY IN THE PRESENCE OF A SFCL WAS INVESTIGATED. BOTH THE RELAYS AND THE SHIELDED-CORE INDUCTIVE LIMITER WERE COUPLED TO THE REAL TIME SIMULATOR (HYPERSIM) THROUGH SINGLE-PHASE LINEAR POWER AMPLIFIERS AND A VARIETY OF DEFAULTS WERE APPLIED. SO FAR, THIS SETUP HAS ALLOWED US TO EVALUATE THE IMPACT OF INSERTING A SFCL ON OVER-CURRENT AND DISTANCE RELAYS, IN A SIMPLE RADIAL DISTRIBUTION NETWORK. THE RESULTS SHOW THAT COORDINATION HAS INDEED TO BE SLIGHTLY REVISED.

WORK FUNDED BY NSERC, FQRNT AND CFI.

3LP3H-05

IMPACTS OF SUPERCONDUCTING FAULT CURRENT LIMITERS ON THE RECLOSER OPERATION IN DISTRIBUTION ELECTRIC POWER SYSTEMS ***S. B. RHEE[1], B. W. LEE[2];*** [1]SUNGKYONKWAN UNIVERSITY, [2]HANYANG UNIVERSITY. — SUPERCONDUCTING FAULT CURRENT LIMITERS (SFCL) ARE IDEAL AND EFFECTIVE DEVICES FOR CONTROLLING THE EXCESSIVE FAULT CURRENT DUE TO ITS NATURAL QUENCHING MECHANISM. AMONG THE VARIOUS TYPES OF SFCL, A RESISTIVE SFCL IS HIGHLY RECOMMENDED FOR COMMERCIALIZATION AND PRACTICAL APPLICATION OF POWER SYSTEMS WHICH REQUIRE MORE FAST AND EFFECTIVE LIMITATION OF EXCESSIVE FAULT CURRENT. IN ORDER TO APPLY RESISTIVE TYPES OF SFCL INTO DISTRIBUTION ELECTRIC SYSTEM WITH HIGH RELIABILITY, SPECIFIC STUDIES CONSIDERING ITS CHARACTERISTICS SUCH AS QUENCHING, RECOVERY, AND LIMITING IMPEDANCE RELATED WITH RECLOSING SCHEME SHOULD BE INVESTIGATED. THE RECLOSERS ARE MOST IMPORTANT

PROTECTIVE DEVICES IN POWER SYSTEMS, WHICH SENSE OVER CURRENTS, INTERRUPT THEM, AND THEN AUTOMATICALLY RECLOSE TO RE-ENERGIZE THE SYSTEM. INSTALLATION OF SFCL SHOULD NOT PERMIT CHANGE THE RECLOSING SCHEME OR TIME ABOUT THE "OPEN-DEAD-CLOSE" OF ITS NATURE OPERATION. IN THIS WORK, IMPACTS OF SFCL ON THE RECLOSER OPERATION WERE ANALYZED USING EMTP SIMULATIONS AND THE SIMULATION RESULTS SHOW THAT THE QUENCHING AND RECOVERY CHARACTERISTICS OF SFCL SHOULD BE CONTROLLED ACCORDING TO THE REQUIREMENTS OF RECLOSING SCHEME. SIMULATION RESULTS AND DISCUSSIONS ABOUT THE APPLICATION OF SFCL INTO DISTRIBUTION GRID CONSIDERING RECLOSING SCHEME WERE PRESENTED AND DISCUSSED.

3LP3H-06

PROOF-OF-CONCEPT OF A SMART FAULT CURRENT CONTROLLER WITH A SUPERCONDUCTING COIL FOR THE SMART GRID ***M. AHN***[1]*, T. KO*[2]*;* [1]KUNSAN NATIONAL UNIVERSITY, [2]YONSEI UNIVERSITY. — THE POWER GRID, ESPECIALLY DISTRIBUTION GRID, HAS BEEN MORE COMPLICATED DUE TO DISTRIBUTED GENERATIONS (DGS) WITH RENEWABLE ENERGY SOURCES AND THE SMART GRID. THE COMPLEXITY CHANGES TWO THINGS IN TERMS OF A FAULT; HIGHER PROSPECTIVE FAULT CURRENT AND THE TEMPORAL VARIATION OF SOURCES AND LOADS. TO CORRESPOND TO THOSE REMARKABLE CHANGES, WE PROPOSE A FAULT CURRENT CONTROLLER (FCC) NAMED "SMART FCC." THE SMART FCC CONSISTS OF A SUPERCONDUCTING COIL WITH A FREEWHEELING DIODE IF NECESSARY, FOUR THYRISTORS, AND A CONTROL UNIT. SMART FCC CAN NOT ONLY LIMIT BUT ALSO CONTROL THE CURRENT WHEN A FAULT OCCURS. THE SMART GRID TECHNOLOGY CAN PROVIDE SO ENOUGH INFORMATION THAT IT IS POSSIBLE TO ESTIMATE WHICH LEVEL OF LIMITED CURRENT SHOULD BE THE BEST IN THE REAL-TIME SITUATION OF THE GRID. BASED ON A REAL-TIME CALCULATION OF OPTIMAL FAULT CURRENT USING THE SMART GRID MONITORING TECHNOLOGIES, THIS NEW DEVICE IS ALWAYS READY TO ADJUST THE FAULT CURRENT. IN THIS PAPER, WE INTRODUCE A CONCEPT OF THE SMART FCC AND PROVE THE CONCEPT. VARIOUS TOPOLOGIES HAVE BEEN PROPOSED AND SIMULATED. FINALLY, A CASE STUDY ON A DISTRIBUTION CLASS OF 22.9 KV SMART FCC HAS BEEN CONDUCTED BASED ON A CONCEPTIONAL SYSTEM DESIGN.

THIS WORK WAS SUPPORTED BY MANPOWER DEVELOPMENT PROGRAM FOR ENERGY & RESOURCES OF MKE WITH YONSEI ELECTRIC POWER RESEARCH CENTER (YEPRC) AT YONSEI UNIVERSITY, SEOUL, KOREA.

3LP3H-07

COOPERATION BETWEEN SUPERCONDUCTING FAULT CURRENT LIMITER AND RECLOSING SYSTEM ***Y. S. CHO***[1]*, B. I. JUNG*[1]*, K. H. HA*[2]*, S. G. CHOI*[2]*, H. M. PARK*[2]*, H. S. CHOI*[1]*, D. C. CHUNG*[3]*, J. S. HWANG*[4]*, J. W. HWANG*[5]*;* [1]DEPARTMENT OF ELECTRICAL ENGINEERING, CHOSUN UNIVERSITY, [2]CHOSUN UNIVERSITY, [3]DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING, WOOSUK UNIVERSITY, [4]DEPARTMENT OF RENEWABLE ENERGY ELECTRICITY, JEONNAM PROVINCIAL COLLEGE, [5]DEPARTMENT OF ELECTRICAL ENGINEERING, DONGSHIN UNIVERSITY. — TO APPLY THE SUPERCONDUCTING FAULT CURRENT LIMITER (SFCL) IN POWER SYSTEM, THERE HAVE BEEN MANY PROBLEMS AS FOLLOWS: THE CAPACITY INCREMENT OF SFCL, THE COOPERATION WITH THE PROTECTIVE RELAY SYSTEMS, AND OPERATIONAL RELIABILITY OF RECLOSING SYSTEM ETC.. THE RELIABLE OPERATION OF RECLOSING SYSTEM AMONG THESE IS MOST IMPORTANT TO APPLY THE SFCL INTO THE POWER SYSTEM. WHEN THE MOMENTARY GROUNDING FAULT OCCURRED, THE RECLOSING SYSTEM SHUTS OFF THE FAULT. AFTER SETTING TIME, RECLOSING SYSTEM CLOSES THE CIRCUIT BREAKER TO SUPPLY THE ELECTRICITY. IF THE FAULT STILL EXISTS, THE PROTECTIVE RELAY, THAT SENSING THE COMPLETE FAULT, TURNS OFF AGAIN THE CIRCUIT BREAKER. WHEN THE SFCL WAS APPLIED TO POWER SYSTEM, THE VOLTAGE GENERATED IN THE FAULT SECTION SHOULD BE ZERO BY THE COMPLETE RECOVERY OF THE QUENCHED SUPERCONDUCTING UNITS (S.U.) WITHIN THE TURN-OFF TIME OF CIRCUIT BREAKER. IF IT IS NOT, THE STABILITY OF THE POWER SYSTEM WILL BE REDUCED BECAUSE THERE IS POWER LOSS DUE TO THE RESISTANCE OF THE SFCL EVEN THOUGH THE FAULT IS REMOVED. IN THE EXPERIMENT, WE INVESTIGATED THE RECOVERY CHARACTERISTICS OF THE SFCL ACCORDING TO OPERATION OF RECLOSING SYSTEM. TO RECOVER THE S.U.S WITHIN THE TURN-OFF TIME OF CIRCUIT BREAKER, THE POWER BURDEN BETWEEN S.U.S SHOULD HAVE AN EQUAL MAGNITUDE BY SIMULTANEOUS QUENCHING. IN ADDITION, THE VOLTAGE GENERATED IN S.U.S SHOULD RETURN TO ZERO VALUE ACCORDING TO THE RECOVERY OF S.U.S.

3LP3H-08

IMPROVEMENT OF RECLOSER-FUSE OPERATION AND COORDINATION IN POWER DISTRIBUTION SYSTEM WITH SFCL *M. KIM,* ***S. LIM****, J. KIM;* SOONGSIL UNIVERSITY. — IN THIS PAPER, WE DESCRIBES HOW TO COORDINATE BETWEEN RECLOSER AND FUSE IN POWER DISTRIBUTION SYSTEM WITH SUPERCONDUCTING FAULT CURRENT LIMITER (SFCL). RECLOSER AND FUSES ARE THE MAIN OVERCURRENT PROTECTIVE DEVICES IN POWER DISTRIBUTION SYSTEM. UNIVERSALLY, TO PROTECT AGAINST PERMANENT FAULTS, FUSES ARE INSTALLED ON OVERHEAD FEEDER LATERALS AND THE RECLOSERS AS A BACKUP PROTECTION AGAINST TEMPORARY FAULTS REMOVE MANY UNNECESSARY OUTAGES. HERE, THE RECLOSER IS SET TO TRIP USING TCC CURVE FOR A TEMPORARY FAULT BEFORE ANY OF THE FUSES CAN MELT. IF THE FAULT IS A PERMANENT FAULT, THE FUSE HAS TO MELT JUST BEFORE THE LAST DELAY TRIP OF THE RECLOSER. HOWEVER, THE APPLICATION OF A RESISTIVE SFCL IN POWER DISTRIBUTION SYSTEM AFFECTS THE RECLOSER-FUSE OPERATION AND COORDINATION AS DECREASED FAULT CURRENTS. IN CASE THAT WHEN A PERMANENT FAULT OCCURS, THE RECLOSER COULD BE LOCKED-OUT AFTER THE LAST DELAY TRIP BEFORE THE FUSES OPERATE.THEREFORE, TO SOLVE THESE CASES, WE PERFORMED EXPERIMENTS WHICH ARE THE RECLOSER-FUSE OPERATION AND COORDINATION IN THE MODELED POWER DISTRIBUTION SYSTEM WITH THE SFCL. BASED ON THE EXPERIMENTAL VERIFICATION, WE IMPROVED

TO COORDINATE THE RECLOSER-FUSE IN POWER DISTRIBUTION SYSTEM WITH SFCL.

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3LP3J-01

STRESS ANALYSIS AND QUENCH ANALYSIS ON A LARGE ROOM SPLIT-GAP HIGH MAGNETIC FIELD SUPERCONDUCTING MAGNET SYSTEM ***Q. WANG;*** INSTITUTE OF ELECTRICAL ENGINEERING, CHINESE ACADEMY OF SCIENCES. — YINGMING DAI[A], HOUSENG WANG[A], YUANZHONG LEI[A], SOUSENG SONG[A], BINGJUN GAO[B], YUNPIN SUN[B], GUANGLI KUANG[B], YUNHENG ZHANG[B], LUGUAN YAN[AA]INSTITUTE OF ELECTRICAL ENGINEERING, CHINESE ACADEMY OF SCIENCES, P.O.BOX 2703, BEIJING, 100080, CHINA[B]CENTER OF HIGH MAGNETIC FIELD, CHINESE ACADEMY OF SCIENCES, CHINAQIULIANG@MAIL.IEE.AC.CNTHERE IS A VERY STRONG DEMAND FOR SUPERCONDUCTING MAGNETS WITH VERY HIGH FIELDS (23.5 T AND ABOVE) AS BASIS FOR EXPERIMENTAL HIGH MAGNETIC FIELD FACILITIES AND NEW GENERATIONS OF SPECIAL MATERIAL PROCESSING. A HIGH MAGNETIC FIELD SUPERCONDUCTING MAGNET HAS BEEN DESIGNED WITH THE CENTER FIELD OF 10 T AND WARM BORE OF 100 MM, WARM SPLIT-GAPE OF 100 MM. TWO GM CRYOCOOLERS ARE EMPLOYED TO COOL DOWN THE WHOLE SYSTEM. THE SUPERCONDUCTING MAGNET SYSTEM CONSISTS OF 6 HIGH TEMPERATURE SUPERCONDUCTING COILS WITH THE SUPERCONDUCTING PROPERTIES OF COMMERCIALLY AVAILABLE BI-HTS WIRES AND 8 NBTI SUPERCONDUCTING COILS. THE HIGH MAGNETIC SUPERCONDUCTING MAGNETS ABOUT STRESS SUPPORT AND QUENCH ANALYSIS ARE STUDIED, A NEW STRESS ANALYSIS AND PROTECT TECHNOLOGY ARE SUGGESTED IN THE PAPER.

3LP3J-02

JOINT DESIGN AND TEST FOR THE SCH ***H. BAI,*** *T. ADKINS, S. BOLE, E. MARKS, G. MILLER, P. NOYES, T. A. PAINTER, R. STANTON, H. W. WEIJERS, T. XU;* NATIONAL HIGH MAGNETIC FIELD LABORATORY. — THE NHMFL SERIES CONNECTED HYBRID (SCH) MAGNET WILL PROVIDE AN ENERGY-EFFICIENT 36 T TO THE DC USER FACILITY BY EMPLOYING A 20 KA SUPERCONDUCTING OUTSERT COIL IN SERIES WITH A RESISTIVE INSERT. THE ELECTRICAL JOINTS IN THE SUPERCONDUCTING OUTSERT REQUIRE LOW DC RESISTANCE TO MINIMIZE THE REFRIGERATION REQUIREMENT AT THE OPERATIONAL 4.5 K TEMPERATURES AND LOW AC LOSSES TO ENSURE GOOD STABILITY AGAINST QUENCHING DURING THE FAST RAMPS REQUIRED BY THE DC USERS. A RELIABLE, ROBUST SOLDERLESS JOINT TECHNOLOGY HAS BEEN DEVELOPED AT THE NHMFL TO ADDRESS THESE ESSENTIAL REQUIREMENTS. THE OUTSERT CONSISTS OF THREE CONCENTRIC LAYER-WOUND SUB-COILS USING THREE DIFFERENT GRADES OF NB_3SN CABLE-IN CONDUIT CONDUCTORS (CICC): HIGH FIELD (HF), MIDDLE FIELD (MF) AND LOW FIELD (LF). THERE ARE FOUR INTERNAL SPLICE JOINTS IN THE OUTSERT, WHICH ARE NB_3SN TO NB_3SN JOINTS WITH THE SAME DESIGN CONFIGURATION. THERE ARE ALSO TWO TERMINAL JOINTS BETWEEN THE NB_3SN OUTSERT AND THE TWO NBTI BUSLINES, WHICH CONNECT THE OUTSERT TERMINALS TO THE TWO CURRENT LEADS. THE TWO TERMINAL JOINTS ARE NB_3SN TO NBTI JOINT WITH IDENTICAL CONFIGURATIONS. ALL OF THE JOINTS WILL BE PRAYING-HANDS CONFIGURATION WITH AN OPERATION CURRENT OF 20 KA. THIS ARTICLE DISCUSSES THE CICC JOINT DESIGN AND TEST RESULTS.

THIS WORK IS SUPPORTED BY THE NSF DIVISION OF MATERIALS RESEARCH THROUGH GRANT

3LP3J-04

VERY HIGH FIELD HTS MAGNET STUDIES ***P. TIXADOR[1], J. REY[2], C. BRUZEK[3], E. MOSSANG[4], F. DEBRAY[5];*** [1]GRENOBLE INP, [2]CEA-DSM-IRFU-SACM, [3]NEXANS FRANCE, [4]CNRS-LNCMI, [5]CNRS LNCMI. — HIGH CRITICAL TEMPERATURE SUPERCONDUCTORS (HTS) BRING A LOT OF OPPORTUNITIES FOR VERY HIGH FIELD MAGNETS. THE LARGE CURRENT DENSITIES UNDER VERY HIGH FIELDS AND THE MECHANICAL STRENGTH FOR SOME HTS CONDUCTORS (ESPECIALLY IBAD ROUTE REBACUO COATED CONDUCTORS) ARE VERY FAVORABLE CHARACTERISTICS. DEMANDS FOR HIGH FIELDS ARE GROWING: HIGH SPECIFIC ENERGY SMES, NMR, HIGH ENERGY PHYSICS, [[UNSUPPORTED CHARACTER - ⋯]] DUE TO THE NECESSARY SUSTAINABLE DEVELOPMENT THE SUPERCONDUCTING (SC) MAGNETS ARE AN ATTRACTING SOLUTION TO PRODUCE MAGNETIC FLUX DENSITIES. WE CARRY OUT SEVERAL ACTIONS TO DEVELOP HTS MAGNETS. WE HAVE DEVELOPED TOOLS TO TEST CONDUCTORS AND SMALL COILS (UP TO 130 MM IN DIAMETER) AT VARIABLE TEMPERATURES UNDER MAGNETIC FLUX DENSITIES UP TO 20 T. PRELIMINARY INSERT SOLENOIDS HAVE BEEN REALIZED USING REBACUO COATED CONDUCTORS. WE HAVE CONDUCT STUDIES TO MECHANICALLY REINFORCE SOME CONDUCTORS. THE HTS MAGNET PROTECTION IS PART OF OUR CONCERNS SINCE IT IS AN IDENTIFIED ISSUE. AN OVERVIEW OF OUR PROGRAM AND THE FIRST RESULTS WILL BE PRESENTED.

WORKS SUPPORTED BY THE EC PROJECT EUCARD AND ANR PROJECT “SUPER-SMES”.

3LP3J-05

STATUS OF THE JLAB HALL B 12 GEV UPGRADE ***L. QUETTIER,*** *V. BURKERT, D. KASHY, E. LEUNG, W. SCHNEIDER;* JLAB. — FOR NEW STUDIES OF QUARK CONFINEMENT, NUCLEON STRUCTURE, THE PHYSICS OF NUCLEI AND THE STANDARD MODEL'S LIMITS, JEFFERSON LAB HAS BEGUN AWARDING CONTRACTS TO DOUBLE THE 6 GEV ENERGY OF THE CONTINUOUS ELECTRON BEAM ACCELERATOR FACILITY (CEBAF), UPGRADE ITS EXPERIMENTAL HALLS AND ADD A FOURTH HALL. FOR HALL B, THE UPGRADE CONSISTS IN REPLACING THE EXISTING CEBAF LARGE ACCEPTANCE SPECTROMETER DETECTOR (CLAS) WITH A NEW DETECTOR SYSTEM, CLAS12, WHICH CONTAINS NEW MAGNETS AND DETECTORS TO CAPTURE THE MORE FORWARD-FOCUSED REACTION PRODUCTS AT THE INCREASED LUMINOSITY. THE

FORWARD PART OF CLAS12 WILL USE A NEW TORUS COIL THAT RETAINS THE SIX SECTOR SYMMETRY OF CLAS TO REUSE EXISTING DETECTORS. MADE OF SIX VERY THIN COILS TO LIMIT OBSTRUCTION OF ACCEPTANCE, THE TORUS MAGNET IS DESIGNED TO ALLOW MOMENTUM ANALYSIS FOR HIGH MOMENTUM TRACKS FROM 5 TO 40 DEGREES. THE CENTRAL PART OF CLAS12 IS BASED ON A 5T SOLENOID MAGNET DESIGNED TO ALLOW THE MOMENTUM ANALYSIS OF CHARGED PARTICLES AT LARGE ANGLES, TO CREATE A HOMOGENEOUS MAGNETIC FIELD REGION IN THE CENTER FOR DYNAMICALLY POLARIZED TARGET OPERATION AND TO PROVIDE MAGNETIC SHIELDING OF THE PARTICLE DETECTORS FROM THE INTENSE BACKGROUND OF MOELLER ELECTRONS. FINALLY, THIS MAGNET IS ACTIVELY SHIELDED TO MINIMIZE THE STRAY FIELD AT SPECIFIC LOCATIONS. THE CONSTRUCTION OF THE TWO MAGNETS HAS BEEN AWARDED TO WANG NMR AND THE UPGRADE IS PLANNED TO BE OPERATIONAL IN 2013.

3LP3J-06

DEVELOPMENT OF A 5T-MAGNETOMETER FOR SYNCHROTRON RADIATION EXPERIMENTS ***B. WANG***[1]*, J. CHEN*[1]*, B. WAHRER*[1]*, C. TAYLOR*[1]*, L. XU*[1]*, B. WAGNER*[1]*, M. WANG*[1]*, S. PRESTEMON*[2]*, E. ARENHOLZ*[2]*;* [1]WANG NMR INC., [2]LAWRENCE BERKELEY NATIONAL LABORATORY. — THE 5T VECTOR MAGNET WILL PROVIDE UNPRECEDENTED ACCESS TO HIGH MAGNETIC FIELD VECTOR CONTROL FOR SOFT X-RAY EXPERIMENTS X-RAY MAGNETIC CIRCULAR DICHROISM (XCMD) AND X-RAY MAGNETIC LINEAR DICHROISM (XMLD). THE KEY SPECIFICATIONS FOR THE 5T VECTOR MAGNET ARE: (1) BO = 0 TO 5T IN ANY DIRECTION WITH FIELD UNIFORMITY OF 0.1% OVER 1 MM3; (2) FAST FIELD RAMP RATE INCLUDING FIELD REVERSAL $\geq$ 0.05T/S AND (3) ACCESS SAMPLE PORT $\geq$ 38 MM DIAMETER.TO ACHIEVE 5T FIELD, WE NEED NB3SN COIL BECAUSE PEAK FIELD IN WINDING IS 12T. EIGHT CONE-SHAPED SUPERCONDUCTING COILS ARE ARRANGED OCTAHEDRALLY TO FORM 4 INDEPENDENT DIPOLE PAIRS, FACILITATING 5 TO 6 ACCESS PORTS AND/OR A 210 DEGREES SLIT OPENING FOR LARGE ANGLE PHOTON IN-PHOTON OUT EXPERIMENTS. VECTOR MAGNETOMETERS ARE HIGHLY SOUGHT INSTRUMENTS, ALLOWING DETAIL INVESTIGATION OF MAGNETIC NANOSTRUCTURE FROM RARE-EARTH MULTI-LAYERS TO HIGH TEMPERATURE SUPERCONDUCTORS.WE SHALL PRESENT DETAILED DESIGN OF THREE OPTIONS: OPTION A WILL BE CRYOGEN-FREE WITH TWO PULSED TUBE CRYOCOOLERS AND 8 HI-TC LEADS WITHIN A LIQUID HELIUM BATH; OPTION B WILL BE CONDUCTION-COOLED BY CRYOCOOLER WITHOUT CRYOGEN. IN THIS DESIGN, WE COULD ADD PHOTON IN- PHOTON OUT SLIT AND FINALLY, OPTION C WILL SUBMERGE THE COIL ASSEMBLY IN POOL-BOILING HELIUM WITHOUT CRYOCOOLER. IN ADDITION, WE NEED TO PROVIDE A LIQUID NITROGEN SHIELD WITH LIQUID NITROGEN RESERVOIR. ALL CRYOGEN REFILLS WILL BE 48 HOURS.

3LP3J-07

PRELIMINARY DESIGN OF JLAB CLAS12 LARGE SUPERCONDUCTING SIX COIL TORUS MAGNETS ***B. WANG***[1]*, B. WAHRER*[1]*, C. TAYLOR*[1]*, J. ZBANSIK*[1]*, D. DELL'ORCO*[1]*, J. ROSS*[1]*, J. CHEN*[1]*, L. XU*[1]*, H. CHEN*[1]*, B. WAGNER*[1]*, R. PONG*[1]*, T. JUANG*[1]*, M. WANG*[1]*, C. CARTER*[1]*, P. CHENG*[1]*, V. BURKERT*[2]*, L. QUETTIER*[2]*, D. KASHY*[2]*;* [1]WANG NMR INC., [2]JEFFERSON LABORATORY (JLAB). — HALL B AT JEFFERSON LABORATORY (JLAB) WILL NEED A 6-COIL TORUS PRODUCING REQUIRED THE INTEGRAL OF B DL FOR AN UPGRADE 12 GEV BEAM. ON SEPT. 2009, WANG NMR WAS AWARDED TO DESIGN, FABRICATE, ASSEMBLE, DELIVER, AND TEST AT JLAB THIS EXCITING MAGNET BY OCT. 12, 2012.THE PRELIMINARY DESIGN REVIEW WAS COMPLETED BY DEC. 2009 AND INTERMEDIATE DESIGN REVIEW WILL BE COMPLETED BY JULY 2010. PROTOTYPE COIL CONSTRUCTION, PRODUCTION OF SOLDERED CONDUCTOR WITH SSC CABLE AND FINAL DESIGN REVIEW WILL BE ALSO COMPLETED IN 2010.WE SHALL DESCRIBE PRELIMINARY DESIGN AND INTERMEDIATE DESIGN FOR COIL/CRYOSTAT, TORUS CENTRAL CYLINDER (HUB), 48 COLD MASS SUSPENSIONS, TWO INTERCOIL SUPPORT RINGS, CRYOCONTROL TOWER, AND ADAPTER TO TORUS COIL, MAGNET QUENCH PROTECTION, AND CHARGE/ DISCHARGE CONTROL, AND THE TWO PARALLEL PATH COOLING DESIGN BY SUPERCRITICAL HELIUM.BECAUSE OF COIL IN-PLANE AND OUT-OF-PLANE EM FORCES OVER THESE HUGE THIN COILS (EACH ABOUT 2M X 4M X 0.1M THICK), VACUUM LOAD, G LOAD, COOLDOWN THERMAL STRESS, WE SHALL PRESENT THE DETAILED FINITE ELEMENT ANALYSES (FEA) ON COIL STRUCTURE, 48 COLD MASS SUPPORTS, INTERCOIL COLD RINGS, COIL/ CRYOSTAT VACUUM VESSEL, CRYOTOWER CRYOSTAT, AND TORUS HUB.FINALLY, WE SHALL SHOWS THAT ALL PRESSURE/ VACUUM VESSELS AND ITS WELDMENT HAS SATISFIED ASME CODE.

3LP3J-08

CRYOSTAT DESIGN FOR THE NHMFL SERIES-CONNECTED HYBRIDS ***J. CHEN****, H. BAI, M. BIRD, K. CANTRELL, S. BOLE;* NATIONAL HIGH MAGNETIC FIELD LABORATORY. — THE NATIONAL HIGH MAGNETIC FIELD LABORATORY (NHMFL) IS DESIGNING SERIES-CONNECTED HYBRID MAGNETS, WHICH HAS 40MM DIAMETER VERTICAL WARM BORE WITH A CYLINDRICAL PROFILE. THE MAGNET WILL GENERATE 36T FIELD WITH 13 MW POWER FOR HIGH HOMOGENEITY VERSION (1PPM HOMOGENEITY) OR >40T FOR HIGH FIELD VERSION. THIS HYBRID SHARES THE DESIGN OF SUPERCONDUCTING COIL WITH ANOTHER SCH DESIGNED FOR BERLIN, GERMANY. THE CRYOSTAT, HOWEVER, NEED TO BE DESIGNED DUE TO DIFFERENT CONFIGURATIONS. IN THIS PAPER THE DESIGN OF THE NHMFL CRYOSTAT ARE PRESENTED. THE MAIN FEATURES ARE DESCRIBED AT FIRST FOLLOWED BY THE DISCUSSION OF THE FEA MODELS AND RESULTS.

3LP3J-09

25 TESLA HTS MAGNET INSERT COIL IN ZERO BOIL OFF CRYOSTAT ***J. GOOD****;* CRYOGENIC LTD. — THERE IS INCREASING INTEREST IN MAGNETIC FIELDS FOR NMR AT ABOVE 1 GHZ (23.48 TESLA) BUT THESE FIELDS ARE NOT AVAILABLE WITH COMMERCIAL LOW TEMPERATURE SUPERCONDUCTORS (LTS) AT EITHER 4.2 K OR AT 2.2 KAT PRESENT THE ONLY WAY FIELDS OF 25 TESLA CAN BE

GENERATED CONTINUOUSLY IS BY A HYBRID OR RESISTIVE MAGNET. HOWEVER, HYBRID COILS REQUIRE 10 MEGAWATTS OF DC POWER TO OPERATE AND THE FIELD GENERATED IS NOT SUFFICIENTLY STABLE.CRYOGENIC LTD HAS MANUFACTURED A COIL WHICH IS DESIGNED TO DEMONSTRATE THE FEASIBILITY OF A MAGNETIC FIELD OF 25 TESLA IN A WORKING BORE OF 50MM. THE MAGNET USES HTS CONDUCTORS COMBINED WITH LTS AND IS SUITED TO SOLID STATE RESEARCH FOR NMR AND ESR. IT IS COOLED BY CLOSED CYCLE ZERO HELIUM BOIL OFF CRYOSTAT AND RUNS AT 4.2K.THE APPLICATION OF HIGH TEMPERATURE SUPERCONDUCTOR (HTS) IS ADDITIONALLY ATTRACTIVE BECAUSE THE MAGNET CAN RUN AT 4.2K RATHER THAN BEING PUMPED TO 2.2K AS THE CRITICAL FIELD OF HTS IS MUCH HIGHER THAN 25 TESLA.THE MAGNET CONSISTS OF 5 COILS; THE OUTER COIL IS OF NBTI SECTION, AND THE NEXT OF NB3SN SECTION. INSIDE ARE 3 COILS OF A HIGH-TEMPERATURE SUPERCONDUCTOR HTS BISRCACUO-2223 TAPE. THE OUTER TWO COILS HAVE A 140MM BORE AND PROVIDE 14 TO 15 TESLA AT 4.2K. THE TARGET FOR THE HTS IS TO PROVIDE AT LEAST 10 TESLA AT 4.2K.THE PERFORMANCE OF THE MAGNET BOTH LTS AND HTS SECTION IS DISCUSSED TOGETHER WITH THE OPERATING CHARACTERISTICS OF THE CLOSED CYCLE CRYOSTAT.

3LX-01

DAMPING OF SUBSYNCHRONOUS WHIRL IN ROTORS WITH HIGH-TEMPERATURE SUPERCONDUCTING BEARINGS ***J. HULL,*** *M. STRASIK, J. MITTLEIDER, C. MCIVER, K. MCCRARY, J. GONDER, P. JOHNSON;* THE BOEING COMPANY. — SUBSYNCHRONOUS WHIRL HAS BEEN OBSERVED IN EXPERIMENTS WHEN SOME FLYWHEELS WITH HIGH-TEMPERATURE SUPERCONDUCTING BEARINGS RUN TO SPEEDS ABOVE THE BEARING CRITICAL. THE CHARACTERISTIC OF THIS RESONANCE IS THAT IT APPEARS AT SOME ROTATIONAL FREQUENCY ABOVE THAT OF THE BEARING CRITICAL, AND THAT IT CONSISTS OF A FORWARD WHIRL, WITH THE WHIRL FREQUENCY EQUAL TO THAT OF THE BEARING CRITICAL FREQUENCY. TYPICALLY, THE AMPLITUDE OF THIS WHIRL GROWS WITH ROTATIONAL FREQUENCY. IN SOME INSTANCES, THE WHIRL AMPLITUDE BECOMES SO LARGE THAT IT LIMITS THE MAXIMUM FLYWHEEL SPEED TO A VALUE LESS THAN THAT DICTATED BY ITS MECHANICAL STRENGTH.INTERNAL DAMPING IS CAUSED BY HYSTERETIC LOSS IN THE ROTOR MATERIAL WHEN THERE IS A CENTER OF MASS OFFSET AND CREATES A FORCE THAT ADDS ENERGY TO THE FORWARD WHIRL. WE THEORETICALLY EXAMINE THE EFFECT OF INTERNAL DAMPING AS THE CAUSE OF THE WHIRL AND COMPARE THEORETICAL PREDICTIONS TO EXPERIMENTAL DATA. WE NEXT SHOW HOW IT IS POSSIBLE TO DAMP THE WHIRL FROM A THEORETICAL CONTEXT AND SUGGEST SEVERAL PRACTICAL APPROACHES TO ACCOMPLISH THIS THAT HAVE HAD SUCCESS IN OUR LABORATORY EXPERIMENTS.

THIS WORK WAS SUPPORTED BY THE U.S. DEPT. ENERGY, OFFICE OF ELECTRICITY DELIVERY AND ENERGY RELIABILITY UNDER DE-FC36-99G010825, AND SANDIA NATIONAL LABORATORIES ENERGY STORAGE PROGRAM UNDER 598172.

3LX-02

FIELD-DEPLOYABLE FLYWHEEL ENERGY STORAGE WITH HIGH-TEMPERATURE SUPERCONDUCTING BEARINGS ***M. STRASIK,*** *J. HULL, J. MITTLEIDER, J. GONDER, C. MCIVER, K. MCCRARY, P. JOHNSON;* THE BOEING COMPANY. — A DESIGN WILL BE PRESENTED FOR A SMALL FLYWHEEL ENERGY STORAGE THAT IS DEPLOYABLE IN A FIELD INSTALLATION. THE FLYWHEEL IS SUSPENDED BY HIGH-TEMPERATURE SUPERCONDUCTING (HTS) BEARINGS THAT ARE CONDUCTION COOLED BY CONNECTION TO A CRYOCOOLER. AT FULL SPEED, THE FLYWHEEL HAS 5 KWH OF KINETIC ENERGY, AND IT CAN DELIVER 3 KW OF THREE-PHASE 208 V POWER TO AN ELECTRICAL LOAD. THE ENTIRE SYSTEM, WHICH INCLUDES A CONTAINMENT STRUCTURE, IS COMPATIBLE WITH TRANSPORTATION BY FORKLIFT OR CRANE. LABORATORY MEASUREMENTS OF THE BEARING LOSS ARE COMBINED WITH THE PARASITIC LOADS TO ESTIMATE THE ROUNDTRIP EFFICIENCY OF THE SYSTEM. OPERATIONAL EXPERIENCE WITH THE SYSTEM COMPONENTS AND ASSEMBLED SYSTEM IS DESCRIBED.

THIS WORK WAS PARTIALLY SUPPORTED BY THE U.S. DEPARTMENT OF ENERGY, SANDIA NATIONAL LABORATORIES ENERGY STORAGE PROGRAM CONTRACT 598172.

3LX-03

NUMERICAL ANALYSIS AND EXPERIMENTAL MEASUREMENTS OF MAGNETIC BEARINGS BASED ON MGB_2 HOLLOW CYLINDERS ***A. MORANDI***[1]*, E. PERINI*[2]*, G. GIUNCHI*[2]*, M. FABBRI*[1]*;* [1]UNIVERSITY OF BOLOGNA, DIE - DEPT. OF ELECTRICAL ENGINEERING, VIALE RISORGIMENTO 2, 40136 BOLOGNA, ITALY, [2]EDISON SPA, R&D DIVISION – FORO BUONAPARTE 31 20121 MILANO - ITALY. — FREELY ROTATING MAGNETIC BEARINGS BASED ON A MGB_2 SUPERCONDUCTING HOLLOW CYLINDER AND A ROTOR MADE BY STACKS OF NDFEB PERMANENT MAGNETS ARE OF POTENTIAL INTEREST IN SEVERAL ROTATING APPARATUS FOR ENERGY STORAGE AS FLYWHEELS OR FOR MORE EFFICIENT ELECTRIC MOTORS/GENERATORS, OPERATING AT TEMPERATURES UP TO 30K. A NUMERICAL MODEL BASED ON A INTEGRAL FORMULATION OF THE MAXWELL EQUATIONS IS DEVELOPED IN ORDER TO INVESTIGATE THE ELECTRODYNAMIC BEHAVIOUR OF SUCH A SYSTEM AND TO CALCULATE THE MECHANICAL INTERACTION BETWEEN THE STACK OF PERMANENT MAGNETS AND THE SUPERCONDUCTING HOLLOW CYLINDER. THE PARAMETERS OF THE MODEL ARE IDENTIFIED ON THE BASE OF THE EXPERIMENTAL LEVITATIONAL FORCES MEASURED FOR MGB_2 HOLLOW CYLINDERS OF ABOUT 100 MM HEIGHT AND OF ABOUT 30-40 MM INTERNAL DIAMETERS. THE AXIAL BEHAVIOUR OF THE FORCES, AS WELL AS THE STIFFNESS ASSOCIATED TO TRANSVERSE AND LIBRATION MOVEMENTS OF SEVERAL KINDS OF ROTORS ARE CONSIDERED IN THE COMPUTATIONAL ANALYSIS. THE EFFECT OF THE AIR GAP BETWEEN THE ROTOR AND THE SUPERCONDUCTING CYLINDER ON THE LEVITATION FORCE IS INVESTIGATED. THE APPLICATION OF THE MODEL TO THE DESIGN OF REAL SYSTEMS IS ALSO DISCUSSED.

3LX-04

DYNAMICS OF A FLYWHEEL WITH SUPERCONDUCTIVE BEARING BASED ON MAGNETIC POTENTIAL WELL (MPW) PHENOMENON ***L. GRYGOR'YEVA;*** TARAS SHEVCHENKO NATIONAL UNIVERSITY OF KYIV. — THE GOAL IS TO DEMONSTRATE THAT SUPERCONDUCTIVE MAGNETIC BEARINGS (SMBS) OPERATING ON THE BASIS OF THE MAGNETIC POTENTIAL WELL (MPW) PHENOMENON CAN BE EFFECTIVELY USED TO HOLD A HIGH-SPEED FLYWHEEL YIELDING INCOMPARABLY HIGH ENERGY STORAGE. THE ROTOR STATIC AND DYNAMIC STABILITY PROBLEMS, DYNAMIC BEHAVIOR OF A FLYWHEEL ROTOR SUSPENDED BY THE MPW-SMBS, ROTORDYNAMIC CHARACTERISTICS AND COMPUTER SIMULATION RESULTS ARE DISCUSSED.MAGNETIC BEARING HOLDING FREE FLYWHEEL IS MODELED BY TWO STATOR'S COAXIAL IMMOBILE SUPERCONDUCTIVE RINGS MAGNETICALLY INTERACTING WITH TWO SETS OF N SUPERCONDUCTIVE SMALL PLANAR CIRCULAR LOOPS ATTACHED TO THE ROTOR. THE POTENTIAL ENERGY OF A FREE ROTOR IS THE FUNCTION OF MAGNETIC FLUXES AND MECHANICAL COORDINATES OF A ROTOR AS A FREE RIGID BODY. THE NEWTON-EULER APPROACH IS USED FOR DERIVING MOTION EQUATIONS FOR THE FLYWHEEL'S ROTOR AS A RIGID BODY. THE STABILITY SUFFICIENT CONDITIONS IN THE PARAMETER SPACE ARE DERIVED. THE LAST CAN BE SATISFIED BY THE MPW MANIFESTATION AND RELEVANT SELECTION OF GEOMETRICAL AND MAGNETIC PARAMETERS OF A FLYWHEEL SUSPENDED BY THE MPW-SMB.NUMERICAL SOLUTIONS OF THE NONLINEAR DYNAMIC SYSTEM ARE DERIVED AND PLOTTED ALONG WITH PHASE PORTRAITS. FORCE AND STIFFNESS CHARACTERISTICS ARE CONSIDERED IN COMPARATIVE STUDY OF OTHER PASSIVE SMBS. ESSENTIAL INCREASE OF RADIAL STIFFNESS OF THE PROPOSED MAGNETIC BEARING BASED ON MPW IS SHOWN.

I WOULD LIKE TO EXPRESS MY GRATITUDE TO PROFESSOR VASYL' KOZOREZ FOR HIS ADVISES AND DISCUSSIONS OF MATHEMATICAL MODEL

3LX-05

TESTS ON A SUPERCONDUCTOR LINEAR MAGNETIC BEARING OF A REAL SCALE MAGLEV VEHICLE ***G. G. SOTELO[1], D. H. N. DIAS[2], R. DE ANDRADE JR.[2], R. M. STEPHAN[2];*** [1]FLUMINENSE FEDERAL UNIVERSITY, [2]FEDERAL UNIVERSITY OF RIO DE JANEIRO. — A REAL SCALE MAGLEV VEHICLE PROTOTYPE HAS BEEN DEVELOPED BY THE TEAM OF THE LABORATORY FOR APPLIED SUPERCONDUCTIVITY FROM THE FEDERAL UNIVERSITY OF RIO DE JANEIRO. THIS VEHICLE IS NAMED MAGLEV COBRA (COBRA MEANS SNAKE IN PORTUGUESE), BECAUSE IT IS COMPOSED BY SEVERAL MODULES AND DURING THE CURVES IT RESEMBLES THE MOVEMENT OF A SNAKE. THE SUSPENSION TECHNOLOGY PROPOSED FOR THIS VEHICLE IS THE LEVITATION OF BULK SUPERCONDUCTORS ABOVE A RAIL MADE WITH ND-FE-B MAGNETS AND STEEL. THE MAIN ADVANTAGES OF THE MAGLEV COBRA VEHICLE ARE: LOW ENERGY CONSUMPTION, NEGLIGIBLE NOISE EMISSION, CURVATURE RADIUS OF 45 METERS AND CAPABILITY TO ASCEND RAMPS OF 15 %. THESE PROPERTIES ALLOW THE VEHICLE TO BE PERFECTLY ADJUSTED TO BIG CITIES LAYOUT AND TO BE CONSTRUCTED ALONG ROADS AND RIVERS PROFILES. ONE OF THE MOST IMPORTANT PARTS OF THIS PROJECT IS THE DEVELOPMENT OF THE SUPERCONDUCTOR LINEAR MAGNETIC BEARING (SLMB) FOR THE MAGLEV. IN THIS WORK, SOME NEW RESULTS OF THE LINEAR SMB ARE PRESENTED. MEASUREMENTS OF THE VERTICAL LEVITATION FORCE OF THE SLMB AND THE EFFECT OF THE FLUX CREEP ON THIS FORCE ARE PRESENTED. ALSO, SOME TESTS WERE MADE TO INVESTIGATE THE INFLUENCE OF THE LOAD VARIATION ON THE LEVITATION FORCE AND THE SLMB LEVITATION GAP. THIS SITUATION SIMULATES THE PASSENGERS BOARDING AND DISCHARGE DURING A LONG TERM OPERATION OF THE VEHICLE.

THIS WORK IS FINANCIALLY SUPPORTED BY THE BRAZILIAN AGENCIES FAPERJ, CNPQ AND CAPES.

3LX-06

TOWARDS AN OPTIMIZED MAGNET-SUPERCONDUCTOR CONFIGURATION IN ACTUAL MAGLEV DEVICES ***N. DEL-VALLE[1], A. SANCHEZ[1], C. NAVAU[1], D. CHEN[2];*** [1]UNIVERSITAT AUTONOMA DE BARCELONA, [2]ICREA AND UNIVERSITAT AUTONOMA DE BARCELONA. — THERE IS AN INTENSE RESEARCH IN MAGLEV TECHNOLOGY FOR PROVIDING CONVENIENT AND SAFE TRANSPORTATION. IN PARTICULAR, SEVERAL PROJECTS ARE BEING CARRIED OUT WORLDWIDE - PARTICULARLY IN GERMANY, BRASIL, AND CHINA- FOR CONSTRUCTING FULL-SCALE MAGLEV TRAINS. THEY ARE BASED ON THE LEVITATION OF SUPERCONDUCTING PELLETS OVER MAGNETIC GUIDEWAYS. THE OPTIMIZATION OF THEIR GEOMETRICAL PARAMETERS AND THE PROPERTIES OF BOTH SUPERCONDUCTING AND MAGNETIC PARTS BECOME VERY IMPORTANT. THEORETICAL SIMULATIONS CAPTURING THE ESSENTIAL PHYSICS OF THE SUPERCONDUCTING LEVITATION BECOME A VERY USEFUL TOOL FOR UNDERSTANDING AND IMPROVING THE DEVICES. IN THIS WORK, WE EXTEND PREVIOUS NUMERICAL MODELS DEVELOPED IN OUR GROUP [JAP 99, 113904(2006); APL 91, 112507 (2007); SUST 21, 125008 (2008); JAP 105, 023906 (2009)] TO INCORPORATE NEW FEATURES IN ORDER TO SIMULATE AS GOOD AS POSSIBLE THE ACTUAL MAGLEV DESIGNS. IN PARTICULAR, WE ANALYZE HOW THE LEVITATION FORCE AND STABILITY ARE MODIFIED WHEN THE SUPERCONDUCTING PART IS COMPOSED OF SEVERAL SUPERCONDUCTORS AS COMPARED WITH A SINGLE LARGE ONE. OUR SIMULATIONS SHOW GOOD AGREEMENTS WITH MEASURED RESULTS AND THEREFORE CAN BE USED AS A GUIDE FOR FURTHER DEVELOPMENTS IN THE FIELD.

3LX-07

RECENT UP - SCALING IN HTS BULK MAGNETIC DEVICE TECHNOLOGY ***F. N. WERFEL,*** *U. FLOEGEL-DELOR, R. ROTHFELD, T. RIEDEL, B. GOEBEL, D. WIPPICH, P. SCHIRRMEISTER;* ADELWITZ TECHNOLOGIEZENTRUM GMBH (ATZ). — MAGNET - HIGH TEMPERATURE SUPERCONDUCTING (HTS) INTERACTION SHOWS A GREAT POTENTIAL IN ROTATIONAL BEARING AND LINEAR MAGLEV TECHNOLOGY.

BESIDES THE SUPERCONDUCTORS, WHICH ARE OFTEN OVERVALUED, EACH APPLICATION SETS ADDITIONAL SPECIFIC TECHNICAL REQUIREMENTS. THE CHALLENGES OF USE THE VARIOUS CONSTRUCTIONS AND APPLICATIONS IN THE COMBINATION OF THE COLD HTS MATERIAL AND THE REQUIRED TECHNICAL PERIPHERY ARE DISCUSSED. TODAY'S 0.5 TON HTS MATERIAL PRODUCTION P.A. AT ATZ HAS ENABLED INCREASED PERFORMANCE IN A NUMBER OF MAGNETIC DEMONSTRATION DEVICES. ENGINEERING PROPERTIES, ADVANCED MAGNETIC EXCITATION SYSTEMS, AND THERMAL AND MECHANICAL STABILITY OF ROBUST HIGH - LOAD YBCO BEARINGS UP TO 1 TON HAVE BEEN DEMONSTRATED. HTS BEARING TECHNOLOGY IS NOW ESTABLISHED ALSO IN DESIGN, COOLING AND COMPACT CONSTRUCTION. YET, EFFORT IS BEING MADE IN THE DEVELOPMENT OF MOBILE HTS MAGLEV DEVICES. WE HAVE DESIGNED AND PRODUCED ADVANCED 40 CM LONG BULK CRYOSTATS, HAVING 2 MM MAGNETIC DISTANCE TO THE OUTSIDE AND OPERATING ON A PM TRACK WITH 2.5 KN FORCE DURING MORE THAN 30 HOURS. AN APPROPRIATE SET OF 24 VACUUM CRYOSTATS HAVE BEEN MANUFACTURED FOR A MAGNETIC TRAIN CONSTRUCTION CAPABLE TO TRANSPORT 60 KN TOTAL VEHICLE AND PASSENGER WEIGHT AND DEDICATED TO OPERATE ON A 200 M LONG TRACK.

3LX-08

CHARACTERIZATION OF 2G SUPERCONDUCTOR MAGNETIC SHIELDS AT 50 - 77 K *J. KVITKOVIC[1], P. PATIL[1], **S. PAMIDI**[1], J. VOCCIO[2];* [1]CENTER FOR ADVANCED POWER SYSTEMS, FLORIDA STATE UNIVERSITY, [2]AMERICAN SUPERCONDUCTOR CORPORATION. — MAGNETIC SHIELDING PROPERTIES OF HIGH TEMPERATURE SUPERCONDUCTING MATERIALS (HTS) CAN BE IMPROVED SIGNIFICANTLY BY COOLING THE SHIELDS TO TEMPERATURES BELOW 77 K. OPERATING TEMPERATURES OF T < 77 K HAVE THE POTENTIAL TO REDUCE BOTH THE SIZE AND WEIGHT OF THE SHIELDS AND INCREASE THE ATTENUATION FACTORS. EXCELLENT MAGNETIC SHIELDING PROPERTIES OF 2G SUPERCONDUCTING TAPE HAVE BEEN RECENTLY DEMONSTRATED AT 77 K. THIS PAPER PRESENTS RESULTS OF CHARACTERIZATION OF 2G SUPERCONDUCTING SHIELDS COOLED TO TEMPERATURES IN THE RANGE OF 50 -77 K. THE DEGREE OF MAGNETIC FIELD ATTENUATION BY THE SHIELDS WAS STUDIED AS A FUNCTION OF OPERATING TEMPERATURE, MAGNETIC FIELD AMPLITUDE AND FREQUENCY. ATTENUATION FACTORS OF > 95 % WERE OBSERVED AT MAGNETIC FIELD AMPLITUDES OF 10 MT. SIGNIFICANT DIFFERENCES WERE OBSERVED IN THE FREQUENCY DEPENDENCE OF SHIELDING FACTORS OF VARIOUS GEOMETRIC SHAPES OF THE SHIELDS. THE EFFECT OF GEOMETRY AND ORIENTATION ON THE EFFECTIVENESS THE SHIELDS WILL ALSO BE PRESENTED.

3LY-01

DESIGN CHALLENGES FOR A WIDE-APERTURE INSERTION QUADRUPOLE MAGNET ***S. RUSSENSCHUCK**, B. AUCHMANN, Y. BONCOMPAGNI, T. SAHNER, G. KIRBY, N. SCHWERG, M. KARPPINEN, D. DUARTE RAMOS, J. CARLOS PEREZ, P. FESSIA;* CERN. — THE DESIGN AND DEVELOPMENT OF A 120-MM-APERTURE QUADRUPOLE MAGNET FOR AN UPGRADE OF THE LHC INSERTION REGION FACES CHALLENGES ARISING FROM THE LHC BEAM OPTICS REQUIREMENTS AND THE HEAT-DEPOSITION. THE FIRST TRIGGERED EXTENSIVE STUDIES OF COIL ALTERNATIVES WITH FOUR AND SIX COIL-BLOCKS IN VIEW OF FIELD QUALITY AND OPERATION MARGINS. THE LATTER REQUIRES MORE POROUS INSULATION SCHEMES FOR BOTH THE CABLES AND THE GROUND-PLANE. THIS IN TURN NECESSITATES EXTENSIVE HEAT-PROPAGATION AND QUENCH-VELOCITY STUDIES, AS WELL AS MORE EFFICIENT QUENCH HEATERS. THE ENGINEERING DESIGN OF THE MAGNET INCLUDES INNOVATIVE FEATURES SUCH AS SELF-LOCKING COLLARS, WHICH WILL ENABLE THE COLLARING TO BE PERFORMED WITH THE COILS ON A HORIZONTAL ASSEMBLY BENCH, A SPRING-LOADED AND COLLAPSIBLE ASSEMBLY MANDREL, TUNING-SHIMS FOR FIELD QUALITY, POROUS COLLARING-SHOES, AND COIL END-SPACER DESIGN BASED ON DIFFERENTIAL GEOMETRY METHODS. THE PROJECT ALSO INITIATED CODE EXTENSIONS IN THE QUENCH-SIMULATION AND CAD/CAM MODULES OF THE CERN FIELD COMPUTATION PROGRAM ROXIE.

3LY-02

MECHANICAL DESIGN AND ANALYSIS OF AN EIGHT-POLE SUPERCONDUCTING VECTOR MAGNET FOR SOFT X-RAY MAGNETIC DICHROISM MEASUREMENTS ***D. ARBELAEZ**[1], E. ARENHOLZ[1], A. BLACK[1], S. O. PRESTEMON[1], B. WANG[2], J. CHEN[2];* [1]LAWRENCE BERKELEY NATIONAL LABORATORY, [2]WANG NMR INC.. — A HIGH-FIELD EIGHT-POLE SUPERCONDUCTING MAGNET IS BEING DEVELOPED FOR SOFT X-RAY MAGNETIC DICHROISM (XMD) EXPERIMENTS ON THE ADVANCED LIGHT SOURCE AT LAWRENCE BERKLEY NATIONAL LABORATORY (LBNL). EIGHT CONICAL NB3SN COILS WITH HOLMIUM POLES ARE ARRANGED IN AN OCTAHEDRAL PATTERN TO FORM FOUR DIPOLE PAIRS THAT PROVIDES MAGNETIC FIELDS OF UP TO 5 T IN ANY DIRECTION RELATIVE TO THE INCOMING X-RAY BEAM. THE DIMENSIONS OF MAGNET YOKE AND POLES TAPER, DIAMETER, AND LENGTH WERE OPTIMIZED FOR MAXIMUM PEAK FIELD IN THE MAGNET CENTER USING THE SOFTWARE PACKAGE TOSCA. THE STRUCTURAL ANALYSIS OF THE MAGNET IS PERFORMED USING ANSYS WITH THE COIL PROPERTIES BEING DERIVED USING A NUMERICAL HOMOGENIZATION SCHEME. IT IS FOUND THAT THE USE OF ORTHOTROPIC MATERIAL PROPERTIES FOR THE COIL HAS AN IMPORTANT INFLUENCE IN THE DESIGN OF THE SUPPORT STRUCTURE. MEASUREMENTS OF THE DIMENSIONAL CHANGES FROM ROOM TEMPERATURE TO LIQUID NITROGEN TEMPERATURE OF A TEST COIL SECTION ARE PERFORMED AND COMPARED WITH ANALYTICAL AND COMPUTATIONAL MODELS.

3LY-04

MECHANICAL PERFORMANCE OF THE LARP NB3SN QUADRUPOLE MAGNET LQS01 ***P. FERRACIN**[1], G. AMBROSIO[2], M. ANERELLA[3], B. BINGHAM[1], R. BOSSERT[2], S. CASPI[1], D. CHENG[1], G. CHLACHIDZE[2], H. FELICE[1], R. HAFALIA[1], R. HANNAFORD[1], W. MUMPER[2], F. NOBREGA[2], S. PRESTEMON[1], G. SABBI[1], J. SCHMALZLE[3], C. SYLVESTER[2], M. TARTAGLIA[2], P.*

WANDERER[3]*, A. ZLOBIN*[2]*;* [1]LBNL, [2]FNAL, [3]BNL. — AS PART OF THE EFFORT TOWARDS THE DEVELOPMENT OF NB3SN MAGNETS FOR FUTURE LHC LUMINOSITY UPGRADES, THE LHC ACCELERATOR RESEARCH PROGRAM (LARP) HAS FABRICATED AND TESTED THE QUADRUPOLE MAGNET LQS01. THE MAGNET IMPLEMENTS 3.4 M LONG NB3SN COILS CONTAINED IN A SUPPORT STRUCTURE CHARACTERIZED BY AN EXTERNAL ALUMINUM SHELL SEGMENTED IN FOUR SECTIONS. THE ROOM TEMPERATURE PRE-LOAD OF THE STRUCTURE IS OBTAINED BY SHIMMING LOAD KEYS THROUGH BLADDERS, PRESSURIZED DURING THE LOADING OPERATIONS AND REMOVED BEFORE COOL-DOWN. TEMPERATURE COMPENSATED STRAIN GAUGES, MOUNTED ON STRUCTURE COMPONENTS AND COIL POLES, MONITOR THE MAGNET'S MECHANICAL BEHAVIOR DURING ASSEMBLY, COOL-DOWN AND, EXCITATION. DURING THE FIRST TEST, LQS01 REACHED THE TARGET GRADIENT OF 200 T/M; THE GAUGE DATA INDICATED THAT THE ALUMINUM SHELL WAS PRE-TENSIONED TO THE TARGET VALUE ESTIMATED BY NUMERICAL MODELS, BUT A LACK OF PRE-LOAD WAS MEASURED IN THE COIL INNER LAYER DURING RAMPING. AS A RESULT, THE TEST WAS INTERRUPTED AND THE MAGNET DISASSEMBLED, AND INSPECTED. A SECOND TEST (LQS01B) WAS THEN CARRIED OUT FOLLOWING A RE-LOADING OF THE MAGNET. THE PAPER REPORTS ON THE STRAIN GAUGE RESULTS OF THE FIRST TEST AND THE ANALYSIS PERFORMED TO IDENTIFY CORRECTIVE ACTIONS TO IMPROVE THE COIL PRE-STRESS DISTRIBUTION. THE MECHANICAL PERFORMANCE OF THE MAGNET DURING THE SECOND COOL-DOWN AND TEST IS THEN PRESENTED AND DISCUSSED.

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3LY-05

FIELD QUALITY OF THE FIRST LARP NB3SN 3.7M-LONG QUADRUPOLE MODEL OF LQ SERIES ***G. VELEV***[1]*, G. AMBROSIO*[1]*, N. ANDREEV*[1]*, M. ANERELLA*[2]*, R. BOSSERT*[1]*, S. CASPI*[3]*, G. CHLACHIDZE*[1]*, J. DIMARCO*[1]*, J. ESCALLIER*[2]*, H. FELICE*[3]*, P. FERRACIN*[3]*, V. KASHIKHIN*[1]*, M. LAMM*[1]*, A. NOBREGA*[1]*, E. PREBYS*[1]*, G. SABBI*[3]*, J. SCHMALZLE*[2]*, M. TARTAGLIA*[1]*, P. WANDERER*[2]*, A. ZLOBIN*[1]*;* [1]FNAL, [2]BNL, [3]LBL. — THE US-LHC ACCELERATOR RESEARCH PROGRAM (LARP) BUILT AND TESTED THE FIRST 3.7-M LONG NB3SN QUADRUPOLE MODEL OF LQ SERIES WITH A 90 MM BORE DIAMETER AND A TARGET FIELD GRADIENT OF 200 T/M. THE LQ SERIES, DEVELOPED IN COLLABORATION AMONG FERMILAB, LBNL AND BNL, IS A SCALE UP OF THE PREVIOUSLY TESTED 1-M LONG TECHNOLOGY QUADRUPOLES OF TQ SERIES BASED ON SIMILAR COILS AND TWO DIFFERENT MECHANICAL STRUCTURES (COLLAR-BASED TQC AND SHELL-BASED TQS), WITH A PRIMARY GOAL OF DEMONSTRATING THE NB3SN ACCELERATOR MAGNET TECHNOLOGY FOR THE LUMINOSITY UPGRADE OF LHC INTERACTION REGIONS. IN THIS PAPER, WE PRESENT THE FIELD QUALITY MEASUREMENTS IN THE FIRST 3.7-M LONG LQS01 MODEL BASED ON THE MODIFIED TQS MECHANICAL STRUCTURE. THE RESULTS ARE COMPARED TO THE EXPECTATIONS FROM THE MAGNET GEOMETRY AND MAGNETIC PROPERTIES OF COILS AND IRON YOKE. MOREOVER, WE PRESENT A COMPARISON BETWEEN THIS MAGNET AND THE SHORT MODELS PREVIOUSLY MEASURED.

WORK SUPPORTED BY THE U.S. DEPARTMENT OF ENERGY

3LY-06

THE STUDY OF SINGLE NB3SN QUADRUPOLE COILS USING A MAGNETIC MIRROR STRUCTURE ***G. CHLACHIDZE****, N. ANDREEV, E. BARZI, R. BOSSERT, V. KASHIKHIN, V. KASHIKHIN, M. LAMM, F. NOBREGA, I. NOVITSKI, D. ORRIS, M. TARTAGLIA, J. TOMPKINS, D. TURRIONI, R. YAMADA, A. ZLOBIN;* FERMILAB. — FERMILAB IS DEVELOPING A NEW GENERATION OF ACCELERATOR MAGNETS BASED ON NB3SN SUPERCONDUCTOR. THE DEVELOPMENT AND IMPLEMENTATION OF THIS NEW TECHNOLOGY INVOLVES THE FABRICATION AND TEST OF A SERIES OF MODEL MAGNETS, COILS AND OTHER COMPONENTS WITH VARIOUS DESIGN AND PROCESSING FEATURES.SEVERAL 90-MM QUADRUPOLE COILS MADE OF 0.7-MM NB3SN STRAND BASED ON THE "RESTACK ROD PROCESS" OF 108/127 DESIGN, WITH CORED AND NON-CORED CABLES AND DIFFERENT CABLE INSULATION, WERE FABRICATED AND INDIVIDUALLY TESTED AT FERMILAB USING A TEST STRUCTURE DESIGNED TO PROVIDE A QUADRUPOLE MAGNETIC FIELD ENVIRONMENT. THE COILS WERE INSTRUMENTED WITH VOLTAGE TAPS AND STRAIN GAUGES TO STUDY QUENCH PERFORMANCE AND MECHANICAL PROPERTIES.THE NB3SN STRAND AND CABLE PARAMETERS, THE COIL FABRICATION DETAILS, THE MIRROR MODEL ASSEMBLY PROCEDURE AND TEST RESULTS AT TEMPERATURES OF 4.5 K AND 1.9 K ARE REPORTED AND DISCUSSED.

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3LY-07

RADIATION HEAT LOADS TO SUPERCONDUCTING QUADRUPOLES FOR BIGRIPS IN-FLIGHT SEPARATOR AT RIKEN ***K. KUSAKA***[1]*, M. OHTAKE*[1]*, T. OHNISHI*[1]*, A. YOSHIDA*[1]*, K. YOSHIDA*[1]*, T. KUBO*[1]*, Y. YANO*[1]*, M. NOBUTOKI*[2]*, H. ITO*[3]*, N. KAKUTANI*[3]*, T. TSUCHIHASHI*[3]*, K. SATO*[3]*;* [1]RIKEN NISHINA CENTER FOR ACCELERATOR-BASED SCIENCE, [2]TAIYO-NIPPON-SANSO, [3]TOSHIBA. — THE BIGRIPS FRAGMENT SEPARATOR IN THE RIKEN RIBF PROJECT IS CHARACTERIZED BY THE FOURTEEN SUPERCONDUCTING TRIPLET QUADRUPOLES (STQ'S) WITH LARGE APERTURES AND HIGH-FIELD GRADIENTS. WHILE THE FIVE STQ'S ON THE FIRST STAGE OF THE BIGRIPS ARE COOLED BY A LIQUID HELIUM CRYOGENIC PLANT, THE NINE STQ'S ON THE SECOND STAGE ARE COOLED BY SMALL CRYOCOOLERS ON THEIR CRYOSTAT. THIS FIRST STAGE SERVES TO PRODUCE AND SEPARATE RI BEAMS, SO THAT THE FIRST TWO STQS ARE EXPOSED TO THE HIGH RADIATION FROM THE PRODUCTION TARGET AND BEAM DUMPS, WHICH CAUSES RADIATION HEAT LOADS AS WELL AS RADIATION DAMAGES. MEASUREMENTS OF THE RADIATION HEAT LOADS TO THE CRYOSTATS OF THE FIRST TWO STQS DURING COMMISSIONING OPERATIONS OF THE RIBF FACILITY ARE REPORTED.

3LY-08

STATUS OF SUPERCONDUCTING MAGNET SYSTEM FOR THE J-PARC NEUTRINO BEAM LINE ***T. NAKAMOTO***[1]*, Y. FUJII*[1]*, N. KIMURA*[1]*, Y. MAKIDA*[1]*, T. NAKADAIRA*[1]*, T. OGITSU*[1]*, T. OKAMURA*[1]*, K. SASAKI*[1]*, B. PARKER*[2]*, P. WANDERER*[2]*;* [1]KEK, [2]BNL. — A SUPERCONDUCTING MAGNET SYSTEM TO TRANSPORT PRIMARY PROTON BEAM TO THE NEUTRINO PRODUCTION TARGET FOR THE T2K LONG BASELINE NEUTRINO OSCILLATION EXPERIMENT AT J-PARC HAS BEEN CONSTRUCTED. SUPERCONDUCTING COMBINED FUNCTION MAGNETS (SCFM) THAT CAN PROVIDE A DIPOLE FIELD OF 2.6 T COMBINED WITH A FIELD GRADIENT OF 19 T/M FOR 50 GEV PROTONS AT 7345 A BELOW 5 K UNDER SUPERCRITICAL HELIUM (SHE) COOLING WERE SUCCESSFULLY DEVELOPED. IN ADDITION, FOR BEAM STEERING, SUPERIMPOSED HORIZONTAL- AND VERTICAL- SUPERCONDUCTING CORRECTOR MAGNETS PROVIDED BY BNL HAVE BEEN ADOPTED FOR THE BEAM LINE. THE CORRECTOR MAGNETS ARE OPERATED BELOW 5.5 K BY CONDUCTION COOLING FROM SHE LINES. FOLLOWING THE HARDWARE COMMISSIONING OF THE MAGNET SYSTEM INCLUDING A HELIUM REFRIGERATOR, THE BEAM OPERATION WITH PROTON ENERGIES OF 30 GEV HAS BEEN STARTED SINCE APRIL 2009. MAIN SCFMS HAVE BEEN OPERATED WITHOUT ANY SERIOUS PROBLEM AND AN EXPERIMENT RUN WITH HIGHER BEAM POWER IS ANTICIPATED IN 2010. HOWEVER, ALL THE CORRECTOR MAGNETS CONSISTENTLY QUENCHED AT LOWER CURRENT THAN THE NOMINAL ONE. SYSTEMATIC UNWANTED RESISTIVE VOLTAGES AT LEAD JOINTS WERE OBSERVED IN THE LATEST MEASUREMENT AND FURTHER INVESTIGATION AND REPAIR WORK WILL BE MADE TO TRACE THE REASON AND TO IMPROVE THE PERFORMANCE. STATUS OF THE SUPERCONDUCTING MAGNET SYSTEM FOR THE J-PARC NEUTRINO BEAM LINE WILL BE REPORTED IN THE CONFERENCE.

3LZ-01

TEST RESULTS OF 60 KVA CURRENT LIMITING TRANSFORMER WITH FULL RECOVERY UNDER LOAD ***A. BERGER****, M. NOE, W. GOLDACKER, A. KUDYMOW;* KARLSRUHE INISTITUTE OF TECHNOLOGY (KIT). — SUPERCONDUCTING FAULT CURRENT LIMITING TRANSFORMERS (SFCLT) IN ELECTRICAL POWER DISTRIBUTION NETWORKS OFFER THE POSSIBILITY TO HAVE BOTH HIGH SHORT-CIRCUIT POWER DURING NORMAL OPERATION AND LIMITED SHORT-CIRCUIT CURRENTS UNDER FAULT CONDITIONS. DURING THE CURRENT LIMITATION, THE TEMPERATURE OF THE SUPERCONDUCTOR INCREASES BECAUSE OF THE RESISTIVE LOSSES UNTIL THE SHORT-CIRCUIT IS SWITCHED OFF. AFTER THE CURRENT LIMITATION, THE SUPERCONDUCTOR HAS TO COOL DOWN TO BECOME SUPERCONDUCTING AGAIN. RECOVERY UNDER LOAD IS A VERY IMPORTANT REQUIREMENT FOR SUPERCONDUCTING CURRENT LIMITING TRANSFORMERS BECAUSE IN MANY APPLICATIONS IT IS NOT ALLOWED TO INTERRUPT THE POWER SUPPLY. IN THIS CASE THE SUPERCONDUCTOR HAS TO COOL DOWN UNDER REGULAR LOAD CONDITIONS. THIS PAPER PRESENTS THE TEST RESULTS OF A 60 KVA CURRENT LIMITING TRANSFORMER DEMONSTRATOR WITH FULL RECOVERY UNDER LOAD. THE DESIGN AND THE TEST RESULTS OF THE DEMONSTRATOR ARE SHOWN IN DETAIL AND THE TEST RESULTS CONFIRM THAT FULL RECOVERY UNDER LOAD CAN BE ACHIEVED.

3LZ-02

NOVEL 3-PHASE SELF-LIMITING TRANSFORMER WITH TRANSFORMING MAGNETIC FLUX APPLYING PERFECT CLOSED YBCO WIRE LOOPS ***J. KOSA****;* KECSKEMET COLLEGE FACULTY OF MECHANICAL ENGINEERING AND AUTOMATION. — WITH THIS SOLUTION WE **WANTED** TO EXAMINE WHETHER IT IS POSSIBLE TO CREATE A 3-PHASE SELF-LIMITING TRANSFORMER APPLYING A NEW METHOD NEVER USED BEFORE. THEREFORE WE MADE A WORKING NEW MODEL FOR TESTING. THE PRIMARY AND SECONDARY COILS ARE ON TWO INDEPENDENT IRON CORES IN ALL THE THREE PHASES. WE CREATED THE COUPLING BETWEEN THE **PRIMAR**Y AND SECONDARY COILS USING PERFECT CLOSED YBCO LOOPS WITH PARALLEL AND SERIAL TURNS. THE ADVANTAGE OF THIS SOLUTION IS THAT THE TRANSFORMER IS ABLE TO BREAK THE COUPLING SO THERE IS NO CURRENT IN THE SECONDARY COIL IN AN IDEAL CASE. WE TESTED THE RESULTS IN THE CASE OF THE1-, 2- AND 3-PHASE FAULT CURRENT AND IN THE CASE OF THE BREAK OF ONE SECONDARY COIL. THE PAPER PRESENTS THE RESULTS OF OUR EXPERIMENTS AND OPENS NEW ADVANCED APPLICATIONS OF THE FLUX TRANSFORMER. WE CONSIDERED THE EFFICIENCY AND SIGNIFICANCE OF THE PERFECT CLOSED LOOP MADE FROM YBCO WIRE.

THE AUTHOR THANKS SUPERPOWER, INC. IN NEW YORK FOR THE GOOD QUALITY YBCO WIRE AND THE DATA PROVIDED.

3LZ-03

DEVELOPMENT OF A 1 MVA 3-PHASE SUPERCONDUCTING TRANSFORMER USING YBCO ROEBEL CABLE ***N. GLASSON***[1]*, M. STAINES*[1]*, R. BUCKLEY*[1]*, M. PANNU*[2]*;* [1]INDUSTRIAL RESEARCH LIMITED, [2]WILSON TRANSFORMER COMPANY. — WE PRESENT DESIGN DETAILS AND TESTING RESULTS FOR THE PLANNED CONSTRUCTION OF A 3-PHASE 1 MVA 11 KV/415 V TRANSFORMER USING YBCO ROEBEL CABLE. THE YBCO ROEBEL CABLE IS A PROMISING TECHNOLOGY FOR CARRYING HIGH CURRENTS. IT SIMPLIFIES MANUFACTURE OF THE WINDING WHILE MANAGING AC LOSS.WE PRESENT THE TRANSFORMER WINDING DESIGN WHICH FOLLOWS A SIMPLE LAYOUT WITH THE LOW-VOLTAGE WINDINGS UTILISING A 15 STRAND X 5MM (15/5) ROEBEL CABLE IN A SINGLE-LAYER 24 TURN SOLENOID. THE TARGET RATED CURRENT CAPACITY OF THE CABLE IS 1400 A AT 77 K. THE HIGH-VOLTAGE WINDING WILL BE IN THE FORM OF A STACK OF DOUBLE PANCAKE COILS ARRANGED ON A COMPOSITE FORMER OUTSIDE THE LOW-VOLTAGE WINDINGS. THE COILS WILL BE IMMERSED IN SUB-COOLED LIQUID NITROGEN WITH A TARGET MAXIMUM OPERATING TEMPERATURE OF 70 K. THE DEVELOPMENT METHODOLOGY IS DESCRIBED ALONG WITH THE RESULTS OF EXPERIMENTS AND MODELLING TO VALIDATE THE PERFORMANCE CHARACTERISTICS OF THE WINDINGS. EXPERIMENTS ON AC

LOSS IN THE LOW-VOLTAGE WINDING AND HEAT TRANSFER FROM THE WINDINGS ARE PRESENTED.

THIS PROJECT IS FUNDED FROM THE NEW ZEALAND FOUNDATION FOR RESEARCH IN SCIENCE AND TECHNOLOGY UNDER TRST CONTRACT CO8X0818, INDUSTRY PARTNERS AND INDUSTRIAL RESEARCH LIMITED

3LZ-04

PROGRESS IN DEVELOPMENT OF SUPERCONDUCTING FAULT CURRENT LIMITING TRANSFORMER (SFCLT) ***N. HAYAKAWA,*** *H. KOJIMA, F. ENDO, H. OKUBO;* NAGOYA UNIVERSITY. — WE HAVE BEEN DEVELOPING SUPERCONDUCTING FAULT CURRENT LIMITING TRANSFORMER (SFCLT), WHICH HAS MULTIFUNCTION OF BOTH A SUPERCONDUCTING TRANSFORMER IN NORMAL OPERATING CONDITION AND A SUPERCONDUCTING FAULT CURRENT LIMITER IN FAULT CONDITION. THE FUNCTION OF SFCLT IS CHARACTERIZED BY THE FOLLOWINGS: (1) REDUCTION OF LEAKAGE IMPEDANCE AS A TRANSFORMER, (2) LIMITATION OF FAULT CURRENT AS A FAULT CURRENT LIMITER, (3) ENHANCEMENT AND COORDINATION OF STATIC/TRANSIENT SYSTEM STABILITY, AND (4) RECOVERY INTO SUPERCONDUCTING STATE AFTER FAULT CLEARANCE.THIS PAPER WILL INTRODUCE THE PROGRESS IN OUR SFCLT PROJECT SINCE 1998, FROM STEP-1 TO THE LATEST STEP-5, WITH THE CONCEPT, DESIGN, FABRICATION AND TEST RESULTS OF SFCLT. IN THE STEP-1, EMTP SIMULATION VERIFIED THE FUNDAMENTAL FUNCTION OF SFCLT AND OPTIMIZED THE LEAKAGE IMPEDANCE AND LIMITING IMPEDANCE IN A SIMPLIFIED POWER SYSTEM. IN THE STEP-2, A MODEL SFCLT USING NBTI WIRE IN LHE AT 4.2K WAS DESIGNED, FABRICATED AND TESTED. THE HTS-SFCLT IN LN_2 AT 77K WAS DEVELOPED USING BI2212/CUNI BULK IN THE STEP-3 AND YBCO TAPES IN THE STEP-4 AND 5, RESPECTIVELY. IN THE LATEST STEP-5, 2MVA, 22/6.6KV CLASS SFCLT WAS DEVELOPED AND VERIFIED THE FUNDAMENTAL FUNCTION OF A TRANSFORMER, EFFECTIVE CURRENT LIMITING FUNCTION AS A FAULT CURRENT LIMITER, AND RECOVERY CHARACTERISTICS AFTER THE FAULT CLEARANCE WITH ITS OPERATIONAL CRITERION.

THIS WORK WAS SUPPORTED BY GRANT-IN-AID FOR SCIENTIFIC RESEARCH (S) OF THE MINISTRY OF EDUCATION, CULTURE, SPORTS, AND TECHNOLOGY, JAPAN.

3LZ-05

CURRENT LIMITING AND RECOVERY CHARACTERISTICS OF 2 MVA CLASS SUPERCONDUCTING FAULT CURRENT LIMITING TRANSFORMER (SFCLT) ***H. KOJIMA,*** *M. KOTARI, T. KITO, N. HAYAKAWA, F. ENDO, H. OKUBO;* NAGOYA UNIVERSITY. — WE HAVE BEEN DEVELOPING SUPERCONDUCTING FAULT CURRENT LIMITING TRANSFORMER (SFCLT) WITH THE FUNCTION OF BOTH SUPERCONDUCTING TRANSFORMER IN NORMAL OPERATING CONDITION AND SUPERCONDUCTING FAULT CURRENT LIMITER IN FAULT CONDITION. AS THE STEP-5 OF SFCLT PROJECT, 2 MVA CLASS HTS-SFCLT USING YBCO COATED CONDUCTORS WITH THE RATINGS OF 22 KV/6.6 KV HAS BEEN DEVELOPED.ONE OF THE IMPORTANT CONCERNS FOR THE DEVELOPMENT OF HTS-SFCLT IS THE CURRENT LIMITING AND RECOVERY CHARACTERISTICS AS WELL AS THE TRANSFORMER FUNCTION. THUS, IN THIS PAPER, CURRENT LIMITATION AND RECOVERY TESTS OF THE HTS-SFCLT WERE CARRIED OUT. THE CURRENT LIMITING TEST REVEALED THAT THE HTS-SFCLT EXHIBITED THE EXCELLENT CURRENT LIMITING FUNCTION AS A SUPERCONDUCTING FAULT CURRENT LIMITER, WHERE THE PROSPECTIVE SHORT-CIRCUIT CURRENT I_{PRO}=784 A_{PEAK} WAS REDUCED TO 34 % AT THE FIRST PEAK AND 18 % AT THE 5TH CYCLES. THE HTS-SFCLT COULD RECOVER INTO SUPERCONDUCTING STATE IMMEDIATELY AFTER THE FAULT CLEARANCE. ACCORDING TO THE TRANSITION OF GENERATED RESISTANCE OF THE HTS-SFCLT, THE CRITERIA OF RECOVERY INTO SUPERCONDUCTING STATE WERE QUANTIFIED FOR DIFFERENT COMBINATIONS OF LOAD CURRENT BEFORE THE FAULT AND PROSPECTIVE SHORT-CIRCUIT CURRENT DURING THE FAULT.

THIS WORK WAS SUPPORTED BY THE GRANT-IN-AID FOR SCIENTIFIC RESEARCH (S) OF THE MINISTRY OF EDUCATION, CULTURE, SCIENCE AND TECHNOLOGY, JAPAN.

3LZ-06

DEVELOPMENT OF A REBCO SUPERCONDUCTING TRANSFORMER WITH CURRENT LIMITING FUNCTION ***M. IWAKUMA***[1]*, A. TOMIOKA*[1]*, T. OTONARI*[1]*, T. OGATA*[1]*, S. SATO*[1]*, H. HAYASHI*[2]*, H. OKAMOTO*[2]*, Y. IIJIMA*[3]*, T. SAITOH*[3]*, Y. AOKI*[4]*, T. KOIZUMI*[4]*, T. HASEGAWA*[4]*, N. FUJIWARA*[5]*, Y. GOSHO*[5]*, Y. YAMADA*[5]*, T. IZUMI*[5]*, Y. SHIOHARA*[5]*;* [1]KYUSHU UNIVERSITY, [2]KYUSHU ELECTRIC POWER CO. INC., [3]FUJIKURA LTD., [4]SHOWA CABLE SYSTEMS CO., LTD., [5]ISTEC. — A SINGLE-PHASE SUPERCONDUCTING TRANSFORMER WAS DESIGNED AND FABRICATED WITH REBCO SUPERCONDUCTING TAPES. THE VOLTAGE RATIO WAS 1:1 AND THE RATED VOLTAGE WAS 400 V. THE AIM WAS TO QUANTITATIVELY INVESTIGATE THE TRANSITION PHENOMENON OF REBCO SUPERCONDUCTING TAPES TO NORMAL STATE DUE TO THE EXCESS FAULT CURRENT FOR THE PURPOSE OF DEVELOPING A 400 KVA-6.9KV SUPERCONDUCTING TRANSFORMER WITH CURRENT LIMITING FUNCTION. THE PRESENT TRANSFORMER HAD FOUR WINDINGS. THE PRIMARY AND SECONDARY WINDINGS HAD AUXILIARY WINDINGS IN ADDITION TO MAIN ONES RESPECTIVELY. ALL THE WINDINGS WERE COAXIALLY ARRANGED, AND THE PRIMARY AUXILIARY ONE WAS LOCATED IN THE OUTERMOST SIDE AND THE SECONDARY ONE WAS IN THE INNERMOST SIDE. THE MAIN AND AUXILIARY WINDINGS WERE CONNECTED IN PARALLEL IN THE BOTH SIDES. IN STEADY STATE ALMOST OF THE CURRENT FLOWED IN THE MAIN WINDINGS DUE TO THE SMALL LEAKAGE INDUCTANCE BETWEEN THEM. WHEN THE EXCESS FAULT CURRENT WAS APPLIED, ONLY THE MAIN WINDINGS WERE QUENCHED AND THE FAULT CURRENT WAS TRANSFERRED TO THE AUXILIARY ONES. SINCE THE LEAKAGE INDUCTANCE BETWEEN THE AUXILIARY WINDINGS WAS LARGE, THE TRANSFERRED FAULT CURRENT WAS ALSO REDUCED AND THE AUXILIARY ONES HELD SUPERCONDUCTING STATE. THE ADDITION OF THE AUXILIARY WINDINGS MADE IT POSSIBLE TO OBSERVE THE INDUCED NORMAL RESISTANCES IN THE RESPECTIVE MAIN

ONES INDIVIDUALLY. IN THIS PAPER, THE EXPERIMENTAL RESULTS WILL BE PRESENTED.

THIS WORK WAS SUPPORTED BY NEW ENERGY AND INDUSTRIAL TECHNOLOGY DEVELOPMENT ORGANIZATION (NEDO) AS TECHNOLOGICAL DEVELOPMENT OF YTTRIUM-BASED SUPERCONDUCTING POWER EQUIPMENT.

3LZ-07

SURFACE FLASHOVER VOLTAGE OF CYLINDRICAL G10 UNDER AC AND DC VOLTAGES AT ROOM AND CRYOGENIC TEMPERATURES. ***H. RODRIGO**, W. BAUMGARTINGER, G. H. HELLER, D. G. CROOK, S. L. RANNER;* FLORIDA STATE UNIVERSITY. — THE RESULTS OF EXPERIMENTAL DETERMINATION OF SURFACE FLASHOVER UNDER AC AND DC VOLTAGES ARE PRESENTED. THE CYLINDRICAL SAMPLES WERE 5 MM IN LENGTH AND THE DIAMETERS 9.59 MM, 12.7 MM AND 19 MM. THE SAMPLES WERE HELD CENTRALLY BETWEEN TWO 25 MM DIAMETER BRUCE PROFILED UNIFORM FIELD ELECTRODES, MADE OF STAINLESS STEEL. THE EXPERIMENTS WERE CONDUCTED AT ROOM TEMPERATURE (293 K) WITH THE ELECTRODES CONTAINING THE SAMPLES IMMERSED IN TRANSFORMER OIL, AND SIMILARLY AT 77 K THEY WERE IMMERSED IN A BATH OF LIQUID NITROGEN. THE RESULTS HAVE BEEN ANALYZED USING WEIBUL STATISTICS.THEY SHOW THAT THERE IS SIGNIFICANT IMPROVEMENT IN BOTH THE FLASHOVER VOLTAGE AND THE RELIABILITY UNDER BOTH AC AND DC AT THE LOWER TEMPERATURE.

WORK PERFORMED UNDER DOE CONTRACT NUMBER : DE-FC26-07NT43221

3MA-01

(INVITED) **DYNAMIC RESISTANCE OF YBCO COATED CONDUCTORS IN APPLIED AC FIELDS WITH DC TRANSPORT CURRENTS AND DC BACKGROUND FIELDS UP TO 2 T** ***R. C. DUCKWORTH**, Y. ZHANG, T. HA, M. J. GOUGE;* OAK RIDGE NATIONAL LABORATORY. — IN ORDER TO PREDICT HEAT LOADS IN FUTURE, SATURABLE-CORE FAULT CURRENT LIMITING DEVICES DUE TO AC FRINGING FIELDS, DYNAMIC RESISTANCE IN YBCO COATED CONDUCTORS WAS MEASURED AT 77 K IN PEAK AC FIELDS UP TO 25 MT AT 60 HZ AND IN DC FIELDS UP TO 2 T. WHILE SAMPLE ORIENTATION WAS SET SUCH THAT THE CONDUCTOR FACE WAS EITHER PARALLEL OR PERPENDICULAR TO THE APPLIED FIELDS, THE DC CURRENT WAS APPLIED AT DIFFERENT FRACTIONS OF THE CRITICAL CURRENT DETERMINED BY THE GIVEN DC FIELD TO DETERMINE THE DYNAMIC RESISTANCE. WITH RESPECT TO FIELD ORIENTATION, THE DYNAMIC RESISTANCE FOR FIELDS PERPENDICULAR TO THE CONDUCTOR FACE WAS TWO ORDERS OF MAGNITUDE HIGHER THAN THE CASE WITH THE FIELDS PARALLEL TO THE CONDUCTOR FACE. IT WAS ALSO OBSERVED THAT THE DYNAMIC RESISTANCE: 1) INCREASED WITH INCREASING FRACTION OF THE DC TRANSPORT CURRENT TO THE CRITICAL CURRENT, 2) WAS PROPORTIONAL TO THE INVERSE OF THE CRITICAL CURRENT, AND 3) DEMONSTRATED A LINEAR DEPENDENCE WITH THE APPLIED AC FIELD ONCE A THRESHOLD FIELD WAS EXCEEDED. THIS BEHAVIOR WAS SIMILAR TO EXISTING DYNAMIC RESISTANCE THEORIES, BUT SLIGHT MODIFICATIONS WERE NECESSARY TO ACCOUNT FOR THE UNIQUE COATED CONDUCTOR GEOMETRY.

RESEARCH SPONSORED BY THE U.S. DEPARTMENT OF ENERGY, OFFICE OF ELECTRICITY DELIVERY AND ENERGY RELIABILITY, ADVANCED CABLES AND CONDUCTORS, UNDER CONTRACT DE-AC05-00OR22725 WITH OAK RIDGE NATIONAL LABORATORY, MANAGED AND OPERATED BY UT-BATTELLE, LLC

3MA-02

AC MAGNETIZATION LOSSES IN COPPER-STABILIZED YBCO COATED CONDUCTORS SUBJECTED TO REPEATED MECHANICAL STRESSES *T. UNO[1], T. OJIMA[1], S. MITSUI[1], T. TAKAO[1],* ***O. TSUKAMOTO**[2];* [1]FACULTY OF SCIENCE AND TECHNOLOGY SOPHIA UNIVERSITY, TOKYO, JAPAN, [2]OFFICE OF INDUSTRY AND COMMUNITY LIAISON ENGINEERING YOKOHAMA NATIONAL UNIVERSITY, YOKOHAMA, JAPAN. — HTS COATED CONDUCTORS (CCS) ARE PROMISING AS CONDUCTORS FOR SUPERCONDUCTING AC POWER APPARATUSES, E.G. POWER CABLES, FAULT CURRENT LIMITERS AND TRANSFORMERS, BECAUSE THE AC LOSSES IN CCS ARE POTENTIALLY SMALLER THAN BI/AG SHEATHED WIRES. THE CCS IN THE APPARATUSES ARE SUBJECTED TO REPEATED MECHANICAL STRESSES CAUSED BY THERMAL CONTRACTION AND ELECTROMAGNETIC FORCES. THE REPEATED MECHANICAL STRESSES CAUSE FATIGUE EFFECTS ON SUPERCONDUCTORS. THE FATIGUE EFFECTS CAUSE DEGRADATION OF THE CRITICAL CURRENTS AND INFLUENCE AC LOSS CHARACTERISTICS. FOR THE CCS TO WORK RELIABLY AND STABLY, THEY ARE USUALLY COPPER STABILIZED. THIS WORK IS TO INVESTIGATE INFLUENCE OF REPEATED MECHANICAL STRESSES ON AC MAGNETIZATION LOSSES IN YBCO CCS WITH COPPER STABILIZATION LAYERS, COMPARING WITH AC TRANSPORT CURRENT LOSSES. REPEATED UNI-AXIAL TENSILE STRESSES/STRAINS WERE APPLIED TO THE CCS IN THE LONGITUDINAL DIRECTION AND AC MAGNETIZATION LOSSES WERE MEASURED ELECTRICALLY AT 77K. IN THE PAPER, EXPERIMENTAL RESULTS ARE PRESENTED AND INFLUENCE OF THE REPEATED MECHANICAL STRESSES ON THE AC MAGNETIZATION LOSSES ARE EXPLAINED USING A MODEL OF CC IN WHICH CRACKS IN SUPERCONDUCTOR LAYER ARE DEVELOPED AND GROWN BY REPEATED MECHANICAL STRESSES.

YBCO CCS USED IN THE EXPERIMENT WERE SUPPLIED BY SUPERPOWER LTD.

3MA-03

EFFECT OF TAPE GAP AND CABLE RADIUS ON AC LOSS OF IBAD CABLES ***D. N. NGUYEN**, S. P. ASHWORTH;* LOS ALAMOS NATIONAL LABORATORY. — EXPERIMENTAL AND NUMERICAL APPROACHES WERE EMPLOYED TO UNDERSTAND THE EFFECT OF THE GAP BETWEEN HTS TAPES IN A LAYER AND THE LAYER RADIUS ON AC LOSS IN AN IBAD CABLE. WE CONSTRUCTED SOLENOID-LIKE CABLES WITH ONE AND TWO LAYERS USING A SINGLE 12 MM WIDE IBAD FLEXIBLE IBAD TAPE FOR EACH

LAYER. THE SINGLE-TAPE-PER-LAYER DESIGN ALLOWS US TO MAKE CABLES WITH VERY UNIFORM GAP AND TO AVOID ANY CHANCE OF UNBALANCED CURRENT DISTRIBUTIONS. SEVERAL CABLES WITH THE SAME RADIUS BUT WITH DIFFERENT VALUES OF GAPS WERE FABRICATED, MEASURED AND COMPARED. THE EXPERIMENTAL DATA WERE THEN USED TO VALIDATE NUMERICAL MODELS BEFORE THEY WERE UTILIZED FOR FURTHER STUDY OF THE EFFECT OF CABLE RADIUS ON AC LOSS. THE RESULTS SHOWED THAT THE TAPE-TO-TAPE GAP, WHICH INFLUENCES THE LOCAL PERPENDICULAR MAGNETIC FIELD NEAR THE EDGES OF TAPES, IS A VERY IMPORTANT PARAMETER INFLUENCING THE AC LOSS IN AN IBAD CABLE AND MUST BE CONSIDERED IN DESIGNING LOW AC LOSS CABLE. ON THE CONTRARY, THE CABLE RADIUS, WHICH DETERMINES THE AMPLITUDE OF THE CABLE CIRCUMFERENTIAL FIELD, IS NOT AS IMPORTANT.

3MA-04

INNOVATIVE BOLOMETRIC AC LOSS MEASUREMENT OF HTSC FOR POWER APPLICATIONS ***K. SEE**, C. C.D., D. S.X.;* UNIVERSITY OF WOLLONGONG. — THE APPLICATIONS OF HIGH-TEMPERATURE SUPERCONDUCTORS (HTS) IN ELECTRIC POWER COMPONENTS HAVE BEEN WIDELY REPORTED AND VARIOUS STUDIES HAVE BEEN MADE TO DEFINE THEIR ALTERNATING CURRENT (AC) LOSSES-A KEY DESIGN PARAMETER FOR ANY PRACTICAL HIGH POWER ELECTRICAL ENGINEERING APPLICATION. VERY FEW STUDIES OVER THE RANGE 25 TO 45K HAVE BEEN CONDUCTED EVEN THOUGH THIS IS ONE OF THE FAVORED TEMPERATURE RANGES FOR COST-EFFECTIVE APPLICATIONS OF HTS. METHODS AND TECHNIQUES USED HAVE BEEN SO FAR GROUPED INTO 'ELECTRICAL' AND 'CALORIMETRIC' APPROACHES WITH EXTERNAL CONDITIONS SET TO RESEMBLE THE APPLICATION CONDITIONS. IN THIS PAPER, WE PRESENT AN APPROACH OF BOLOMETRIC METHOD TO DETERMINE LOSSES IN THE AC AND DC FIELDS LIKELY TO BE EXPERIENCED IN PRACTICAL DEVICES SUCH AS FAULT CURRENT LIMITERS. THIS TECHNIQUE PROVIDES GREAT SIMPLIFICATION COMPARED TO PICK-UP COIL AND LOCK-IN AMPLIFIER METHODS AND IS APPLIED TO A LOWER TEMPERATURE RANGE FROM 25K TO 45K WHILE EXPOSING A SAMPLE SIMULTANEOUSLY TO AC MAGNETIC FIELDS AND DIRECT CURRENT (DC) BACKGROUND MAGNETIC FIELDS. THE VARIATION OF THE LOSSES WITH APPLIED MAGNETIC FIELD, BOTH AC AND DC, AND TEMPERATURE, IS REPORTED. THE DATA OF LOSSES OBTAINED ON THIS SAMPLE TESTING WILL ALLOW THE ESTIMATION AND MINIMIZATION OF LOSSES IN PRACTICAL HIGH POWER HTS COILS AND WILL BE USED IN THE VERIFICATION OF NUMERICAL COIL MODELS.

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3MA-05

MODEL FOR ELECTROMAGNETIC FIELD ANALYSIS OF SUPERCONDUCTING POWER TRANSMISSION CABLE COMPRISING COATED CONDUCTORS CONSIDERING SPIRAL CABLE STRUCTURE ***N. AMEMIYA**[1], K. TAKEUCHI[1], T. NAKAMURA[1], N. FUJIWARA[2];* [1]KYOTO UNIVERSITY, [2]SUPERCONDUCTIVITY RESEARCH LABORATORY. — NUMERICAL ELECTROMAGNETIC FIELD ANALYSIS BASED ON THE FINITE ELEMENT METHOD IS ONE OF THE USEFUL TOOLS TO ESTIMATE AC LOSSES IN SUPERCONDUCTORS. IN CASE OF SUPERCONDUCTING POWER TRANSMISSION CABLES COMPRISING COATED CONDUCTORS, THEIR SPIRAL STRUCTURE AND VERY THIN SUPERCONDUCTOR LAYER OF COATED CONDUCTOR CAUSE A DIFFICULTY IN MODELING FOR ELECTROMAGNETIC FIELD ANALYSIS. IF THE CROSS-SECTION OF VERY THIN SUPERCONDUCTOR LAYER OF COATED CONDUCTOR IS DIVIDED BY MESHES WITH MODERATE ASPECT RATIO, HUGE NUMBER OF MESHES IS REQUIRED, AND THE EXTENSION OF THIS MODELING TO A THREE-DIMENSIONAL MODELING OF A CABLE WITH SPIRAL STRUCTURE IS NOT REALISTIC FROM THE VIEWPOINT OF CPU TIME AND MEMORY. IN ORDER TO REDUCE THE REQUIRED MEMORY AND CONSUMED CPU TIME, WE ADOPTED A THIN STRIP APPROXIMATION TO EACH COATED CONDUCTOR, IN WHICH THE MAGNETIC FIELD COMPONENT NORMAL TO SUPERCONDUCTOR LAYER IS CONSIDERED, AND THE TANGENTIAL MAGNETIC FIELD COMPONENT IS NEGLECTED. THIN STRIPS OF SUPERCONDUCTOR WERE WOUND SPIRALLY AROUND A ROUND FORMER TO REPRESENT A LAYER IN A CABLE. THE ANALYSES WERE MADE FOR TWO-LAYER CABLES WHERE THE SPIRAL PITCH OF THE INNER LAYER AND THAT OF THE OUTER LAYER ARE DIFFERENT. THE MAGNETIC FLUX AND CURRENT DISTRIBUTION ON SPIRAL COATED CONDUCTORS ARE VISUALIZED, AND AC LOSS CHARACTERISTICS OF EACH COATED CONDUCTOR AS WELL AS THOSE OF ENTIRE CABLE ARE STUDIED.

THIS WORK WAS SUPPORTED BY THE NEDO IN M-PACC PROJECT.

3MA-06

MODELING AND ELECTRICAL MEASUREMENT OF TRANSPORT AC LOSS IN HTS-BASED SUPERCONDUCTING COILS FOR ELECTRICAL MACHINES ***M. D. AINSLIE**, W. YUAN, Z. HONG, R. PEI, T. J. FLACK, T. A. COOMBS;* UNIVERSITY OF CAMBRIDGE. — AC LOSS CAN BE A SIGNIFICANT PROBLEM FOR ANY APPLICATIONS THAT UTILISE OR PRODUCE AN AC CURRENT OR MAGNETIC FIELD, SUCH AS AN ELECTRIC MACHINE. THE EPEC SUPERCONDUCTIVITY GROUP AT THE UNIVERSITY OF CAMBRIDGE IS CURRENTLY INVESTIGATING THE ELECTROMAGNETIC PROPERTIES OF HIGH TEMPERATURE SUPERCONDUCTORS WITH A PARTICULAR FOCUS ON THE AC LOSS IN COILS MADE FROM YBCO SUPERCONDUCTORS.IN THIS PAPER, A 2D FINITE ELEMENT MODEL BASED ON THE H FORMULATION IS USED TO CALCULATE THE TRANSPORT AC LOSS USING BOTH A BULK APPROXIMATION AND MODELLING THE INDIVIDUAL TURNS IN A RACETRACK-SHAPED COIL. THE COIL MODEL IS BASED ON THE COILS USED IN CAMBRIDGE'S SUPERCONDUCTING PERMANENT MAGNET SYNCHRONOUS MOTOR DESIGN, WHICH UTILISES WOUND YBCO COATED CONDUCTOR ON THE STATOR. THE TRANSPORT AC LOSS OF A STATOR COIL IS MEASURED USING ELECTRICAL METHODS BASED ON CAPACITIVE AND INDUCTIVE COMPENSATION. THE SIMULATED RESULTS ARE COMPARED WITH THE EXPERIMENTAL RESULTS, VERIFYING THE VALIDITY OF THE MODEL, AND THE INFLUENCE OF THESE RESULTS ON THE

PERFORMANCE CHARACTERISTICS OF THE MOTOR IS DISCUSSED.

3MA-07

TRANSPORT AC LOSS MEASUREMENTS IN SUPERCONDUCTING COILS *J. KIM,* ***C. KIM****, G. IYYANI, J. KVITKOVIC, S. V. PAMIDI;* FLORIDA STATE UNIVERSITY. — TRANSPORT AC LOSS MEASUREMENTS IN HIGH TEMPERATURE SUPERCONDUCTING (HTS) COILS OR COMPLEX STACKS AND BUNDLES OF SUPERCONDUCTING TAPE ARE COMPLICATED BECAUSE OF LARGE INDUCTIVE VOLTAGES AND NON-UNIFORM CURRENT DISTRIBUTION. CALORIMETRIC MEASUREMENTS PROVIDE A CONVENIENT METHOD TO EVALUATE AC LOSSES IN HTS COILS AND STACKS. CALORIMETRIC MEASUREMENTS, HOWEVER, HAVE LOWER SENSITIVITY AND ARE MORE CUMBERSOME COMPARED TO ELECTRICAL MEASUREMENTS. THIS PAPER PRESENTS CALORIMETRIC STUDIES, BASED ON LIQUID NITROGEN BOIL-OFF METHOD, OF TRANSPORT AC LOSS MEASUREMENTS ON HTS PANCAKE COILS. THE RESULTS OF THE CALORIMETRIC MEASUREMENTS WERE USED TO STANDARDIZE ELECTRICAL TECHNIQUE FOR TRANSPORT AC LOSS MEASUREMENTS IN COILS. THIS PAPER WILL PRESENT DETAILS OF THE MEASUREMENT SET UP AND DATA ON SEVERAL PANCAKE COILS AS WELL AS COMPARISON OF THE DATA OBTAINED WITH THE ELECTRICAL AND CALORIMETRIC MEASUREMENTS.

3MB-01

HIGH TRANSPORT CRITICAL CURRENTS IN THE IRON PNICTIDE SUPERCONDUCTING WIRES AND TAPES ***Y. MA****, L. WANG, Y. QI, Z. GAO, D. WANG, X. ZHANG;* INSTITUTE OF ELECTRICAL ENGINEERING, CHINESE ACADEMY OF SCIENCES. — THE RECENT DISCOVERY OF SUPERCONDUCTIVITY IN THE IRON BASED SUPERCONDUCTORS WITH VERY HIGH UPPER CRITICAL FIELDS PRESENTS A NEW POSSIBILITY FOR PRACTICAL APPLICATIONS, BUT FABRICATING FINE-WIRE IS A CHALLENGE BECAUSE OF MECHANICALLY HARD AND BRITTLE POWDERS AND THE TOXICITY AND VOLATILITY OF ARSENIC. IN THIS TALK, WE REPORT THE ACHIEVEMENT OF TRANSPORT CRITICAL CURRENTS IN $SR_{0.6}K_{0.4}FE_2AS_2$ WIRES AND TAPES WITH A T_C = 34 K. THE WIRES AND TAPES WERE FABRICATED THROUGH THE COMMON POWDER-IN-TUBE PROCESS. SILVER WAS USED AS A SHEATH MATERIAL. ALL THE WIRE AND TAPE SAMPLES HAVE SHOWN THE ABILITY TO TRANSPORT SUPERCONDUCTING CURRENT. CRITICAL CURRENT DENSITY J_C WAS ENHANCED UPON ADDITION (AG OR PB), AND AT 4.2 K, A LARGEST J_C OF ~3750 A/CM^2 (I_C = 37.5 A) WAS ACHIEVED FOR OUR BEST WIRE SAMPLES, WHICH IS THE HIGHEST IN IRON-BASED WIRES AND TAPES SO FAR. SUCH A HIGH TRANSPORT CRITICAL CURRENT DENSITY IS ATTRIBUTED TO THE WEAK REACTION BETWEEN THE SILVER SHEATH AND THE SUPERCONDUCTING CORE, AS WELL AS AN IMPROVED CONNECTIVITY BETWEEN GRAINS. WE ALSO IDENTIFY A WEAK-LINK BEHAVIOR FROM THE APPARENT DROP OF J_C AT LOW FIELDS AND A HYSTERETIC PHENOMENON. THESE RESULTS CLEARLY DEMONSTRATE THE FEASIBILITY OF PRODUCING SUPERCONDUCTING PNICTIDE COMPOSITE WIRES, EVEN GRAIN BOUNDARY PROPERTIES REQUIRE MUCH MORE ATTENTION.

3MB-02

FE/BA (FE1-XCOX) 2AS2 BILAYERS AND THEIR SUPERCONDUCTING PROPERTIES ***K. IIDA****, J. HAENISCH, R. HUEHNE, T. D. THERSLEFF, M. KIDSZUN, S. HAINDL, A. KAUFFMANN, S. TROMMLER, F. KURTH, L. SCHULTZ, B. HOLZAPFEL;* IFW DRESDEN. — HIGH-QUALITY, EPITAXIAL THIN FILMS HAVE BEEN SUCCESSFULLY DEPOSITED ON VARIOUS SUBSTRATES, SUCH AS SRTIO3, (LA,SR)(TA,AL)O3, AND LAALO3 BY PULSED LASER DEPOSITION.[1] THE SUPERCONDUCTING TRANSITION TEMPERATURE IS OBSERVED TO INCREASE FROM 17 K TO 24.5 K WITH INCREASING RATIO OF THE LATTICE PARAMETERS, C/A, MAINLY DUE TO A LATTICE DISTORTION. FURTHERMORE, THE LATTICE STRAIN SUBSTANTIALLY AFFECTS THE UPPER CRITICAL FIELD. DETAILED STUDIES WILL BE DISCUSSED IN THIS CONTRIBUTION.[1] K. IIDA, J. HAENISCH, R. HUEHNE, F. KURTH, M. KIDSZUN, S. HAINDL, J. WERNER, L. SCHULTZ AND B. HOLZAPFEL, APPL. PHYS. LETT. 95, 192501 (2009).

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3MB-03

GROWTH OF SUPERCONDUCTING NDFEAS(O,F) THIN FILMS BY MOLECULAR BEAM EPITAXY ***H. IKUTA****, T. KAWAGUCHI, H. UEMURA, T. OHNO, M. TABUCHI, T. UJIHARA, K. TAKENAKA, Y. TAKEDA;* NAGOYA UNIVERSITY, JST TRIP. — WE HAVE SUCCEEDED IN AN *IN-SITU* GROWTH OF SUPERCONDUCTING THIN FILMS OF THE 1111-TYPE IRON-PNICTIDE SUPERCONDUCTOR, NDFEAS(O,F). THE FILMS WERE GROWN BY MOLECULAR BEAM EPITAXY ON GAAS(001) SUBSTRATES. ALL ELEMENTS WERE SUPPLIED FROM SOLID SOURCES CHARGED IN KNUDSEN CELLS; FE, AS, NDF_3, AND FE_2O_3. HERE FE_2O_3 WAS USED AS AN OXYGEN SOURCE. THE GROWTH WINDOW OF NDFEAS(O,F) WAS FOUND TO BE VERY NARROW AND IT WAS NECESSARY TO PRECISELY ADJUST THE FLUX RATIO OF ND, FE, AND O_2. ESPECIALLY, THE CONTROL OF THE FLUX AMOUNT OF O_2 WAS VERY IMPORTANT FOR SUPPRESSING THE FORMATION OF ARSENIDE IMPURITIES SUCH AS NDAS. EPITAXIAL FILMS WITH *C*-AXIS PERPENDICULAR TO THE SUBSTRATE WERE SUCCESSFULLY GROWN WITH A VERY HIGH REPRODUCIBILITY AFTER CAREFULLY ADJUSTING THE GROWTH PARAMETERS. THE *AS-GROWN* FILMS SHOWED A SUPERCONDUCTING TRANSITION WITH A T_C UP TO 48 K FOR THE ONSET AND 42 K FOR ZERO RESISTANCE. FOR THE BEST OF OUR KNOWLEDGE, THESE ARE THE FIRST THIN FILMS OF THE 1111 FAMILY THAT EXHIBIT A SUPERCONDUCTING TRANSITION WITHOUT THE NEED OF A POST-ANNEALING TREATMENT AND POSSESS THE HIGHEST TRANSITION TEMPERATURE AMONG THE THIN FILMS OF THE IRON-BASED SUPERCONDUCTORS REPORTED SO FAR.

3MB-04

TEMPLATE ENGINEERING OF CO-DOPED $BAFE_2AS_2$ SINGLE-CRYSTAL THIN FILMS ***S. LEE***[1]*, J. JIANG*[2]*, Y. ZHANG*[3]*, C. W. BARK*[1]*, J. D. WEISS*[2]*, C. TRANTINI*[2]*, C. T. NELSON*[3]*, H. W. JANG*[1]*, C. M. FOLKMAN*[1]*, S. H. BAEK*[1]*, A. POLYANSKII*[2]*, D. ABRAIMOV*[2]*,*

A. YAMAMOTO[2], J. W. PARK[1], X. Q. PAN[3], E. E. HELLSTROM[2], D. C. LARBALESTIER[2], C. B. EOM[1]; [1]UNIVERSTIY OF WISCONSIN - MADISON, [2]FLORIDA STATE UNIVERSITY, [3]THE UNIVERSITY OF MICHIGAN - ANN ARBOR. — UNDERSTANDING NEW SUPERCONDUCTORS REQUIRES HIGH-QUALITY EPITAXIAL THIN FILMS TO EXPLORE INTRINSIC ELECTROMAGNETIC PROPERTIES, CONTROL GRAIN BOUNDARIES AND STRAIN EFFECTS, AND EVALUATE DEVICE APPLICATIONS. WE HAVE GROWN SIGNLE CRYSTAL EPITAXIAL THIN FILMS OF FERROPNICTIDE ON VARIOUS OXIDE SUBSTRATES BY USING PULSED LASER DEPOSTION. WE HAVE EMPLOYED NOVEL TEMPLATE ENGINEERING USING SINGLE-CRYSTAL INTERMEDIATE LAYERS OF (001) SRTIO3 AND BATIO3 GROWN ON VARIOUS PEROVSKITE SUBSTRATES THAT ENABLES GENUINE EPITAXIAL FILMS OF CO-DOPED BAFE2AS2 WITH HIGH TRANSITION TEMPERATURE (TC, RESISTIVITY = 0 OF 21.5K), SMALL TRANSITION WIDTHS (DELTA TC = 1.3K), SUPERIOR JC OF 4.5 MA/CM2 (4.2K, SELF FIELD) AND STRONG C-AXIS FLUX PINNING. IMPLEMENTING SRTIO3 OR BATIO3 TEMPLATES TO MATCH THE ALKALINE EARTH LAYER IN THE BA-122 WITH THE ALKALINE EARTH-OXYGEN LAYER IN THE TEMPLATES OPENS NEW AVENUES FOR EPITAXIAL GROWTH OF FERROPNICTIDES ON MULTI-FUNCTIONAL SINGLE CRYSTAL SUBSTRATES. WE WILL DISUCSS THE NATURE AND GROWTH MECHANISMS OF COLUMNAR DERFECTS AND THEIR INFLUENCE ON FLUX PINNING.

3MB-05

JOSEPHSON JUNCTION WITH FE-BASED SUPERCONDUCTOR CO DOPED $BAFE_2AS_2$ EPITAXIAL FILM ***T. KATASE[1], Y. ISHIMARU[2], A. TSUKAMOTO[2], H. HIRAMATSU[3], T. KAMIYA[1], K. TANABE[2], H. HOSONO[1];*** [1]MATERIALS AND STRUCTURES LABORATORY, TOKYO INSTITUTE OF TECHNOLOGY, [2]SUPERCONDUCTIVITY RESEARCH LABORATORY, INTERNATIONAL SUPERCONDUCTIVITY TECHNOLOGY CENTER, [3]FRONTIER RESEARCH CENTER, TOKYO INSTITUTE OF TECHNOLOGY. — FE-BASED SUPERCONDUCTORS HAVE ATTRACTIVE PROPERTIES SUCH AS HIGH CRITICAL TEMPERATURES UP TO 56 K[1,2] AND HIGH CRITICAL MAGNETIC FIELDS (UPPER CRITICAL FIELDS > 100 T),[3] WHICH AROUSES ACTIVE RESEARCH ON EPITAXIAL FILMS. WE SUCCEEDED IN FABRICATING EPITAXIAL FILMS OF LAFEASO,[4] AND SUPERCONDUCTING EPITAXIAL FILMS OF CO-DOPED *AE*FE_2AS_2 (*AE* = SR AND BA).[5,6] SEVERAL GROUPS ALSO HAVE REPORTED THE FABRICATION OF EPITAXIAL FILMS OF FE-BASED SUPERCONDUCTORS SUCH AS F-DOPED *LN*FEASO (*LN* = LA, ND), CO-DOPED *AE*FE_2AS_2 AND $FESE_{1-X}TE_X$. HOWEVER, AT PRESENT, THEY DO NOT HAVE ENOUGH PROPERTIES FOR APPLICATION TO JOSEPHSON JUNCTIONS, WHICH ARE ESSENTIAL FOR ELECTRONIC APPLICATION.HERE, WE SHOW THE FIRST DEMONSTRATION OF A JOSEPHSON JUNCTION USING AN EPITAXIAL FILM OF CO-DOPED $BAFE_2AS_2$ ($BAFE_2AS_2$:CO) WITH A HIGH CRITICAL CURRENT DENSITY J_C OF 2-5 MA/CM^2. WE FABRICATED JOSEPHSON JUNCTIONS WITH 10 MM-WIDE MICRO-BRIDGES ACROSS A BICRYSTAL GRAIN BOUNDARY IN $BAFE_2AS_2$:CO FILMS ON LSAT [001]-TILT BICRYSTAL SUBSTRATES. THE *I - V* CURVE SHOWED RESISTIVELY-SHUNTED-JUNCTION (RSJ) TYPE CHARACTERISTICS BELOW 17 K. THE CRITICAL CURRENT WAS CLEARLY MODULATED BY A WEAK EXTERNAL MAGNETIC FIELD APPLIED PERPENDICULAR TO THE FILM SURFACE.[1]Y. KAMIHARA ET AL., *JACS* (2008). [2]C. WANG ET AL., *EPL* (2008). [3]F. HUNTE ET AL., *NATURE* (2008). [4]H. HIRAMATSU ET AL., *APL* (2008). [5]H. HIRAMATSU ET AL., *APEX* (2008). [6]T. KATASE ET AL., *SSC* (2009).

3MB-06

(INVITED) **SUPERCONDUCTING PROPERTIES OF IRON-CHALCOGENIDE FILMS ON SINGLE CRYSTALLINE AND BUFFERED TECHNICAL SUBSTRATES** ***Q. LI[1], W. SI[1], Q. JIE[1], J. ZHU[1], S. SOLOVYOV[1], A. GOYAL[2], V. MATIAS[3];*** [1]BROOKHAVEN NATIONAL LABORATORY, [2]OAK RIDGE NATIONAL LABORATORY, [3]LOS ALAMOS NATIONAL LABORATORY. — WE REPORT OUR EFFORTS ON THE FABRICATION OF IRON-CHALCOGENIDE SUPERCONDUCTING FILMS ON A VARIETY OF SUBSTRATES TO INVESTIGATE THEIR SUPERCONDUCTING PROPERTIES AND EXPLORE POTENTIAL DEVICE APPLICATIONS. ROBUST THIN FILMS OF $FESE_{0.5}TE_{0.5}$ HAVE BEEN EPITAXIALLY GROWN ON $SRTIO_3$ AND $LAALO_3$ SUBSTRATES BY PULSED LASER DEPOSITION. ENHANCED ONSET T_C (~ 17 K) IS OBSERVED. STRUCTURAL ANALYSIS REVEAL THAT THESE FILMS GENERALLY HAVE SIGNIFICANTLY SHORTER OUT-OF-PLANE LATTICE CONSTANT THAN THE BULK VALUE, SUGGESTING THAT THE OUT-OF-PLANE CHANGES HAVE A DOMINATING IMPACT ON T_C IN IRON-BASED SUPERCONDUCTORS. $H_{C2}(0)$ OF THOSE FILMS REACHES ~ 50 T. THIN FILMS OF FETE:O_X EPITAXIALLY GROWN ON $SRTIO_3$ SUBSTRATES IN CONTROLLED OXYGEN ATMOSPHERE ARE SUPERCONDUCTING (ONSET T_C ~12 K), ALTHOUGH BULK FETE IS NOT SUPERCONDUCTING. INTERESTINGLY, $H_{C2}(0)$ OF THE FETE:O_X FILMS ESTIMATED FROM THE MAGNETIC RESISTIVE METHOD REACHES A MUCH HIGH VALUE OVER 100 T. THIS IS ESPECIALLY REMARKABLE, CONSIDERING THE FAIRLY LOW T_C IN THE IRON CHACOGENIDES, AS COMPARED TO THE HIGH T_C CUPRATES. WE WILL ALSO PRESENT THE RESULTS OF THESE FILMS GROWN ON SEVERAL WELL-KNOWN BUFFERED METALLIC SUBSTRATES, TOGETHER WITH THE MEASUREMENTS OF MAGNETIC FIELD STRENGTH- AND ANGLE-DEPENDENCE OF CRITICAL CURRENT DENSITY J_C. WE THINK THERE EXISTS A UNIQUE OPPORTUNITY FOR THIS CLASS OF MATERIALS IN HIGH FIELD APPLICATION.

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3MB-07

SUPERCONDUCTING PROPERTIES OF FESE FAMILY ***Y. TAKANO;*** NATIONAL INSTITUTE FOR MATERIALS SCIENCE (NIMS). — SINCE FESE FAMILY HAS THE SIMPLEST CRYSTAL STRUCTURE AMONG IRON-BASED SUPERCONDUCTORS, IT IS ONE OF THE BEST TARGETS TO ELUCIDATE THE MECHANISM OF IRON-BASED SUPERCONDUCTIVITY. FESE SHOWS THE CRYSTAL STRUCTURAL TRANSITION AROUND 70K WITHOUT MAGNETIC ORDER, AND SUPERCONDUCTIVITY APPEARS AROUND 10K. THE TC OF FESE WAS DRAMATICALLY IMPROVED UP TO 37K WITH APPLYING PRESSURE AROUND 4-

6GPA THE TC=37K IS THE THIRD RECORD OF 2 ELEMENTS SUPERCONDUCTORS. ON THE OTHER HANDS, FETE SHOWS CLEAR MAGNETIC ORDER AROUND 70K WITHOUT SUPERCONDUCTIVITY. BETWEEN FESE AND FETE, THERE IS A COMPETITION OF SUPERCONDUCTIVITY AND MAGNETIC ORDER. WE SUMMARIZE THE PHASE DIAGRAM FROM FESE TO FETE INCLUDING THE MOISTURE INDUCED SUPERCONDUCTOR FE(TE,S). AND ANION HEIGHT DEPENDENCE OF TC WILL BE ALSO DISCUSSED.[1] Y. MIZUGUCHI ET AL., APPL. PHYS. LETT. 93, 152505 (2008).[2] Y. MIZUGUCHI, ET AL, APPL. PHYS. LETT. 94, 012503 (2009).[3] Y. MIZUGUCHI, ET AL, ARXIV: 0912.2240.

SUPPORTED BY JST TRIP

3MP1A-01

TOWARDS FASTER FEM SIMULATION OF THIN FILM SUPERCONDUCTORS: A MULTISCALE APPROACH ***V. M. RODRIGUEZ-ZERMENO***[1]*, N. MIJATOVIC*[2]*, C. TRÆHOLT*[2]*, T. ZIRNGIBL*[3]*, E. SEILER*[3]*, A. B. ABRAHAMSEN*[3]*, N. PEDERSEN*[2]*, M. SØRENSEN*[1]*;* [1]TECHNICAL UNIVERSITY OF DENMARK - DEPARTMENT OF MAHEMATICS, [2]TECHNICAL UNIVERSITY OF DENMARK - DEPARTMENT OF ELECTRICAL ENGINEERING, [3]TECHNICAL UNIVERSITY OF DENMARK - RISØ - MATERIALS RESEARCH DIVISION. — THIS WORK PRESENTS A METHOD TO SIMULATE THE ELECTROMAGNETIC PROPERTIES OF SUPERCONDUCTORS WITH HIGH ASPECT RATIO SUCH AS THE COMMERCIALLY AVAILABLE SECOND GENERATION SUPERCONDUCTING WIRES, (YBCO). THE METHOD IS BASED ON A MULTISCALE REPRESENTATION FOR BOTH THICKNESS AND WIDTH OF THE SUPERCONDUCTING DOMAINS. A COUPLE OF TEST CASES WERE SUCCESSFULLY SIMULATED AND FURTHER INVESTIGATIONS WERE MADE BY MEANS OF STRUCTURED MESHES. HERE, LARGE ASPECT RATIO ELEMENTS WERE USED TO SIMULATE THIN MATERIAL LAYERS WITH A REDUCED NUMBER OF ELEMENTS. HENCE, MORE COMPLEX GEOMETRIES CAN BE STUDIED AT CONSIDERABLE LOWER COMPUTATIONAL TIME. SEVERAL TEST CASES WERE SIMULATED INCLUDING TRANSPORT CURRENT, EXTERNALLY APPLIED MAGNETIC FIELD AND A COMBINATION OF BOTH. THE RESULTS ARE IN GOOD AGREEMENT WITH EXPERIMENTAL DATA AND RECENTLY PUBLISHED NUMERICAL SIMULATIONS. THE COMPUTATIONAL TIME TO SOLUTION OF THE PRESENT MULTISCALE APPROACH IN 2D IS ESTIMATED AS TWO ORDERS OF MAGNITUDE FASTER THAN OTHER 2D METHODS.

WE ACKNOWLEDGE SUPPORT FROM VESTAS WIND SYSTEMS, THE RESEARCH SCHOOL OF DCAMM, TECHNICAL UNIVERSITY OF DENMARK AND SEP-MEXICO.

3MP1A-02

STUDY OF YBCO TAPE NON-UNIFORMITY BASED ON THE DISTRIBUTION OF MAGNETIC FIELD IN CURRENT TRANSPORT ***M. SOLOVYOV****, F. GÖMÖRY;* IEE SAS. — THE SIMPLEST MODELS IN CALCULATIONS OF AC LOSSES IN YBCO TAPES ASSUME A RECTANGULAR CROSS-SECTION OF SUPERCONDUCTING LAYER AND CONSTANT CRITICAL CURRENT DENSITY. MODELS THAT ARE MORE COMPLEX CONSIDER THE CRITICAL CURRENT DENSITY DEPENDING ON MAGNETIC FIELD AND ITS ORIENTATION. IN SOME AC LOSS EXPERIMENTS THE OBSERVED DEVIATION FROM THEORETICAL PREDICTIONS COULD BE EXPLAINED BY A NON-UNIFORMITY OF THE SUPERCONDUCTING LAYER ACROSS THE TAPE WIDTH. THEREFORE, WE TRY TO DETERMINE THIS NON-UNIFORMITY FROM THE MEASURED DISTRIBUTION OF MAGNETIC FIELD IN THE TAPE VICINITY. THE EXPERIMENTAL PROFILES WERE COMPARED WITH THOSE CALCULATED BY NUMERICAL METHOD BASED ON THE CRITICAL STATE MODEL, COMPRISING NON-UNIFORMITY IN THE SUPERCONDUCTOR PROPERTIES OR THE LAYER THICKNESS. THIS PROCEDURE REQUIRES LESS COMPUTATION TIME THEN THE MODEL OPTIMIZATION FOR THE PURPOSE OF AGREEMENT OF AC LOSS CALCULATIONS WITH EXPERIMENTS. FROM THE SERIES OF MAGNETIC FIELD DISTRIBUTIONS CALCULATED WITH DIFFERENT PARAMETERS OF THE CRITICAL CURRENT NON-UNIFORMITY, THE CANDIDATES EXHIBITING THE BEST AGREEMENT WITH EXPERIMENTAL OBSERVATION HAVE BEEN SELECTED. PRACTICAL USE OF THIS PROCEDURE IN THE EVALUATION OF TAPE QUALITY IS DISCUSSED.

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3MP1A-03

DESIGN OF FERROMAGNETIC PARTS IN POWER DEVICES FROM HIGH TEMPERATURE SUPERCONDUCTORS. ***M. VOJENCIAK****, J. SOUC, F. GÖMÖRY;* IEE, SLOVAK ACADEMY OF SCIENCES. — HIGH TEMPERATURE SUPERCONDUCTORS HAVE ADVANTAGE OF HIGH CURRENT DENSITY AND LOW LOSS IN COMPARISON TO CONVENTIONAL CONDUCTORS. HOWEVER, BOTH THE ADVANTAGES ARE STRONGLY AFFECTED BY MAGNETIC FIELD IN POWER APPLICATIONS LIKE WINDING OF MOTORS, GENERATORS, TRANSFORMERS AND CABLES. EFFORT TO MINIMIZE THE MAGNETIC FIELD ACTING ON THE SUPERCONDUCTOR SURFACE USING FERROMAGNETIC PARTS TOOK PLACE RECENTLY. UTILIZED FERROMAGNETIC MATERIALS WERE MAINLY CHOSEN FROM EASY AVAILABLE ONES. THIS CONTRIBUTION CONCENTRATES ON THE DESIGN OF FERROMAGNETIC PARTS AND THE CORRESPONDING REQUIREMENTS ON FERROMAGNETIC MATERIAL PROPERTIES. A NUMERICAL METHOD IS EMPLOYED TO CALCULATE THE PERFORMANCE AND CONSEQUENTLY OPTIMIZATION OF MATERIAL PARAMETERS OF THE PARTICULAR FERROMAGNETIC PART. REALISTIC MATERIAL PROPERTIES ARE CONSIDERED IN OUR CALCULATIONS. THE FERROMAGNETIC MATERIAL IS CHARACTERIZED BY A NON-LINEAR MAGNETIZATION CURVE. PAPER SUMMARIZES THE PROPERTIES OF ACTUAL FERROMAGNETIC MATERIALS AND DISCUSSES THE POSSIBILITIES TO USE THEM FOR MAGNETIC SHIELDING OF DEVICE PARTS FROM HIGH TEMPERATURE SUPERCONDUCTORS.

3MP1A-04

NEW APPROACH FOR COMPUTING TOP/BOTTOM AC LOSSES IN COATED CONDUCTOR WINDINGS ***S. BRAULT***[1]*, F. SIROIS*[1]*, F. GRILLI*[2]*;* [1]ECOLE POLYTECHNIQUE DE MONTREAL, [2]KARLSRUHE INSTITUTE OF TECHNOLOGY. — IT HAS BEEN RECENTLY

SHOWN THAT 1-D MODELS BASED ON INTEGRAL EQUATIONS ARE FAST AND USEFUL TO EVALUATE THE AC LOSSES IN HTS COATED CONDUCTORS ASSEMBLIES SUCH AS STACKS, COILS AND CABLES. IN MOST CASES, THE RESULTS ARE VERY CLOSE TO THOSE OBTAINED WITH A FULL 2-D FINITE ELEMENT MODEL, ALTHOUGH THE COMPUTATION TIME IS DRASTICALLY REDUCED. HOWEVER, WHEN TAPES ARE VERY CLOSELY PACKED, E.G., IN ANTI-INDUCTIVE COIL CONFIGURATIONS, THE 1-D MODEL FAILS TO PROVIDE THE CORRECT VALUE OF LOSSES. THIS IS EXPLAINED BY THE FACT THAT THE TOP/BOTTOM LOSSES, I.E. THE LOSSES DUE TO THE PENETRATION OF THE TANGENTIAL MAGNETIC FLUX INTO THE SAMPLE'S THICKNESS, CANNOT BE TAKEN INTO ACCOUNT. THIS PAPER PROVIDES A SOLUTION TO THIS PROBLEM BY DETERMINING A SCALING LAW FOR THE LOSSES AS A FUNCTION OF THE FREQUENCY OF THE POWER SOURCE AND THE MAXIMUM TANGENTIAL COMPONENT OF THE APPLIED FIELD. IT IS SHOWN THAT THE CORRECT AC LOSSES CAN BE COMPUTED A POSTERIORI, BY ADDING THIS ANALYTIC CONTRIBUTION (TOP/BOTTOM LOSSES) TO THE NUMERICALLY COMPUTED LOSSES, CORRESPONDING TO THE EDGE LOSS CONTRIBUTION.

WORK FUNDED BY NSERC AND MITACS.

3MP1A-06

YBCO FILMS GROWN ON SAPPHIRE FIBERS BY MAGNETRON SPUTTERING AND MODIFIED TFA-MOD PROCESS ***Y. XU****, Z. QIAN, Z. XU, P. HE, R. BHATTACHARYA;* UES INC. — THERE HAVE BEEN GREAT ADVANCEMENTS FOR THE 2ND GENERATION (2G) HIGH TEMPERATURE SUPERCONDUCTORS (HTS) WIRES TERMED COATED CONDUCTORS (CCS). NEVERTHELESS, DUE TO THE HIGH ASPECT RATIO, AC LOSS IS A SEVERE PROBLEM FOR THE COATED CONDUCTORS. TECHNICAL APPROACHES OF CUTTING THE WIDE CC TAPES INTO SMALL STRIPS HAVE BEEN EXPLORED AND CONFIRMED TO BE EFFECTIVE IN REDUCING AC LOSS. ALSO, SUBSTRATE MAGNETIC AND EDDY CURRENT LOSSES ARE UNAVOIDABLE IN THE CURRENT CC TECHNOLOGIES. FROM THE APPLICATION STAND POINT, CUSTOMERS NEED THIN WIRE (LIKE COMMONLY USED COPPER WIRE) OR MULTI-FILAMENT CABLES RATHER THAN WIDE TAPE CCS. LOW ASPECT RATIO, NON-MAGNETIC, NON-CONDUCTIVE, AND LOW DIELECTRIC CONSTANT NATURE OF OXIDE SINGLE CRYSTAL FIBER WILL PROVIDE EXTREMELY LOW AC LOSS IN CC APPLICATION. BY USING THESE OXIDE FIBERS, SUBSTRATE MAGNETIC AND EDDY CURRENT LOSSES ARE COMPLETELY ELIMINATED. IN THIS RESEARCH, $YBA_2CU_3O_{7-\Delta}$ (YBCO) FILMS HAVE BEEN GROWN SUCCESSFULLY ON SINGLE CRYSTAL FIBERS OF SAPPHIRE BY MAGNETRON SPUTTERING AND MODIFIED TFA-MOD PROCESS. CRITICAL CURRENT DENSITY OVER $1MA/CM^2$ HAS BEEN DEMONSTRATED AT 77K SELF-FIELD.

3MP1A-07

EXPERIMENTAL EVALUATION OF POLYGONAL ARRANGEMENT ON AC LOSS IN YBCO ASSEMBLED CONDUCTORS ***J. OGAWA****, S. FUKUI, T. OKA, T. SATO, T. ITO, J. SUGISAWA, A. TAMURA;* NIIGATA UNIVERSITY. — THE AC TRANSPORT CURRENT LOSS IN A YBCO POLYGONAL ARRANGED ASSEMBLED CONDUCTOR DEPENDS ON THE ARRANGEMENT. THE AZIMUTHAL MAGNETIC FIELD PRODUCED BY THE CURRENTS IN NEIGHBORING TAPES AFFECTS THE CURRENT DISTRIBUTION IN EACH TAPE, AND IT IS EXPECTED THAT THE AC LOSS REDUCTION EFFECT IS GREATEST WITH A ROUND FORM. TO CLARIFY THE AC LOSS CHARACTERISTICS IN A POLYGONAL ARRANGED YBCO ASSEMBLED CONDUCTOR, WE INVESTIGATED THE INFLUENCE OF VARYING TAPE DISTANCES AND THE ANGLE NUMBER OF POLYGONAL SHAPES. TO MEASURE THE INFLUENCE OF DISTANCE, WE MEASURED THE AC LOSSES IN A YBCO HEXAGONALLY ASSEMBLED CONDUCTOR WHICH WAS ARRANGED WITH DISTANCES RANGING FROM 0.2MM - 4.0MM. TO MEASURE THE INFLUENCE OF POLYGONAL SHAPES, WE EVALUATED YBCO POLYGONAL ASSEMBLED CONDUCTORS WHICH WERE ARRANGED AS A SQUARE, PENTAGON, HEXAGON, OCTAGON OR DECAGON AT A DISTANCE OF 0.5MM. THE EXPERIMENTAL RESULTS SHOW THE AC LOSS REDUCTION EFFECT IS GREATEST WHEN ARRANGED AS A ROUND SHAPE.

THIS WORK WAS SUPPORTED IN PART BY GRANT-IN-AID FOR SCIENTIFIC RESERCH (C), THE MINISTRY OF EDUCATION, CULTURE, SPORTS, SCIENCE AND TECHNOLOGY, JAPAN.

3MP1A-08

TRANSPORT AC LOSS CHARACTERISTICS OF A FIVE STRAND YBCO ROEBEL CABLE WITH MAGNETIC SUBSTRATE ***Z. JIANG****[1], K. P. THAKUR[1], M. P. STAINES[1], R. A. BADCOCK[1], N. J. LONG[1], R. G. BUCKLEY[1], N. AMEMIYA[2], D. A. CAPLIN[3];* [1]INDUSTRIAL RESEARCH LIMITED, [2]KYOTO UNIVERSITY, [3]IMPERIAL COLLEGE. — TRANSPORT AC LOSS IN A SHORT LENGTH OF 5/2 YBCO ROEBEL CABLE (FIVE 2 MM WIDE STRANDS) WITH NI-5%W MAGNETIC SUBSTRATE IS MEASURED. THE AC LOSS DATA ARE COMPARED WITH THOSE IN A SINGLE STRAND. ALL THE STRANDS COMPOSING THE CABLE AND THE SINGLE STRAND ARE CUT FROM THE SAME STOCK MATERIAL. TRANSPORT AC LOSS IN THE 5/2 ROEBEL CABLE IS LARGER THAN PREDICTED BY BOTH THE NORRIS STRIP AND ELLIPSE MODELS. THE DIFFERENCE BETWEEN NORMALIZED AC LOSSES IN THE ROEBEL CABLE AND THE SINGLE STRAND IS LARGER AT LOW I/I_C THAN AT HIGH I/I_C. THE ABOVE AC LOSS CHARACTERISTICS WERE NOT OBSERVED IN TRANSPORT AC LOSS RESULTS IN YBCO ROEBEL CABLES COMPOSED OF NON-MAGNETIC SUBSTRATE COATED CONDUCTORS. RESULTS FROM AN ELECTROMAGNETIC CALCULATION ON TWO PARALLEL STACKS OR WIRE WITH MAGNETIC SUBSTRATE ARE PRESENTED TO ELUCIDATE THE RESULTS.

THIS WORK WAS SUPPORTED BY THE NEW ZEALAND FOUNDATION FOR RESEARCH SCIENCE AND TECHNOLOGY.

3MP1B-01

RESONANT BEHAVIOUR OF THE BARRIER OF $YBA_2CU_3O_7$ GRAIN BOUNDARY JOSEPHSON JUNCTIONS FABRICATED ON BICRYSTALLINE SUBSTRATES WITH DIFFERENT GEOMETRIES ***M. A. NAVACERRADA****;* UNIVERSIDAD POLITÉCNICA DE

MADRID. — WE HAVE OBSERVED A RESONANT BEHAVIOUR IN THE DIELECTRIC CONSTANT ASSOCIATED TO THE BARRIER OF $YBA_2CU_3O_7$ (YBCO) GRAIN BOUNDARY JOSEPHSON JUNCTIONS (GBJJS) FABRICATED OF A WIDE VARIETY OF BICRYSTALLINE SUBSTRATES: 12º [001] TILT ASYMMETRIC, 24º [001] TILT ASYMMETRIC, 24º [001] TILT SYMMETRIC, 24º [10] TILT ASYMMETRIC, 45º [100] TILT ASYMMETRIC AND 24º [001] TILT SYMMETRIC + 45 [100] TILT ASYMMETRIC BICRYSTALS. THE RESONANCE FREQUENCY VARIES BETWEEN 7 - 2×10^{11} HZ DEPENDING ON THE SUBSTRATE GEOMETRY. SUCH RANGE POINTS TO A PHONON DYNAMIC INFLUENCE ON THE RESONANCE MECHANISM. IN THE LITERATURE, THE PHONON MODE FREQUENCIES ARE WELL ESTABLISHED FOR YBCO THIN FILMS AND SINGLE CRYSTALS, AND ALSO THEIR DEPENDENCES ON THE OXYGEN CONTENT OF THE SAMPLES HAVE BEEN EXTENSIVELY REPORTED. HOWEVER, ALTHOUGH THE ACTIVE MODES ARE WELL-KNOW, IT HAS BEEN PROVEN THAT, BESIDES OF THE OXYGEN CONTENT OF THE SAMPLE, THE POSITION AND INTENSITY OF THE PHONON MODES DEPEND ON OTHER PROPERTIES SUCH AS CATION DISORDER, ORIENTATION, SPATIAL ORDERING, IMPURITIES AND STRAIN IN THE CASE OF THIN FILM. IN THIS SENSE, THE RAMAN SPECTRA REVEAL A NUMBER OF MANY ADDITIONAL SPECTRAL FEATURES, MOST STRONGLY PRONOUNCED IN POORLY OXYGENATED, DOPED OR MIXED YBCO SAMPLES. IN THE PRESENT WORK, WE DISCUSS IN DETAIL THE POSSIBLE ORIGIN OF THE RESONANCE OBSERVED IN OUR GBJJS IN TERMS OF STRUCTURAL DISORDER AND COMPOSITION OF THE JUNCTION BOUNDARY.

3MP1B-02

SUPERCONDUCTING $SR_{1-X}LA_XCUO_2$ THIN FILMS AND JUNCTIONS ***J. TOMASCHKO***[1]*, V. LECA*[1]*, L. T. CORREDOR*[2]*, M. TURAD*[1]*, R. KLEINER*[1]*, D. KOELLE*[1]*;* [1]PHYSIKALISCHES INSTITUT – CENTER FOR COLLECTIVE QUANTUM PHENOMENA, UNIVERSITÄT TÜBINGEN, AUF DER MORGENSTELLE 14, D-72076 TÜBINGEN, GERMANY, [2]PERMANENT ADDRESS: GRUPO DE FISICA DE NUEVOS MATERIALES, DEPARTAMENTO DE FISICA, UNIVERSIDAD NACIONAL DE COLOMBIA, AA 14490, BOGOTA D.C., COLOMBIA. — THE *N*-DOPED INFINITE-LAYER COMPOUNDS $SR_{1-X}LN_XCUO_2$ (*LN* = LANTHANIDE) HAVE THE HIGHEST TRANSITION TEMPERATURE T_C AMONG *N*-DOPED CUPRATES AND THE SIMPLEST CRYSTAL STRUCTURE OF ANY CUPRATE SUPERCONDUCTOR, MAKING THEM PARTICULARLY INTERESTING FOR FUNDAMENTAL RESEARCH. WE HAVE GROWN SINGLE-CRYSTALLINE $SR_{0.875}LA_{0.125}CUO_2$ (SLCO) THIN FILMS BY MEANS OF PULSED LASER DEPOSITION (PLD) ON $KTAO_3$ (100) AND $BATIO_3$-BUFFERED $SRTIO_3$ (100) SUBSTRATES. IN ORDER TO REMOVE INTERSTITIAL OXYGEN, AS AN IMPORTANT REQUIREMENT TO OBTAIN SUPERCONDUCTIVITY, THE SLCO FILMS WERE COOLED DOWN UNDER REDUCING CONDITIONS. THE EVOLUTION OF THE FILM GROWTH FRONT WAS MONITORED IN-SITU BY HIGH-PRESSURE RHEED WHILE THE SURFACE MORPHOLOGY WAS ANALYZED EX-SITU VIA ATOMIC FORCE MICROSCOPY. X-RAY DIFFRACTION WAS USED TO DETERMINE THE EVOLUTION OF THE CRYSTAL STRUCTURE WITH VARYING DEPOSITION AND COOLING PARAMETERS. THE AS-DEPOSITED FILMS SHOWED SEMICONDUCTING OR METALLIC BEHAVIOR (ABOVE T_C) WITH A MAXIMUM T_C = 22 K (TRANSITION WIDTH ~ 1 K), THE HIGHEST REPORTED VALUE FOR PLD-GROWN $SR_{1-X}LA_XCUO_2$ FILMS SO FAR. WE WILL ALSO DESCRIBE OUR ATTEMPTS TO FABRICATE VARIOUS TYPES OF THIN FILM SLCO JOSEPHSON JUNCTIONS SUCH AS BICRYSTAL GRAIN BOUNDARY JUNCTIONS, PLANAR SLCO/AU/NB JUNCTIONS AND SLCO/AU/NB RAMP-TYPE JUNCTIONS AND REPORT ON ELECTRIC TRANSPORT PROPERTIES OF THESE DEVICES.

THIS WORK HAS BEEN SUPPORTED BY THE DFG (DEUTSCHE FORSCHUNGSGEMEINSCHAFT), BONN (KL930/11-1). J. T. GRATEFULLY ACKNOWLEDGES SUPPORT BY THE EVANGELISCHES STUDIENWERK E.V., VILLIGST

3MP1B-03

MAGNETIC AND TRANSPORT PROPERTIES OF SUPERCONDUCTING YBA2CU3O7 AND FERROMAGNETIC LA2/3CA1/3MNO3 HETEROSTUCTURES ***S. A. FEDOSEEV****, A. V. PAN, S. V. PYSARENKO, O. V. SHCHERBAKOVA, S. X. DOU;* ISEM, UNI OF WOLLONGONG. — WE INVESTIGATED FERROMAGNETIC (LA2/3CA1/3MNO3) AND SUPERCONDUCTING (YBA2CU3O7) MULTILAYERED HETEROSTRUCTURES, EPITAXIALLY GROWN BY PULSED-LASER DEPOSITION ON DIFFERENT MONOCRYSTALLINE SUBSTRATES. THESE HYBRID STRUCTURES HAVE DEMONSTRATED HIGH TC (~89 K) WITH A MINIMUM INFLUENCE OF FERROMAGNETIC LAYERS, WHEREAS OTHER SUPERCONDUCTING PROPERTIES EXPERIENCE A STRONGER INFLUENCE BY THE PRESENCE OF FERROMAGNETIC LAYERS. MAGNETIZATION AND CRITICAL CURRENT DENSITY ARE SENSITIVE TO THE EXTERNAL MAGNETIC FIELD ORIENTATION AND THE THICKNESS OF THE INTERMEDIATE INSULATING LAYERS. THE RESULTS OF MAGNETIC AND TRANSPORT MEASUREMENTS IN THESE STRUCTURES ARE DISCUSSED IN TERMS OF MAGNETIC INTERACTIONS, MAGNETIC ANISOTROPY, AND MAGNETIC MOMENT COMPENSATION.THIS WORK IS SUPPORTED BY THE AUSTRALIAN RESEARCH COUNCIL.

3MP1B-04

INTEGRATION OF PREDEFINED GAS-PHASE CONDENSATED NANOPARTICLES INTO $YBA_2CU_3O_{7-X}$ THIN FILMS MULTILAYERS ***M. SPARING****, T. D. THERSLEFF, J. HÄNISCH, R. HÜHNE, B. RELLINGHAUS, L. SCHULTZ, B. HOLZAPFEL;* IFW DRESDEN, INSTITUTE FOR METALLIC MATERIALS. — THE CRITICAL CURRENT DENSITY J_C IN $YBA_2CU_3O_{7-X}$ (YBCO) THIN FILMS, WHICH LIMITS THEIR APPLICATION IN APPLIED MAGNETIC FIELDS, CAN BE ENHANCED BY THE INTRODUCTION OF ARTIFICIAL PINNING CENTERS E.G. NON-SUPERCONDUCTING NANOPARTICLES AND SURROUNDING DEFECTS AND MICROSTRAIN. A CONTROLLED PREPARATION OF NANOPARTICLES WITH ADJUSTABLE PROPERTIES IS REQUIRED IN ORDER TO UNDERSTAND THE CORRELATION BETWEEN THE SUPERCONDUCTING CHARACTERISTICS, THE PARTICLES AND THE DEFECT STRUCTURE. ISOLATED PARTICLES WITH A PREDEFINED DIAMETER AROUND 10 NM AND AN INDEPENDENTLY CHOSEN AREAL DENSITY CAN BE PREPARED VIA DC-MAGNETRON SPUTTERING IN AN INERT GAS FLOW.WE PRESENT THE INTEGRATION OF SUCH GAS PHASE

CONDENSATED HAFNIUM NANOPARTICLES INTO PLD-GROWN YBCO THIN FILM MULTILAYERS IN A COMBINED PLD-SPUTTERING SYSTEM. THESE HETEROSTRUCTURES WERE INVESTIGATED BY TEM ON CROSS SECTIONAL FIB LAMELLAE. THE INFLUENCE OF AREAL DENSITY AND PARTICLE VOLUME CONTENT ON THE STRUCTURAL AND SUPERCONDUCTING PROPERTIES OF YBCO THIN FILMS IS DISCUSSED. FURTHERMORE, ADVANTAGES AND CONSEQUENCES OF THIS NEW TECHNIQUE FOR THE PREPARATION OF NANOPARTICLE - THIN FILM HETEROSTRUCTURES ARE EVALUATED.

THIS WORK IS PARTIALLY FUNDED BY THE "STUDIENSTIFTUNG DES DEUTSCHEN VOLKES" AND THE EU-FP6 RESEARCH PROJECT "NANOENGINEERED SUPERCONDUCTORS FOR POWER APPLICATIONS" NESPA NO. MRTN-CT-2006-035619.

3MP1B-05

TE AND TM -POLARIZED NONLINEAR GUIDED WAVES IN COPLANAR SUPERLATTICE TRANSMISSION LINES ***V. E. GRISHIN***[1]*, L. A. MURAVEY*[2]*;* [1]AUSTRALIAN NATIONAL UNIVERSITY, CANBERRA, [2]RSTU. — WE HAVE INVESTIGATED THE NONLINEAR PROPERTIES OF COPLANAR SUPERLATTICE WAVEGUIDE TRANSMISSION LINES OF THE S-N(D)-S TYPE. THE SYSTEM UNDER CONSIDERATION CONSISTS OF LAYER BOUNDED AT TWO SIDES BY NONLINEAR MEDIUM CHARACTERIZED BY DIAGONAL DIELECTRIC TENSOR WHOSE ELEMENTS DEPEND ON THE AMPLITUDE OF THE ELECTRIC FIELD TO E11= E22 ~|E1|^2 +|E2|^2. THE POWER-DEPENDENT WAVEVECTOR OF ONE TRANSVERSE ELECTRIC (TE) POLARIZED MODE AND TWO TRANSVERSE MAGNETIC (TM) MODES IS CALCULATED. IT WAS SHOWN THAT BESIDES SYMMETRIC AND ASYMMETRIC THERE EXIST ASYMMETRIC MODES AT LOWER POWER FLOWS EXCEEDING SOME CERTAIN MINIMUM VALUE. BISTABLE STATES OF P-POLARIZED NONLINEAR SURFACE WAVES PROVIDED THAT THE POWER FLOW IN THE WAVE IS THE CONTROL PARAMETER ARE ALSO FOUND .THE PHENOMENA OF SUCH KERR-LIKE NONLINEARITIES ON THE POWER-DEPENDENT WAVEVECTOR AND FIELD DISTRIBUTIONS IS GIVEN FOR A NUMBER OF POTENTIAL DEVICES PROPOSED EARLIER FOR NONLINEAR MEDIA, INCLUDING SUCH AS UPPER AND LOW THRESHOLD DEVICES, OPTICAL LAYERED SWITCHES, ELECTROMAGNETIC CONTROLLED ANTENNA BEAM SCANNING, AND PERHAPS BISTABLE LAYERED SWITCHES. MATERIALS IN GENERAL LIMIT THE EXPERIMENTAL RELATIONS OF ALL THE NONLINEAR GUIDED WAVE PHENOMENA PREDICTED TO DATE.

THE AUTHORS THANK DR. T. MCMINN FOR USEFUL DISCUSSIONS.

3MP1B-06

STIMULATION OF SUPERCONDUCTIVITY IN SUBMOLECULAR STRUCTURES WITH WEAKLY COUPLED SUPERCONDUCTING LAYERS *V. E. GRISHIN*[1]*,* ***L. A. MURAVEY***[2]*, V. A. CHERENKOV*[3]*;* [1]AUSTRALIAN NATIONAL UNIVERSITY, CANBERRA, AUSTRALIA, [2]RSTU, RUSSIA, [3]VNIIMS, RUSSIA. — ELECTROMAGNETIC AND SUPERCONDUCTING PROPERTIES ARE CONSIDERED IN SUPERCONDUCTING LAYERS SEPARATED BY INTERLAYER WITH THE THICKNESS OF THE OXIDE LAYER 10-20A (THE SO-CALLED MULTILAYER LATTICES OF (S-D-S) N-TYPE). IN PARTICULAR, THE PHENOMENON OF STIMULATION OF SUPERCONDUCTIVITY IS EXPOUNDED AND SPECIFIC DEPENDENCE ON THE NUMBER OF OXIDE EVAPORATED LAYERS AND THEIR THICKNESS IS OBTAINED. THE JOSEPHSON ARRAY DEFECTIVITY IS CONSIDERED WITH THE FRUSTRATION PARAMETER. THE NUMBER OF STATES IN THESE MODELS SHOWS A WIDE VARIETY OF CRITICAL BEHAVIOR AS A FUNCTION OF THE FRUSTRATION F (0<F<1). THE CHARACTERISTICS DEFINED DENSITIES OF ELECTRONIC STATES OF SUPERCONDUCTING AND NORMAL-METAL LAYERS IN S/N SUPERLATTICE ARE PRESENTED. IT IS CLEAR THAT EVEN WITH THE CONSTANT INTERACTION CONSERVATION BETWEEN THE NEAREST LAYERS, WHICH IN THE SAME FOR ALL THE LAYERS, THE FRUSTRATION INTRODUCTION OVER THE LAYERS RESULT IN A HYSTERESIS IN T_C (N) , I.E., IN THE IRREVERSIBILITY PHENOMENA SO CHARACTERISTIC OF HIGH-TEMPERATURE SUPERCONDUCTORS. THE CONNECTION OF THIS RESULT WITH TUNNELING SPECTRA OF HIGH-TC SUPERCONDUCTORS SUCH AS YBA_2CU_3O_(7-D), (YBCO) THIN FILMS DEPOSITED ON LAALO_3 SUBSTRATES IS OBSERVED.

THE AUTHORS THANK DR. T. MCMINN FOR USEFUL DISCUSSIONS.

3MP1B-07

DIFFERENTIAL CONDUCTANCE MEASUREMENTS OF MGB_2-BASED JOSEPHSON JUNCTIONS BELOW 1 KELVIN ***S. CARABELLO****, J. LAMBERT, J. MLACK, Z. THRAILKILL, R. RAMOS;* DREXEL UNIVERSITY. — MAGNESIUM DIBORIDE HAS MANY INTRIGUING CHARACTERISTICS, INCLUDING ITS RELATIVELY HIGH CRITICAL TEMPERATURE AND TWO-BAND NATURE. MOST PRIOR STUDIES OF MGB2 THIN FILM JOSEPHSON JUNCTIONS HAVE BEEN CONDUCTED ABOVE 2 KELVIN. WE REPORT RESULTS OF SUB-1 KELVIN EXPERIMENTS OF MGB2/INSULATOR/PB JUNCTIONS WHOSE AB-PLANE IS EXPOSED FOR ELECTRON TUNNELING. BY MEASURING DIFFERENTIAL CONDUCTANCE AT LOW TEMPERATURE, NEW DETAILS IN THE STRUCTURE OF THE SIGMA- AND PI-BAND GAPS ARE OBSERVED, CONSISTENT WITH THEORETICAL PREDICTIONS.

WE THANK X. X. XI AND KE CHEN FOR PROVIDING HIGH-QUALITY MGB2-BASED JUNCTIONS AND IMPORTANT INSIGHTS.

3MP1C-01

INTERFACE EFFECTS AND SUPPRESSION OF T_C IN $LA_{0.7}CA_{0.3}MNO_3$ - $YBA_2CU_3O_7$ BILAYERS ***R. WERNER***[1]*, A. RUOSI*[2]*, C. RAISCH*[3]*, B. A. DAVIDSON*[4]*, R. KLEINER*[1]*, D. KOELLE*[1]*;* [1]PHYSIKALISCHES INSTITUT – CENTER FOR COLLECTIVE QUANTUM PHENOMENA, UNIVERSITÄT TÜBINGEN, AUF DER MORGENSTELLE 14, D-72076 TÜBINGEN, GERMANY, [2]DEPT. OF PHYSICS, UNIVERSITY OF NAPLES, [3]INSTITUT FÜR PHYSIKALISCHE UND THEORETISCHE CHEMIE, UNIVERSITÄT TÜBINGEN, AUF DER MORGENSTELLE 8 D-72076 TÜBINGEN, GERMANY, [4]NFM-TASC NATIONAL LABORATORY, AREA

SCIENCE PARK, S.S. 14, KM 163.5, I-34012 BASOVIZZA (TS), ITALY. — DUE TO THE SMALL IN-PLANE LATTICE MISMATCH THE COMBINATION OF HETEROEPITAXIALLY GROWN $LA_{0.7}CA_{0.3}MNO_3$ (LCMO) AND $YBA_2CU_3O_7$ (YBCO) THIN FILMS IS WELL SUITED TO INVESTIGATE THE COMPETITION BETWEEN THE FERROMAGNETIC AND SUPERCONDUCTING ORDER PARAMETER. IN THIS SYSTEM WE FOCUS ON INTERFACE PROPERTIES AND THE SUPPRESSION OF THE SUPERCONDUCTING TRANSITION TEMPERATURE T_C DUE TO SPIN-POLARIZED PARTICLE INJECTION FROM LCMO. THE LCMO-YBCO BILAYERS WERE GROWN BY PLD ON $SRTIO_3$ (100) SUBSTRATES. THE GROWTH AND LAYER THICKNESS WERE MONITORED BY RHEED. SAMPLE PROPERTIES WERE CHARACTERIZED BY XRD, AFM, SQUID-MAGNETOMETRY AND ELECTRIC TRANSPORT. FURTHERMORE, TO INVESTIGATE THE LCMO-YBCO INTERFACE, X-RAY MAGNETIC CIRCULAR (XMCD) AND LINEAR MAGNETIC DICHROISM MEASUREMENTS WERE CARRIED OUT DOWN TO LOW TEMPERATURES IN TEY- AND FY-MODE. TO INVESTIGATE THE SUPPRESSION OF T_C, WE HAVE GROWN YBCO LAYERS WITH DIFFERENT THICKNESSES WHICH ARE COVERED BY 50 NM THICK LCMO. OUR RESULTS INDICATE A SPIN DIFFUSION LENGTH OF ABOUT 5 NM. RECENTLY, IT WAS REPORTED ON ANTIFERROMAGNETIC ORDERING OF CU SPINS AT THE INTERFACE OF LCMO-YBCO MULTILAYERS, PROBABLY DUE TO SPIN-CANTING DUE TO THE INTERACTION BETWEEN MN-O-CU AT THE INTERFACE. OUR XMCD MEASUREMENTS COULD CONFIRM THE MAGNETIC SIGNAL OF CU AT THE INTERFACE AND THE AMPLITUDE OF OUR SIGNAL IS IN ALMOST PERFECT AGREEMENT WITH RECENTLY PUBLISHED THEORETICAL CALCULATIONS.

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3MP1C-02

INVESTIGATION OF PURE AND BAHFO3-DOPED (RE)BCO THIN FILMS DEPOSITED BY TFA-MOD ***M. ERBE****, J. HÄNISCH, T. THERSLEFF, T. FREUDENBERG, L. SCHULTZ, B. HOLZAPFEL;* IFW DRESDEN. — (RE)BA2CU3O(7-X) (RE=Y, GD) BASED SUPERCONDUCTORS FOR COMMERCIAL APPLICATIONS DO NOT ONLY REQUIRE A RELIABLE AND COST-EFFECTIVE GROWTH PROCESS, BUT ALSO A HIGH CURRENT DENSITY IN APPLIED MAGNETIC FIELDS. AN IMPROVEMENT OF THESE PROPERTIES CAN BE ACHIEVED BY THE INTRODUCTION OF NANO-SIZED BAHFO3 PARTICLES INTO THE (RE)BCO-MATRIX AS PINNING CENTERS. THE CHEMICAL SOLUTION DEPOSITION METHOD TFA-MOD PROVIDES BOTH A SIMPLE AND INEXPENSIVE ROUTE FOR UPSCALING TO INDUSTRIAL PRODUCTION AND FOR THE INCORPORATION OF PINNING ACTIVE NANO-PARTICLES. BOTH COHERENT AND INCOHERENT INCORPORATION OF THESE PARTICLES WAS REPORTED WITH STRONG INFLUENCE ON PINNING PROPERTIES.IN THIS WORK WE PRESENT A ROBUST CHARACTERIZATION OF SAMPLES DOPED WITH DIFFERENT HF-CONCENTRATIONS UP TO 18MOL% AND COMPARE THEM TO SIMILARLY PREPARED PURE (RE)BCO-SAMPLES. FURTHER WE DRAW CONCLUSIONS ABOUT THE DIFFERENT GROWTH BEHAVIOUR ON LAO AND STO SINGLE-CRYSTAL SUBSTRATES AND THE STRONG INFLUENCE OF THE CRYSTALLIZATION TEMPERATURE ON THE NANO-PARTICLE FORMATION, AS WELL AS ON THE (RE)BCO STRUCTURE ITSELF. MEASUREMENTS OF THE CRITICAL CURRENT DENSITY JC(B,T) SHOW PROMISING RESULTS UP TO HIGH DOPING LEVELS.

3MP1C-03

SUPERCONDUCTING PROPERTIES OF CATION COMPOSITION CONTROLLED MOD-Y123 THIN FILMS ***H. KAKU****[1], J. SHIMOYAMA[1], T. AKASAKA[1], H. OGINO[1], K. KISHIO[1], T. TANEDA[2];* [1]TOKYO UNIVERSITY, [2]SUMITOMO ELECTRIC INDUSTRIES, LTD.. — IN OUR RECENT STUDY, POLYCRYSTALLINE SAMPLES OF RE123 (RE = DY, Y, ER) WERE FOUND TO SHOW SYSTEMATIC DECREASE IN T_C ACCOMPANYING AN INCREASE IN THE *A*-AXIS AND A DECREASE IN THE *C*-AXIS WHEN THEY WERE SYNTHESIZED FROM RE EXCESS COMPOSITION ($RE_{1+X}BA_{2-X}CU_3O_Y$) OR UNDER HIGH OXYGEN PARTIAL PRESSURE WHICH MAY PROMOTE PARTIAL SUBSTITUTION OF RE FOR THE BA-SITE. THESE RESULTS INDICATED THAT FURTHER IMPROVEMENT OF SUPERCONDUCTING PROPERTIES OF Y123 CAN BE EXPECTED BY PRECISE CONTROL OF CATION STOICHIOMETRY.IN THE PRESENT STUDY, MOD-Y123 THIN FILMS WITH VARIOUS CATION COMPOSITIONS WERE PREPARED ON STO SUBSTRATE FROM FLUORINE-FREE SOLUTION. THESE SAMPLES WERE HEATED UNDER VARIOUS OXYGEN PARTIAL PRESSURES, TO CONTROL CATION STOICHIOMETRY. THE OXYGEN CONTENT WAS ALSO SYSTEMATICALLY CONTROLLED TO CHANGE THE CARRIER DOPING STATE. RELATIONSHIP BETWEEN SUPERCONDUCTING PROPERTIES, SUCH AS T_C AND J_C-*B* CHARACTERISTICS, AND CATION COMPOSITION OF Y123 FILMS WILL BE SHOWN.

3MP1C-05

FLUX PINNING PROPERTIES IN YBCO THIN FILMS WITH SELF-ALIGNED MAGNETIC NANOPARTICLE INCLUSIONS ***C. TSAI****, Y. ZHU, L. CHEN, H. WANG;* TEXAS A&M UNIVERSITY. — IN THIS PAPER, WE CONDUCTED A SYSTEMIC INVESTIGATION ON BOTH SELF-FIELD AND IN-FIELD PERFORMANCE OF $YBA_2CU_3O_{7-\Delta}$ (YBCO-123) THIN FILMS WITH ORDERED FE_2O_3 MAGNETIC INCLUSIONS AND COMPARED WITH A PURE YBCO REFERENCE SAMPLE. THE DOPING ARCHITECTURES INCLUDE YBCO FILMS WITH ORDERED FE_2O_3 NANOPARTICLES ON THE TOP, WITH ORDERED FE_2O_3 NANOPARTICLES AT THE BOTTOM AND WITH MULTILAYERED NANOPARTICLES IN THE MATRIX. ALL SAMPLES WERE PREPARED BY PULSE LASER DEPOSITION (PLD) THROUGH ALTERNATING TARGETS AND THE YBCO FILM THICKNESS WAS CONTROLLED AT 500NM. THE MICROSTRUCTURE PROPERTIES OF ALL THE SAMPLES WERE EXAMINED BY X-RAY DIFFRACTION (XRD), SCANNING ELECTRON MICROSCOPY (SEM), AND HIGH RESOLUTION CROSS-SECTIONAL TRANSMISSION ELECTRON MICROSCOPY (TEM). WE EXPLORED THE SELF-FIELD AND IN-FIELD PERFORMANCE (J_C^{SF} AND $J_C^{IN\text{-}FIELD}$ (H//*C*)) OF THE YBCO FILMS WITH THE VIBRATING SAMPLE MAGNETOMETER (VSM) IN A PHYSICAL PROPERTY MEASUREMENT SYSTEM (PPMS) AT

VARIOUS TEMPERATURES (65K, 40K, AND 5K) AND CORRELATED WITH THEIR MICROSTRUCTURAL CHARACTERISTICS. THIS WORK SUGGESTS THAT ORDERED FE_2O_3 NANOPARTICLES CAN FORM IN YBCO MATRIX WITHOUT SEVERE DETERIORATION OF YBCO SUPERCONDUCTING PROPERTIES. THEY WORK AS EFFECTIVE PINNING CENTERS AT ALL TEMPERATURES MEASURED AND THE MULTILAYER ARCHITECTURE ONE SHOWS THE BEST PINNING PROPERTIES AMONG ALL THE SAMPLES EXAMINED.

THIS WORK WAS SUPPORTED BY THE AIR FORCE OFFICE OF SCIENTIFIC RESEARCH (CONTRACT NO. FA9550-07-1-0108 AND FA9550-09-1-0114).

3MP1C-06

OPTIMAL BZO DOPING AND TRANSPORT PROPERTIES IN YBCO THIN FILMS DEPOSITED FROM NANOSTRUCTURED TARGETS ON BUFFERED METAL SUBSTRATES ***H. T. HUHTINEN***[1]*, M. IRJALA*[1]*, P. PATURI*[1]*, L. T. KUHN*[2]*, M. FALTER*[3]*;* [1]UNIVERSITY OF TURKU, [2]TECHNICAL UNIVERSITY OF DENMARK, [3]ZENERGY POWER GMBH. — THE EFFECT OF BZO DOPANT CONCENTRATION ON TRANSPORT PROPERTIESIS SYSTEMATICALLY INVESTIGATED IN YBCO THIN FILMSDEPOSITED FROM NANOSTRUCTURED TARGETS ON BIAXIALLY TEXTURED NIW SUBSTRATES.THE AMOUNT OF BZO IS VARIED BETWEEN 0 - 9 WT\% ANDTHE OPTIMIZATION PROCESSSHOWS THAT APPLICATIONS USED IN DIFFERENT MAGNETIC FIELDS ANDTEMPERATURES NEED OPTIMIZATION OF DOPANT CONCENTRATION TO ACHIEVETHE BEST POSSIBLE SUPERCONDUCTING PROPERTIES FOR DIFFERENT OPERATIONALENVIRONMENTS.THE RESULTS ARE QUALITATIVELY EXPLAINED BY A MODEL WHERE OPTIMAL ARRAY OF BZOCOLUMNAR DEFECTSTOGETHER WITH STRONG MOSAIC SPREAD OF YBCO GROWN ON NIW ARE RESPOSIBLEFOR EFFECTIVE PINNING STRUCTURE THAT DOMINATES ESPECIALLY AT LOW TEMPERATURESAND IN HIGH MAGNETIC FIELDS.THIS WORK SHOWS CLEARLY THE POSSIBILITY TO USE NANOSTRUCTURED MATERIAL WITH BZO DOPINGIN YBCO MATRIX IN ORDER TO REACH MORE EFFECTIVE PINNING STRUCTURE FORFUTURE APPLICATIONS IN COATED CONDUCTOR TECHNOLOGY.

3MP1C-08

UNDERSTANDING NANOSTRUCTURES IN YBCO THIN FILMS FOR PRACTICAL PROPERTY ENHANCEMENTS ***S. A. HARRINGTON***[1]*, J. DEAN*[1]*, G. ERCOLANO*[1]*, S. C. WIMBUSH*[1]*, M. BIANCHETTI*[1]*, H. WANG*[2]*, J. L. MACMANUS-DRISCOLL*[1]*;* [1]UNIVERSITY OF CAMBRIDGE, [2]TEXAS A&M UNIVERSITY. — PROPERTIES IN HIGH TEMPERATURE SUPERCONDUCTOR SYSTEMS CAN BE STRONGLY ENHANCED BY MANIPULATING THE STRUCTURE AT THE NANOSCALE. IN PARTICULAR INCORPORATION OF NON-SUPERCONDUCTING SECOND PHASES SUCH AS BAZRO, RETAO, YFEO OR YBANBO/YBATAO CAN LEAD TO NANOSCALE SEGREGATION THAT INCREASES CRITICAL CURRENT BY MORE THAN AN ORDER OF MAGNITUDE. GROWTH DYNAMICS AND THE RESULTING STRAIN LANDSCAPE IN THIN FILMS OF THESE SUPERCONDUCTOR/NON-SUPERCONDUCTOR NANOCOMPOSITES HAVE BEEN INVESTIGATED TO MAP THE COMMON TRENDS ACROSS YBCO DUAL PHASE SYSTEMS. THROUGH OPTIMISATION AND UNDERSTANDING OF GROWTH MECHANISMS NOVEL NANOSTRUCTURES HAVE BEEN DESIGNED TO CONTROL STRAIN AND MANIPULATE THE SUPERCONDUCTING PROPERTIES. YBCO + SECOND PHASE THIN FILMS WERE GROWN BY PULSED LASER DEPOSITION ON SINGLE CRYSTAL SUBSTRATES AND CHARACTERISED BY ATOMIC FORCE MICROSCOPY, X-RAY DIFFRACTION, TRANSMISSION ELECTRON MICROSCOPY, MEASUREMENT OF TRANSPORT PROPERTIES AND NANO-INDENTING.

THANKS TO DOWNING COLLEGE CAMBRIDGE AND NSF GRANT (NSF-0709831)

3MP1C-09

CORRELATION BETWEEN FLUX PINNING PROPERTY AND INTERFACIAL DEFECTS IN $YBA_2CU_{37-\Delta}$/ CEO_2 MULTILAYER THIN FILMS *C. TSAI, Y. ZHU, L. CHEN,* ***H. WANG****;* TEXAS A&M UNIVERSITY. — $YBA_2CU_3O_{7-\Delta}$ (YBCO) THIN FILMS DOPED WITH EITHER SECONDARY NANOPARTICLES OR NANOLAYERS SHOW ENHANCED PINNING PROPERTIES. ONE POSSIBLE REASON FOR THE ENHANCED FLUX PINNING PROPERTIES IS THE INTERFACIAL DEFECTS GENERATED AT THE HETEROGENEOUS INTERFACES BETWEEN YBCO AND NANOPARTICLES/NANOLAYERS. IN THIS WORK, WE CONDUCTED A SYSTEMIC STUDY TO CORRELATE THE PINNING PROPERTIES OF YBCO THIN FILMS BY INTRODUCING CEO_2 MULTILAYERED STRUCTURES WITH THE NANOLAYER DEFECTS. MULTILAYERED YBCO THIN FILMS WITH 1, 2, AND 4 CEO_2 INTERLAYERS AND A PURE YBCO REFERENCE THIN FILM WERE PREPARED BY PULSED LASER ABLATION THROUGH ALTERNATING YBCO AND CEO_2 TARGETS. WE CONTROLLED THE TOTAL THICKNESS OF YBCO LAYERS ON ALL OF THE SAMPLES AT AROUND 500 NM, AND EACH CEO_2 INTERLAYER AT AROUND 10 NM. A DETAILED MICROSTRUCTURE ANALYSIS WAS CONDUCTED BY X-RAY DIFFRACTION (XRD) AND HIGH RESOLUTION CROSS-SECTIONAL TRANSMISSION ELECTRON MICROSCOPY (TEM). WE EXAMINED THE INTERFACIAL DEFECTS INCLUDING MISFIT DISLOCATIONS AND DEPOSITION STEPS ALONG THE INTERFACE OF YBCO AND CEO_2 AS A FUNCTION OF NANOLAYER NUMBER. THE RESULT SHOWED THAT INTRODUCING CEO_2 NANOLAYERS CAN EFFECTIVELY INCREASE THE INTERFACIAL DEFECTS WITHOUT DEGRADING THE EPITAXY QUALITY OF YBCO FILMS. J_C^{SF} AND $J_C^{IN\text{-}FIELD}$ WERE INVESTIGATED AT VARIOUS TEMPERATURES AND CORRELATED WITH THE DENSITY OF INTERFICIAL DEFECTS.

THIS WORK WAS SUPPORTED BY THE AIR FORCE OFFICE OF SCIENTIFIC RESEARCH (CONTRACT NO. FA9550-07-1-0108 AND FA9550-09-1-0114).

3MP1C-10

EFFECT OF IMPURITIES ON THE GROWTH OF CUPRATE FILMS ***C. G. TRETIATCHENKO****, V. S. FLIS, V. L. SVETCHNIKOV, V. M. PAN;* INSTITUTE FOR METAL PHYSICS. — WE ANALYZED COMPLEX VOLUME AND SURFACE STRUCTURES OBSERVED BY HREM AND TEM OF YBCO FILMS WITH $BAZRO_3$ ADDITIONS

PULSE LASER DEPOSITED ON DIFFERENT SINGLE CRYSTAL SUBSTRATES. OUR CONSIDERATION IS BASED ON MOLECULAR DYNAMICS OF CRYSTAL GROWTH IN PRESENCE OF SURFACE IMPURITIES. OUR MODEL ACCOUNTS FOR MANY ASPECTS, SUCH AS HIGH ANISOTROPY OF CHEMICAL BINDING, FORMATION OF MISFIT AND THREADING DISLOCATIONS, STRESS-STRAIN FIELDS AROUND NANOPARTICLES, SURFACE AND VOLUME DIFFUSION. A SUBTLE INTERPLAY OF A LARGE NUMBER OF FACTORS RESULTS IN A GREAT VARIETY OF COLUMNAR AND PLATE-LIKE FORMS AND SURFACE MORPHOLOGIES, WHICH CAN DRAMATICALLY CHANGE EVEN AT SMALL VARIATIONS OF TEMPERATURE, DEPOSITION RATE, GAS PRESSURE AND COMPOSITION, DURATION OF DEPOSITION. OUR MODEL SUGGESTS THAT IMPURITIES PLAY AN ESSENTIAL ROLE IN DETERMINING GROWTH MORPHOLOGIES. SURFACE IMPURITIES CAN REDUCE GROWTH RATE BY ORDERS OF MAGNITUDE COMPARED TO GROWTH OF A CLEAN SURFACE. SUCH A HYPOTHESIS IS CONSISTENT WITH THE OBSERVED NANOSTRUCTURES AND DISTRIBUTION OF $BAZRO_3$ NANOPARTICLES. WE PROPOSE NEW EXPERIMENTS, WHICH CAN PROVIDE FURTHER INSIGHTS INTO GROWTH MECHANISMS AND NANOSTRUCTURE OF SUPERCONDUCTING CUPRATE FILMS.

THIS WORK IS SUPPORTED BY THE NATIONAL ACADEMY OF SCIENCES OF UKRAINE AND BY THE MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

3MP1D-02

CHEMICAL SOLUTION DEPOSITION OF FLUORINE-FREE-$YBA_2CU_3O_{7-X}$ FILMS PREPARED BY INK PLOTTING ***A. KIRCHNER***[1], *R. HÜHNE*[1], *T. D. THERSLEFF*[1], *J. FEYS*[2], *I. VAN DRIESSCHE*[2], *L. SCHULTZ*[1], *B. HOLZAPFEL*[1]; [1]IFW DRESDEN, INSTITUTE FOR METALLIC MATERIALS, HELMHOLTZSTR. 20, 01069 DRESDEN, GERMANY, [2]DEP. INORGANIC AND PHYSICAL CHEMISTRY, GHENT UNIVERSITY, KRIJGSLAAN 281 - S3, 9000 GENT, BELGIUM. — WE REPORT ON THE EPITAXIAL GROWTH OF $YBA_2CU_3O_{7-X}$ THIN FILMS BY CHEMICAL SOLUTION DEPOSITION. THIN FILMS WERE PREPARED BY INK PLOTTING AND SPIN-COATING OF SINGLE CRYSTAL $SRTIO_3$ (100) SUBSTRATES WITH WATER BASED FLUORINE-FREE PRECURSOR SOLUTIONS AND CRYSTALLIZED AT DIFFERENT TEMPERATURES. THE THIN FILM STRUCTURE AND SURFACE MORPHOLOGY WAS CLEARLY INFLUENCED BY THE PROCESSING ATMOSPHERE AND CRYSTALLISATION TEMPERATURE. $YBA_2CU_3O_{7-X}$ THIN FILMS DISPLAYED EXCELLENT SUPERCONDUCTING PROPERTIES SUCH AS HIGH CRITICAL TEMPERATURE AND HIGH CRITICAL CURRENT. WE CORRELATE THE STRUCTURAL DIFFERENCES OF THE FILMS TO THEIR SUPERCONDUCTING PROPERTIES.

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3MP1D-03

OPTIMIZATION OF THE BACEO3 CONCENTRATION IN YBCO FILMS PREPARED BY PULSED LASER DEPOSITION ***M. IRJALA***[1], *H. HUHTINEN*[1], *R. JHA*[2], *V. P. S. AWANA*[2], *P. PATURI*[1]; [1]WIHURI PHYSICAL LABORATORY, DEPARTMENT OF PHYSICS AND ASTRONOMY, FIN-20014 UNIVERSITY OF TURKU, FINLAND, [2]SUPERCONDUCTIVITY DIVISION, NATIONAL PHYSICAL LABORATORY, NEW DELHI-110012, INDIA. — A SERIES OF STUDIES HAVE BEEN CARRIED OUT ON THIN FILMS WHICH WERE PREPARED BY PULSED LASER DEPOSITION (PLD) FROM MICRO-GRAINED TARGETS OF YBA2CU3O7-Y (YBCO) TO DETERMINE THE EFFECT OF DOPING THEM WITH BACEO3 (BCO) IN CONCENTRATIONS BETWEEN X = 0 - 0.10. BCO HAS BEEN FOUND TO INCREASE JC IN E.G. MELT-TEXTURED AND BULK SAMPLES BUT NO WIDE STUDY WITH ABLATED THIN FILMS HAS BEEN PERFORMED. MAGNETOMETRIC MEASUREMENTS UP TO 8 T AND DOWN TO 10 K AS WELL AS STRUCTURAL MEASUREMENTS WITH XRD AND AFM WERE PERFORMED. JC INCREASED WITH DOPING AND HIGHEST JC:S WERE ACHIEVED WITH LOW DOPANT LEVELS (2% AND 4%) VARYING WITH EXTERNAL FIELD AND TEMPERATURE. TC WAS LOWERED WITH INCREASING DOPANT LEVEL BUT COMPARING TO A COMMON BAZRO3 DOPANT, DECREASE WAS MUCH SMALLER. JC RESULTS WITH A COMPARISON WITH STRUCTURAL PROPERTIES WITH INCREASING DOPANT LEVEL WILL BE REPRESENTED.

NATIONAL GRADUATE SCHOOL IN MATERIALS PHYSICS AND WIHURI FOUNDATION

3MP1D-04

PREPARATION OF TI DOPED YBCO THIN FILMS FOR MICROWAVE APPLICATIONS USING TFA-MOD ***Q. LI***[1], *D. SHI*[1], *X. ZHU*[2], *L. WANG*[1], *S. DOU*[1]; [1]INSTITUTE FOR SUPERCONDUCTING AND ELECTRONIC MATERIALS, UNIVERSITY OF WOLLONGONG, [2]KEY LABORATORY OF MATERIALS PHYSICS, INSTITUTE OF SOLID STATE PHYSICS, CHINESE ACADEMY OF SCIENCES. — THE MICROWAVE APPLICATIONS OF YBCO FILMS REQUEST BOTH HIGH CRITICAL CURRENT DENSITY AND LOW SURFACE RESISTIVITY. IN THIS WORK, TI-DOPED YBCO FILMS WERE DEPOSITED ON SINGLE CRYSTAL $LAALO_3$ AND CEO_2 BUFFERED R-CUT AL_2O_3 SUBSTRATES BY TFA-MOD ROUTE. IN-SITU GROWN $BATIO_3$ SECONDARY PHASE WAS OBSERVED WITH TI ADDITION, WHICH WAS CONFIRMED BY XRD AND XPS. THE GROWTH MODE WAS CHANGED FROM LAYER-BY-LAYER MODE FOR PURE YBCO FILM TO COLUMNAR MODE FOR TI DOPED YBCO FILMS. MOREOVER, LARGE AMOUNTS OF NANO-SCALED PARTICLES WERE OBSERVED DUE TO TI ADDITION. THE SELF-FIELD CRITICAL CURRENT DENSITY OF THE TI DOPED YBCO FILM WAS ~3 TIMES LAGER THAN THAT OF THE PURE YBCO FILMS, AND THE SURFACE RESISTIVITY WAS REDUCED SIGNIFICANTLY. THE RESULTS DEMONSTRATE THAT TI-DOPED YBCO FILMS BY TFA-MOD ARE VERY PROMISING CANDIDATES FOR MICROWAVE APPLICATIONS, WHICH PROVIDES A RAPID, LOW-COST AND SCALABLE ROUTE.

WE GRATEFULLY ACKNOWLEDGE THE FINANCIAL SUPPORT FROM THE AUSTRALIAN RESEARCH COUNCIL (ARC) THROUGH THE ARC LINKAGE PROJECT (LP0669456).

3MP1D-05

FABRICATION OF YBCO FILMS ON THE $LAALO_3$ (001) SUBSTRATES BY THE FLUORINE-FREE MOD PROCESS ***J. LEE***[1]*, G. SHIN*[1]*, Y. JOO*[1]*, S. MOON*[2]*, S. YOO*[1]*;* [1]DEPARTMENT OF MATERIALS SCIENCE & ENGINEERING, SEOUL NATIONAL UNIVERSITY, KOREA, [2]SUPERCONDUCTOR, NANO & ADVANCED MATERIALS CORPORATION, ANYANG, KOREA. — YBCO FILMS ON $LAALO_3$ (001) SUBSTRATES WERE FABRICATED VIA FLUORINE-FREE METAL-ORGANIC DEPOSITION (MOD) PROCESS. THE COATING SOLUTIONS WERE PREPARED DISSOLVING YBCO POWDER IN FLUORINE-FREE SOURCES. THE SAMPLES WERE DIP-COATED, PYROLIZED WITHIN 3 H AT THE TEMPERATURE UP TO 600^{O}C, AND FINALLY FIRED AT VARIOUS HIGH TEMPERATURES IN REDUCED OXYGEN PARTIAL PRESSURE. WITH THE OPTIMAL PROCESSING CONDITION, YBCO FILMS EXHIBITED HIGH-J_C VALUE OF ~1MA/CM^2 AT 77K IN A SELF-FIELD. IT WAS FOUND THAT THE MICROSTRUCTURE AND SUPERCONDUCTING PROPERTIES OF FILMS STRONGLY DEPEND ON THE PYROLYSIS AND FIRING CONDITIONS. DETAILS OF THE RELATIONSHIP AMONG THE PROCESSING PARAMETERS, MICROSTRUCTURE, AND SUPERCONDUCTING PROPERTIES OF YBCO FILMS ARE PRESENTED IN THIS PAPER.

THIS WORK WAS SUPPORTED BY A GRANT FROM CENTER FOR APPLIED SUPERCONDUCTIVITY TECHNOLOGY OF THE 21ST CENTURY FRONTIER R&D PROGRAM FUNDED BY THE MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY, REPUBLIC OF KOREA.

3MP1D-06

MOMBE GROWTH OF $YBA_2CU_3O_7$ THIN FILMS WITH C-AXIS, A-AXIS AND 103 ORIENTATIONS ON $SRTIO_3$ SUBSTRATE ***K. ENDO***[1]*, P. BADICA*[2]*, G. UEHARA*[1]*, H. KADO*[1]*;* [1]KANAZAWA INSTITUTE OF TECHNOLOGY, [2]NATIONAL INSTITUTE OF MATERIALS PHYSICS. — WE HAVE GROWN BY MOMBE SUPERCONDUCTING THIN FILMS OF $YBA_2CU_3O_7$ (Y123) ON (001) AND (110) $SRTIO_3$ SUBSTRATES. RHEED INDICATED THAT BEFORE DEPOSITION OF THE FILMS, SUBSTRATES SUFFERED A USEFUL PROCESS OF CLEANING IN A FLOW OF OZONE AT 300C. OZONE WAS ALSO USED DURING DEPOSITION OF THE FILMS AND POST ANNEALING WAS NOT NECESSARY TO INDUCE SUPERCONDUCTIVITY. FOR THE (001) $SRTIO_3$ SUBSTRATE A GROWTH TEMPERATURE OF 600C IS PRODUCING SINGLE PHASE (001)Y123 FILMS, WHILE AT 515C (100)Y123 THIN FILMS ARE OBTAINED. THE FILMS SHOW ZERO-RESISTANCE CRITICAL TEMPERATURES TC(R=0) OF 84 AND 17.4K AND ROUGHNESS (RMS) OF 1 AND 0.4NM, RESPECTIVELY. (103)Y123 FILMS WERE GROWN ON (110) $SRTIO_3$ AT 600C. THEY HAVE TC(R=0)=64K AND RMS=4NM. WE CONCLUDE THAT MOMBE METHOD ALLOWS THE GROWTH OF Y123 THIN FILMS AT LOWER TEMPERATURES THAN OTHER DEPOSITION METHODS, INCLUDING MOCVD OR MBE. THIS BEHAVIOR MIGHT BE USEFUL FOR SOME APPLICATIONS.

3MP1D-07

PREPARATION OF Y123 THICK FILMS BY MOD USING A NEW SOLUTION ***I. YAMAGUCHI****, W. KONDO, T. HIKATA, K. KAMIYA, H. MATSUI, M. SOHMA, K. TSUKADA, Y. NAKAGAWA, T. KUMAGAI, T. MANABE;* NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY. — WE HAVE BEEN PREPARING HIGH-JC $YBA_2CU_3O_7$ (Y123) FILMS ON VARIOUS SINGLE-CRYSTALLINE SUBSTRATES BY FLUORINE-FREE METAL-ORGANIC DEPOSITION (MOD). MOD IS SUITABLE FOR FABRICATION OF LARGE-SIZE METAL OXIDE FILMS AT LOW COST. WHEN WE PREPARE THICK FILMS, IT IS ESSENTIAL TO REPEAT THE COATING AND PREFIRING PROCEDURE. HOWEVER, IT IS DIFFICULT TO PREPARE FILMS WITH A THICKNESS GREATER THAN 400 NM BY SINGLE COATING-PREFIRING PROCEDURE, SINCE SHRINKAGE OF THE FILM CAUSES MICROCRACKS IN THE PYROLYSIS PROCESS. IN THE PRESENT STUDY, WE DEVELOPED A NEW COATING SOLUTION FOR CRACK-FREE FILMS WITH THICKNESSES GREATER THAN 500 NM.WE USED Y-, BA-, AND CU-ACETYLACETONATE-BASED SOLUTION (METAL CONTENT: ~2 MOL/L) WITH VARIOUS ADDITIVES FOR THE COATING SOLUTION. WE PREPARED PREFIRED FILMS ON CEO_2-BUFFERED YSZ OR CEO_2-BUFFERED $SRTIO_3$ SUBSTRATES BY SINGLE COATING-PREFIRING PROCESS USING THIS SOLUTION. WHEN USING SOME ADDITIVES, WE COULD OBTAIN CRACK-FREE PREFIRED FILMS WITH 300-800 NM THICKNESSES ESTIMATED BY OPTICAL MICROSCOPY. THESE PREFIRED FILMS WERE HEAT-TREATED AT HIGH-TEMPERATURES, RESULTED IN EPITAXIAL Y123 FILMS. SUPERCONDUCTIVE PROPERTIES SUCH AS CRITICAL CURRENT (IC) WILL BE SHOWN.

3MP1D-08

THICKNESS DEPENDENCE OF STRUCTURAL AND ELECTRICAL PROPERTIES OF ELECTRON-DOPED $SR_{1-X}LA_XCUO_2$ INFINITE-LAYER THIN FILMS GROWN BY PULSED LASER DEPOSITION *Y. SUN, Y. MA, M. CHEN, J. YANG, H. LI,* ***J. NIE****;* BEIJING NORMAL UNIVERSITY. — AS THE BUILDING BLOCKS FOR ALL OF THE HIGH-TC CUPRATE SUPERCONDUCTORS, INFINITE LAYER (IL) COMPOUNDS HAVE THE SIMPLEST STRUCTURES AND THE HIGHEST *TC* OF ELECTRON-DOPED SUPERCONDUCTORS, ENABLING FUNDAMENTAL RESEARCH AND IMPROVED TECHNIQUES FOR SYNTHESIZING HIGHER TC SUPERCONDUCTORS. HOWEVER, IL STRUCTURE IS ONE OF THE HIGH-PRESSURE FORMS, WHICH MAKES IT DIFFICULT TO SYNTHESIZE A SINGLE CRYSTAL. THEREFORE, IT IS HIGHLY DESIRABLE TO OBTAIN HIGH-QUALITY EPITAXIAL THIN FILMS MAKING USE OF EPITAXIAL EFFECT. ALTHOUGH THERE ARE MANY REPORTED ATTEMPTS TO GROW IL THIN FILMS ON DIFFERENT SUBSTRATES, NO ONE HAS SYSTEMATICALLY STUDIED THE THICKNESS DEPENDENCE OF STRUCTURAL AND ELECTRICAL PROPERTIES OF IL THIN FILMS.IN THIS REPORT, ELECTRON-DOPED SR1-XLAXCUO2 THIN FILMS OF VARIOUS THICKNESSES WERE DEPOSITED ON (001) KTAO3 SUBSTRATE BY PLD. IL PHASE WITH LOW RESISTIVITY OF THE ORDER OF 10^-5 Ω·CM AT ROOM TEMPERATURE WAS OBTAINED. IT IS SHOWN THAT IL PEAK RED SHIFTS WITH INCREASE OF FILM THICKNESS, INDICATING THE REDUCTION OF THE TENSILE STRAIN INTRODUCED BY THE MISMATCH. WITH FURTHER INCREASE OF THICKNESS, THERE EMERGES A MODULATED SUPERSTRUCTURE PHASE WHICH IS BELIEVED TO

DETERIORATE SUPERCONDUCTIVITY. TRANSPORT MEASUREMENTS SHOWED STRONG INFLUENCE OF THE SAMPLE THICKNESS ON RESISTIVITY AND *TC*. A MODERATE THICKNESS IS REQUIRED TO OBTAIN IL THIN FILMS WITH OPTIMAL PROPERTIES.

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3MP1D-09

PREPARATION AND CRITICAL CURRENT MEASUREMENTS OF INFRARED PULSED LASER DEPOSITED Y DOPED BSCCO SUPERCONDUCTING FILMS ***J. C. DE VERO**, G. S. BLANCA, J. R. VITUG, W. O. GARCIA, R. V. SARMAGO;* NATIONAL INSTITUTE OF PHYSICS, UNIVERSITY OF THE PHILIPPINES- DILIMAN. — HIGH T_C SUPERCONDUCTING $BI_2SR_2CA_{1-X}Y_XCU_2O_{8+\Delta}$ (BI-22Y2) WITH $(0\leq X\leq 0.25)$ WERE FABRICATED ON MGO (100) BY INFRARED (1064 NM) PULSED LASER DEPOSITION (IR- PLD) WITH EX-SITU HEAT TREATMENTS. AS- DEPOSITED FILMS WERE PARTIAL MELTED AND SUBSEQUENTLY ANNEALED IN AMBIENT AIR. THE AS-DEPOSITED FILMS EXHIBIT SPHEROIDAL MORPHOLOGY BUT MAINTAINS THE STOICHIOMETRY OF THE TARGET. AFTER HEAT TREATMENTS STEPS, RELATIVELY SMOOTH AND FLAT FILMS WERE ACHIEVED. GRAIN BOUNDARIES BECOME MORE APPARENT AT HIGHER YTTRIUM DOPING. X-RAY DIFFRACTION RESULTS INDICATE THAT THE FILMS ARE HIGHLY C-AXIS ORIENTED. THE ZERO RESISTANCE TEMPERATURE T_C INCREASES FROM 85 K TO 90.5 K BUT DROP WITH ADDITIONAL Y UNTIL 87 K. THE HIGHEST CRITICAL CURRENT DENSITY OBTAINED IS 723.14 A/CM^2 AT 70 K FOR 1% Y-DOPED SAMPLE UNDER ZERO FIELD. THIS DEMONSTRATES THE FEASIBILITY OF IR PLD TO BE USED FOR THIN FILM GROWTH OF DOPED HIGH- TC SUPERCONDUCTORS.

3MP1D-10

SYNTHESIS OF FLUORINE-FREE YBCO THIN FILMS: ELUCIDATION OF THE MECHANISM AND INFLUENCE OF PROCESSING PARAMETERS ON EPITAXY ***P. VERMEIR**[1], I. CARDINAEL[1], G. POLLEFEYT[2], M. BÄCKER[3], O. BRUNKAHL[3], P. LOMMENS[1], J. SCHAUBROECK[2], K. DE BUYSSER[1], I. VAN DRIESSCHE[1];* [1]GHENT UNIVERSITY, BELGIUM, [2]UNIVERSITY COLLEGE GHENT, BELGIUM, [3]ZENERGY POWER GMBH, GERMANY. — TO ACHIEVE AN AFFORDABLE AND FAST SYNTHESIS PROCEDURE FOR SUPERCONDUCTING THIN FILMS, CHEMICAL SOLUTION DEPOSITION (CSD) METHODS SEEM TO BE A SENSIBLE SOLUTION. IN THIS WORK A FLUORINE-FREE CSD METHOD, BASED ON CHEAP METAL ACETATES, TRIETHANOLAMINE AND WATER AS PRIMARY SOLVENT WAS APPLIED, RESULTING IN SUSTAINABLE SUPERCONDUCTING FILMS. IN A FIRST STUDY, AN OPTIMAL HEAT TREATMENT WAS DEVELOPED FOR LAYERS ON $SRTIO_3$. THE INFLUENCE OF PARAMETERS SUCH AS HEATING RAMP, DWELL TIME AND DWELL TEMPERATURE ON CRYSTAL ORIENTATION, POROSITY, MICROSTRUCTURE AND SUPERCONDUCTING PROPERTIES WERE INVESTIGATED. AN INTERMEDIATE HEATING RATE APPEARS NECESSARY TO PREVENT SEGREGATION (TOO SLOW) AND PORES (TOO FAST). FURTHERMORE, DWELL TEMPERATURE AND TIME NEEDED TO BE CONTROLLED TO AVOID NON-SUPERCONDUCTING PHASES LIKE Y211 OR Y124 FROM BEING FORMED. IN A SECOND STUDY, THE REACTION MECHANISM OF FLUORINE-FREE CSD METHODS WAS ELUCIDATED USING TGA-DTA, HT-XRD AND ATR-IR ON BOTH BULK MATERIALS AND THIN FILMS. THIS STUDY REVEALED THAT $BACO_3$, FORMED AS AN INTERMEDIATE PHASE DURING SYNTHESIS, CAN DECARBOXYLATE WELL BELOW TEMPERATURES WHERE YBCO STARTS TO GROW. THEREFORE, $BACO_3$ DOES NOT SUPPRESS THE FORMATION OF THE SUPERCONDUCTING PHASE.

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3MP1E-02

MICROSTRUCTURE AND CRITICAL CURRENT PROPERTIES OF BI-2212 ROUND WIRES FABRICATED WITH DIFFERENT NOMINAL COMPOSITIONS ***A. MATSUMOTO**[1], H. KITAGUCHI[1], H. KUMAKURA[1], Y. HIKICHI[2], T. NAKATSU[2], T. HASEGAWA[2];* [1]NIMS, [2]SHOWA CABLE SYSTEMS CO., LTD.. — THE MICROSTRUCTURE AND SUPERCONDUCTING PROPERTIES OF BI-2212 WIRES ARE STRONGLY INFLUENCED BY THE NOMINAL COMPOSITION OF THE STARTING POWDER. WE FABRICATED BI-2212 ROUND WIRES WITH DIFFERENT STARTING COMPOSITIONS. THE HIGHEST J_C VALUE OF 175KA/CM^2 AT 4.2 K AND 10 T WAS OBTAINED IN THE BI-RICH COMPOSITION SAMPLE. WE CARRIED OUT QUENCHING EXPERIMENTS FROM THE MELTING STATE OF BI-2212 WITH DIFFERENT COMPOSITIONS. WE COMPARED WIRES WITH HIGH J_C AND LOW J_C, PARTICULARLY CHECKING THE FORMATION OF IMPURITY PHASES. WHEN THE VOLUME FRACTION OF THE IMPURITY PHASES WAS THE SAME BUT THE SIZE OF THE IMPURITIES WAS SMALLER, HIGHER J_C VALUES WERE OBTAINED IN MULTIFILAMENT WIRES. WHEN THE REMAINING IMPURITIES IN THE FINAL STATE WERE AS LARGE AS THE FILAMENT SIZE, THE SUPERCURRENT WOULD NOT FLOW IN THAT FILAMENT. ON THE OTHER HAND, WHEN THE SIZE OF THE IMPURITY PHASE WAS NEGLIGIBLE COMPARED WITH THE FILAMENT SIZE, THE SUPERCURRENT COULD FLOW IN THAT FILAMENT. AS A RESULT, SUPERCURRENT PATHS FORMED IN SUCH FILAMENTS, AND MULTIFILAMENTS WITH HIGH J_C VALUES FORMED. IN THIS RESEARCH, WE FOUND THAT THE SIZE OF THE IMPURITY PHASES COULD BE CONTROLLED BY THE NOMINAL POWDER COMPOSITIONS.

3MP1E-03

TRANSPORT AND MAGNETIC, AND SEM CHARACTERIZATION OF A NEW KIND OF BI-2212 STRAND DESIGN ***C. MYERS**[1], M. SUSNER[1], L. MOTOWIDLO[2], M. D. SUMPTION[1];* [1]CENTER FOR SUPERCONDUCTING AND MAGNETIC MATERIALS, THE OHIO STATE UNIVERSITY, [2]SUPRAMAGNETICS, INC. 214 CANAL STREET PLANTSVILLE, CT 06479. — IN THIS WORK, A NEW KIND OF DESIGN FOR BI-2212 STRANDS IS STUDIED. THE STRAND HAS A SINGLE STACK DESIGN WITH RANDOM ORIENTED BI2212 TWO-DIMENSIONAL FILAMENTS. THIS DESIGN LEADS TO HIGH LEVELS OF GRAIN TEXTURE AND AG-

SUPERCONDUCTOR INTERFACE WITHIN THE FILAMENTS, WHILE MAINTAINING A HIGH STRAND FILL FACTOR. TWO STRAND TYPES WERE MANUFACTURED, ONE MADE VIA A CONVENTIONAL PIT PROCESS, AND ONE MADE BY THE NEW PROCESS. HEAT TREATMENTS WERE PERFORMED UNDER 100% FLOWING OXYGEN, AND THE SAMPLES WERE MELT PROCESSED AT 884, 886, 888, AND 891 ºC. THE STRANDS WERE STUDIED WITH TRANSPORT, MAGNETIC, AND ELECTRON OPTICS TECHNIQUES. THE STRANDS MANUFACTURED WITH THE NEW PROCESS SHOWED HIGHER CRITICAL CURRENTS, BOTH IN TERMS OF LAYER JC AND ALSO ENGINEERING JC, ALTHOUGH THE INITIAL STANDS WERE LIMITED BY EXCESSIVE C-CONTENT IN THE POWDERS. AN INTERESTING PROPERTY OF THE NEW STRAND METHOD WAS THAT THE STRANDS WERE LESS SENSITIVE TO SMALL HT TEMPERATURE VARIATIONS IN TERMS OF THEIR FINAL JC PROPERTIES. MAGNETIC AND MICROSTRUCTURE/PHASE ASSEMBLAGE STUDIES OBSERVED FAR LESS FILAMENT BRIDGING IN THE NEW STRAND DESIGN, AND THIS MAY BE CORRELATED WITH THE LOWER SENSITIVITY TO REACTION TEMPERATURE.

THIS WORK WAS FUNDED BY A DOE HEP SBIR

3MP1E-05

MODELING OF THE MICROSTRUCTRE-ELECTRICAL BEHAVIOR RELATIONSHIPS IN $BI_2SR_2CACU_2O_{8+X}$ SUPERCONDUCTING ROUND WIRES ***Q. V. LE****, J. SCHWARTZ;*** NORTH CAROLINA STATE UNIVERSITY. — $BI_2SR_2CACU_2O_{8+X}$ (BI2212) SUPERCONDUCTING ROUND WIRES ARE OF INTEREST FOR HIGH FIELD SUPERCONDUCTING MAGNETS AND ARE THE SUBJECT OF EXTENSIVE PROCESSING-PROPERTY STUDIES. HERE, AN EFFORT TO MODEL THE MICROSTRUCTURE-PROPERTY RELEATIONSHIPS IS REPORTED. IN PARTICULAR, THE ROLE OF MICROSTRUCTURAL FEATURES SUCH AS INTERFILAMENTARY BRIDGING IS NOT FULLY UNDERSTOOD. OUR PREVIOUS EXPERIMENTAL RESULTS SHOW A POSITIVE RELATIONSHIP BETWEEN CRITICAL CURRENT DENSITY AND THESE MICRON-SCALE INTERGROWTHS BETWEEN FILAMENTS INSIDE THE SUPERCONDUCTOR. TO BETTER UNDERSTAND THE ROLE OF THESE INTERGROWTHS IN CURRENT CONDUCTION, A COMPUTATIONAL MODEL IS PRESENTED. RESULTS SUGGEST THAT BOTH CONCENTRATION AND DISTRIBUTION OF INTERGROWTHS HAVE IMPORTANT INFLUENCES ON CONDUCTOR PERFORMANCE.

3MP1E-06

COMPATIBILITY OF BI-2212 WITH SELECTED SILVER ALLOYS ***J. A. KENNISON****[1], T. G. HOLESINGER[1], F. J. BACA[1], J. Y. COULTER[1], K. R. MARKEN[1], X. F. LU[2], N. CHEGGOUR[2];* [1]LOS ALAMOS NATIONAL LABORATORY, [2]NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY - BOULDER. — THE USE OF THE HIGH-TEMPERATURE SUPERCONDUCTOR (HTS) BI2SR2CACU2OY (BI2212) AT LOW-TEMPERATURES AND HIGH-FIELDS PUTS SEVERE DEMANDS ON THE STRENGTH OF THE SILVER ALLOY USED AS THE SHEATH MATERIAL. AS WORK PROGRESSES TOWARDS BI2212 WIRE USE IN MAGNETS OPERATING ABOVE 20 T, IT IS IMPERATIVE THAT WE FIND SILVER-BASED ALLOYS THAT ARE MUCH STRONGER COMPARED TO PURE SILVER. TO THIS END, WE HAVE STARTED INVESTIGATIONS INTO THE COMPATIBILITY OF BI2212 AND RELATED PROCESSING WITH SILVER ALLOYS IN THE SYSTEMS AG-MG-CU, AG-PD-CU, AG-PT-CU, AND SOME VARIATIONS OF THESE SYSTEMS WITH ADDITIONS OF LEAD, ALUMINUM, AND GOLD. THE SILVER ALLOYS WERE FORMED INTO WIRE AND CHARACTERIZED FOR STRUCTURE, HARDNESS, AND STRESS-STRAIN CHARACTERISTICS. PIECES OF THESE WIRES WERE THEN ROLLED INTO FLAT TAPE FOR BI2212 COMPATIBILITY TESTS. BI-2212 FILMS WERE SPIN- OR DIP-COATED ONTO SILVER ALLOY COUPONS AND PROCESSED USING STANDARD BI2212 WIRE PROTOCOLS. SELECTED FILMS WERE THEN TESTED FOR CRITICAL CURRENT DENSITY (JC), TRANSITION TEMPERATURE (TC), AND MICROSTRUCTURE, WITH PARTICULAR ATTENTION PAID TO IDENTIFYING ANY INTERACTIONS BETWEEN THE SILVER ALLOYS AND THE BI2212.

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3MP1E-07

INFLUENCE OF CO-INTRODUCTION OF SILVER AND ZIRCONIA AS ARTIFICIAL PINNING CENTERS ON THE CRITICAL CURRENT DENSITIES OF BI2212 ***E. CURSINO****[1], J. S. GARITAONANDIA[2], D. S. SCHMOOL[3], C. SANTOS[1], A. B. LOPES[4], D. RODRIGUES JR.[1];* [1]ESCOLA DE ENGENHARIA DE LORENA DA UNIVERSIDADE DE SÃO PAULO, SÃO PAULO, BRAZIL, [2]UNIVERSIDAD DEL PAIS VASCO, BILBAO, SPAIN, [3]UNIVERSIDADE DO PORTO, [4]UNIVERSIDADE DE AVEIRO, PORTUGAL. — SEVERAL STUDIES WITH SUPERCONDUCTING CERAMICS HAVE FOCUSED ON DOPING WITH SILVER WHICH, AT CERTAIN CONCENTRATIONS, HELPS THE TEXTURING OF THE MATERIAL AND, CONSEQUENTLY, THE OPTIMIZATION OF THE SUPERCONDUCTING CRITICAL CURRENT DENSITIES. STUDIES OF THE ADDITION OF SILVER IN THE BSCCO COMPOUNDS TO VERIFY THE IMPROVEMENT ON THE CRITICAL CURRENT DENSITIES ARE CONTROVERSIAL. IN BSCCO SUPERCONDUCTING OXIDES, DUE TO THE WEAK PINNING CENTERS EXISTING IN THE MATERIAL, MAINLY ABOVE 20K, IT IS SUGGESTED THE INTRODUCTION OF ARTIFICIAL PINNING CENTERS. IN THIS WORK WE STUDY THE CO-INTRODUCTION OF 0 AND 5% WT SILVER AND 0, 1 AND 2% WT ZIRCONIA AS ARTIFICIAL PINNING CENTERS IN AG/BI-2212 MONOFILAMENTARY TAPES. THE SAMPLES WERE CHARACTERIZED BY MAGNETIZATION, X-RAY DIFFRACTION AND SEM. THE RESULTS SHOWED THAT THE SILVER DEGRADES THE CRITICAL CURRENT DENSITIES..

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3MP1E-08

STUDY OF EFFECTS OF DEFORMATION IN BSCCO-2212 WIRES *E. BARZI[1], **M. BOSSERT**[1], V. LOMBARDO[1], D. TURRIONI[1], T. G. HOLESINGER[2], F. JAVIER BACA[2];* [1]FERMILAB, [2]LOS ALAMOS NATIONAL LABORATORY. — BSCCO-2212 CABLES ARE BEING INVESTIGATED WITHIN THE VERY HIGH FIELD SUPERCONDUCTING MAGNET COLLABORATION (VHFSMC). TO SIMULATE THE PLASTIC PROCESS SEEN BY A BSCCO-2212 ROUND STRAND WHEN BECOMING PART OF A RUTHERFORD CABLE, A NUMBER OF WIRES OF VARIOUS DESIGNS WERE ROLLED DOWN TO DECREASING SIZES. AFTER HEAT TREATMENT, ROLLED SAMPLES WERE CHARACTERIZED FOR TRANSPORT PROPERTIES AND MICROSTRUCTURE, INCLUDING SEM/EDS DETAILING SECONDARY PHASES, INTERCONNECTS AND COMPOSITION. RESULTS WERE COMPARED TO THOSE OBTAINED FOR STRANDS EXTRACTED FROM CABLES. ON THE EXTRACTED STRANDS MICROSTRUCTURAL CHARACTERIZATION INCLUDED LOOKING FOR CONTRAST BETWEEN THE EDGES AND STRAIGHT AREAS. THE CRITICAL CURRENT OF THE ROLLED WIRES WAS COMPARED AT 4.2 K AND 14 T TO THAT OF THE SAME STRAND EXTRACTED FROM CABLES OF VARIOUS PACKING FACTORS. BY MATCHING THE DATA POINTS FOR THE ROLLED AND EXTRACTED STRANDS, ONE CAN FIND A RANGE OF STRAIN FOR ROLLED STRANDS WHERE A REASONABLY GOOD CORRELATION OF IC DEGRADATION IS OBSERVED BETWEEN THE LATTER AND THE EXTRACTED STRANDS.

3MP1E-09

LOSSES IN A BSCCO TAPE WHEN A PLATEAU-LESS CURRENT IMPULSE IS FED INTO IT ***L. FROLEK**, J. ŠOUC;* INSTITUTE OF ELECTRICAL ENGINEERING, SLOVAK ACADEMY OF SCIENCES, BRATISLAVA, SLOVAK REPUBLIC. — PROGRESS IN SUPERCONDUCTIVITY RESEARCH OR APPLICATIONS REQUIRES THE USE OF IMPULSE MEASUREMENT. IT IS NOTICEABLE IN EXPERIMENTAL REQUIREMENTS ON THE CHARACTERIZATION OF SUPERCONDUCTING TAPES WITH HIGH CRITICAL CURRENTS OR OPTIMIZATION OF APPLICATIONS, SUCH AS SUPERCONDUCTING FAULT CURRENT LIMITERS. IN THIS ARTICLE, WE PRESENT MEASUREMENT AND INTERPRETATION OF LOSSES THAT ARISE WHEN CURRENT IMPULSES ARE APPLIED TO A SUPERCONDUCTING AG/BI-2223 MULTIFILAMENTARY COMPOSITE TAPE. FOR THE IMPULSES WE USED UNIPOLAR CURRENT WAVES WITH AN ALMOST PERIODIC SHAPE. THEIR SHAPE IS DEFINED BY A MULTIPLICATION FUNCTION OF DAMPED EXPONENTIAL AND HALF-SINUSOIDAL TIME BEHAVIOUR. THESE CURRENT IMPULSES DO NOT HAVE CURRENT PLATEAU AND ARE WITHIN A MILLISECOND RANGE. FOR THE MEASUREMENT, WE USED A DAQ SYSTEM WITH A SAMPLING RATE UP TO 100 KS/S AND 24 BITS RESOLUTION. THE COMPONENTS OF VOLTAGE INDUCED BY THE CHANGING OF THE MAGNETIC FLUX IN THE MEASUREMENT LOOP WERE COMPENSATED. THE TIME DEPENDENCES OF VOLTAGES AND CURRENTS DURING THE IMPULSES WERE MEASURED SIMULTANEOUSLY. DATA OBTAINED WERE USED FOR THE CALCULATION OF POWER DISSIPATIONS (INSTANTANEOUS POWERS), AND THEIR TIME DEPENDENCES ARE SHOWN. THE LOSSES (AVERAGE POWERS) WERE CALCULATED BY MEANS OF NUMERICALLY INTEGRATED POWER TIME DEPENDENCES. THE RESULTS ARE DEPICTED AS CURRENT DEPENDENCES OF AVERAGE POWERS.

3MP1E-10

THE DEPENDENCE OF ELECTRICAL AND STRUCTURAL PROPERTIES WITH AGING OF SUPERCONDUCTOR CERAMICS ***C. L. CARVALHO**, G. B. TORSONI, V. C. S. REYNOSO;* UNIVERSIDADE ESTADUAL PAULISTA. — THIS WORK PRESENTS THE RESULTS OF ELECTRICAL RESISTANCE MEASUREMENTS AS A FUNCTION OF TEMPERATURE AND X-RAY DIFFRACTOMETRY FOR 2223 SUPERCONDUCTOR PELLETS (CRITICAL TEMPERATURE AT AROUND 110 K), AFTER KEEPING THEM FOR 14 YEARS UNDER NORMAL AMBIENT CONDITIONS (25ºC, 1ATM AND 50-70% HUMIDITY). THE PELLETS WERE OBTAINED AFTER PRESSING A PRECURSOR POWDER PREVIOUSLY PREPARED BY A CHEMICAL PROCESS. THE RESULTS INDICATE THAT THE SAMPLES OBTAINED FROM THE CHEMICAL PROCESS ARE VERY STABLE, WHICH REPRESENTS EXTREMELY IMPORTANT RESULTS FOR TECHNOLOGICAL APPLICATIONS.

THE AUTHORS ARE GRATEFUL TO THE BRAZILIAN AGENCIES FAPESP AND FUNDUNESP FOR FINANCIAL SUPPORT FOR THE DEVELOPMENT OF THIS WORK AND TO THE POLYMER GROUP OF PHYSICS AND CHEMISTRY DEPARTMENT FOR THE XRD MEASUREMENTS.

3MP1F-01

SYNTHESIS OF HIGH PURITY BI(PB)2223 TAPES WITH HIGH T_C ABOVE 115 K ***M. WATANABE**[1], J. SHIMOYAMA[1], K. OBATA[1], K. KISHIO[1], S. KOBAYASHI[2], K. HAYASHI[2];* [1]UNIVERSITY OF TOKYO, [2]SUMITOMO ELECTRIC INDUSTRIES, LTD.. — IN OUR PREVIOUS STUDY, CRITICAL CURRENT PROPERTIES OF BI2212 SINGLE CRYSTAL WERE DRAMATICALLY IMPROVED BY ADJUSTING THE CATION COMPOSITION BEING NEARLY STOICHIOMETRIC, 2:2:1:2. SINCE THE BI(PB)2223 ALSO HAS NONSTOICHIOMETRY IN CATION COMPOSITION, FURTHER IMPROVEMENT IN J_C CHARACTERISTICS OF THE BI(PB)2223 TAPES WILL BE EXPECTED BY CONTROLLING STARTING CATION COMPOSITIONS. IN ADDITION, ENHANCEMENT OF T_C WAS ALSO SUCCEEDED IN BI(PB)2223 TAPES UP TO 117.8 K BY POST-ANNEALING AT ~700°C IN AIR IN OUR RECENT STUDY. HOWEVER, GENERATION OF PB3221 DURING POST-ANNEALING PROCESS DETERIORATED J_C CHARACTERISTICS. BASED ON THESE BACKGROUNDS, WE HAVE ATTEMPTED TO DEVELOP A NEW METHOD TO ACHIEVE BOTH HIGH T_C AND HIGH PHASE PURITY FOR BI(PB)2223 TAPES IN THE PRESENT STUDY.THE MONO-CORE AND MULTI-FILAMENTARY BI(PB)2223 SILVER SHEATHED TAPES WERE SYNTHESIZED WITH VARIOUS STARTING CATION COMPOSITIONS. T_C OF THE AS-SYNTHESIZED TAPES WAS ~110 K. POST-ANNEALING AT ~700°C IN MODERATELY REDUCING ATMOSPHERE, SUCH AS 1%O_2, WERE FOUND TO BE EFFECTIVE FOR BOTH ENHANCEMENT OF T_C UP TO 116 K AND SUPPRESSING GENERATION OF THE PB3221 PHASE. MOREOVER, TAPES STARTING FROM CATION STOICHIOMETRIC COMPOSITION WERE CONFIRMED TO SHOW THE HIGHEST T_C. CRITICAL CURRENT PROPERTIES OF THESE TAPES WILL BE REPORTED.

3MP1F-02

EXCELLENT LONGITUDINAL UNIFORMITY OF COMMERCIAL BI2223 TAPES CHARACTERIZED BY SCANNING HALL-PROBE MICROSCOPY ***R. INADA***[1]*, S. BABA*[1]*, T. MAKIHARA*[1]*, R. OHTSU*[1]*, S. SAKAMOTO*[2]*, Y. NAKAMURA*[1]*, A. OOTA*[1]*;* [1]TOYOHASHI UNIVERSITY OF TECHNOLOGY, [2]KISARAZU NATIONAL COLLEGE OF TECHNOLOGY. — WE INVESTIGATED REMANENT FIELD DISTRIBUTIONS ON COMMERCIAL BI2223 TAPES WITH CRITICAL CURRENT I_C AROUND 150 A DEVELOPED BY SUMITOMO ELECTRIC INDUSTRIES LTD., BY USING SCANNING HALL-PROBE MICROSCOPY (SHM). ALL SAMPLE TAPES WERE PREPARED BY POWDER-IN-TUBE PROCESS AND SINTERED BY CONTROLLED-OVER PRESSURE (CT-OP) PROCESSING AT FINAL SINTERING STAGE. A BARE TAPE AND 3-PLY REINFORCED ONES WITH STAINLESS OR CU-ALLOY LAMINATIONS WERE USED FOR MEASUREMENTS. THE LENGTHS OF ALL SAMPLES WERE 1 M. AFTER THE TAPE WAS FIXED ON THE SAMPLE HOLDER AT 77 K AND ZERO FIELDS, THE MAGNETIC FIELD IN PERPENDICULAR TO THE BROADER FACE OF THE TAPE WAS APPLIED BY THE PERMANENT MAGNET MOVED ALONG A TAPE LENGTH. AFTER REMOVING THE FIELD, THE DISTRIBUTION OF REMANENT FIELD B_{RZ} IN PERPENDICULAR TO BROAD FACE OF A SAMPLE WAS MEASURED BY SHM WITH AN ACTIVE AREA OF 0.05 MM X 0.05 MM, AT A FIXED DISTANCE OF 0.5 MM AWAY FROM A TAPE SURFACE. ALTHOUGH THE ABSOLUTE B_{RZ} VALUES IN REINFORCED TAPES WERE 10% LOWER THAN BARE ONE, THE SHAPE OF B_{RZ} PROFILE ALONG A LATERAL DIRECTION OF TAPE WAS HARDLY AFFECTED BY REINFORCEMENT AND UNIFORMLY DISTRIBUTED ALONG A WHOLE LENGTH OF EACH TAPE. THE B_{RZ} DISTRIBUTIONS AFTER DOUBLE BENDING TEST WITH DIFFERENT BENDING RADII WERE COMPARED AMONG THE TAPES AND THE EFFECT OF METAL TAPE LAMINATIONS ON THE LONGITUDINAL TAPE UNIFORMITY AFTER BENDING IS INVESTIGATED.

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3MP1F-03

EVALUATION OF SELF-FIELD DISTRIBUTIONS FOR BI2223 TAPES WITH OXIDE BARRIERS CARRYING DC TRANSPORT CURRENT ***T. MAKIHARA***[1]*, R. INADA*[1]*, S. SAKAMOTO*[2]*, Y. NAKAMURA*[1]*, A. OOTA*[1]*, C. LI*[3]*, P. ZHANG*[3]*;* [1]TOYOHASHI UNIVERSITY OF TECHNOLOGY, [2]KISARAZU NATIONAL COLLEGE OF TECHNOLOGY, [3]NORTHWEST INSTITUTE FOR NONFERROUS METAL RESEARCH. — FOR REDUCING AC LOSSES IN BI2223 TAPES SUBJECTED TO AN AC EXTERNAL MAGNETIC FIELD, TWISTING THE BI2223 SUPERCONDUCTING FILAMENTS AND/OR INTRODUCING OXIDE LAYERS AS HIGHLY RESISTIVE BARRIERS AROUND EACH FILAMENTS ARE NECESSARY. HOWEVER, THE STRUCTURE OF BARRIER TAPES BECOMES COMPLEX AND THE LONGITUDINAL UNIFORMITY OF BOTH TRANSPORT PROPERTY AND TAPE STRUCTURE COULD BE EASILY DETERIORATED. IN ADDITION, THE INTERFILAMENTARY BARRIERS MAY AFFECT ON THE CURRENT DISTRIBUTIONS IN A TAPE CARRYING TRANSPORT CURRENT. IN THIS PAPER, WE INVESTIGATED THE SELF-FIELD DISTRIBUTIONS FOR NON-TWISTED BI2223 TAPES WITH OXIDE BARRIERS CARRYING DC TRANSPORT CURRENT BY USING A SCANNING HALL-PROBE MICROSCOPY (SHM). 19-FILAMENTARY TAPES WITH OR WITHOUT $SRZRO_3$ + BI2212 BARRIERS WERE PREPARED BY CONVENTIONAL POWDER-IN-TUBE METHOD. THE DEGRADATION OF CRITICAL CURRENT DENSITY J_C BY INTRODUCING BARRIERS WAS WITHIN 15%. TWO-DIMENSIONAL DISTRIBUTION OF SELF-FIELD IN PERPENDICULAR TO THE BROADER FACE OF EACH TAPE CARRYING DC CURRENT BELOW CRITICAL CURRENT I_C WAS MEASURED BY SHM WITH AN ACTIVE AREA OF 0.05 MM X 0.05 MM, AT 0.5 MM AWAY FROM THE TAPE SURFACE. COMPARING BETWEEN EXPERIMENTAL AND NUMERICALLY CALCULATED RESULTS BASED ON BOTH CRITICAL STATE MODEL AND FLUX MINIMIZATION, THE INFLUENCE OF INTRODUCTION OF RESISTIVE BARRIERS ON CURRENT DISTRIBUTIONS IN MULTIFILAMENTARY TAPES IS DISCUSSED.

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3MP1F-04

THE CONSTRUCTION PROGRESS OF A HIGH−TC SUPERCONDUCTING POWER SUBSTATION IN CHINA ***G. ZHANG***[1]*, L. LIN*[1]*, L. XIAO*[1]*, Y. YU*[1]*, S. V. PAMIDI*[2]*, J. SCHWARTZ*[3]*;* [1]INSTITUTE OF ELECTRICAL ENGINEERING,CHINESE ACADEMY OF SCIENCES, [2]CENTER FOR ADVANCED POWER SYSTEM,FSU,USA, [3]NORTH CAROLINA STATE UNIVERSITY,USA. — THE APPLICATION OF SUPERCONDUCTOR TECHNOLOGIES IN POWER GRID CAN DECREASE POWER LOSSES, RELIEVE AN OVERLOADED, AVOID HIGHER TRANSMISSION VOLTAGE LEVELS, INCREASE POWER TRANSMISSION CAPACITY, AND IMPROVE POWER QUALITY AND GRID STABILITY. THUS, IT IS EXPECTED THAT SUPERCONDUCTING TECHNOLOGIES WILL PLAY AN IMPORTANT ROLE IN THE FUTURE SMART GRID. IN RECENT YEARS, SUPERCONDUCTING POWER TECHNOLOGIES HAVE ACHIEVED REMARKABLE PROGRESS. THE HIGH TEMPSUPERCONDUCTING (HTS) POWER DEVICES, SUCH AS HTS POWER CABLES, TRANSFORMERS, FAULT CURRENT LIMITERS (FCLS), AND SUPERCONDUCTING MAGNETIC ENERGY STORAGE DEVICES (SMES) HAVE BEEN TEST OPERATED IN POWER GRID IN MANY COUNTRIES. WITH THE DEVELOPING OF HTS POWER DEVICES, THE CONSTRUCTION OF HTS POWER SUBSTATION IS READY. IN CHINA, A 10.5KV HTS POWER SUBSTATION IS UNDER CONSTRUCTING IN BAIYIN CITY, GANSU PROVINCE. THE SUBSTATION CONSISTS OF A POWER CABLE, A TRANSFORMER, A FAULT CURRENT LIMITER, AND A SUPERCONDUCTING MAGNETIC ENERGY STORAGE DEVICE (SMES). ALL THESE HTS POWER DEVICES, WHICH WERE FORMERLY DEVELOPED BY INSTITUTE OF ELECTRICAL ENGINEERING, CHINESE ACADEMY OF SCIENCES, WERE LONG-TIME TEST OPERATED IN POWER GRID. HERE,

THE DESIGN AND CONSTRUCTING PROGRESS OF THE SUBSTATION ARE INTRODUCED IN DETAIL.

3MP1F-05**ANISOTROPIC THERMAL CONDUCTIVITY OF SILVER SHEATHED BI2223 SUPERCONDUCTING TAPE** *T. NAITO[1], **H. FUJISHIRO**[1], J. FUJIKAMI[2];* [1]IWATE UNIVERSITY, [2]SUMITOMO ELECTRIC INDUSTRIES LTD.. — THE THERMAL CONDUCTIVITY K(T) OF A SILVER SHEATHED BI2223 (DI-BSCCO®) TAPE WAS MEASURED FOR THREE TYPICAL DIRECTIONS; THE LENGTH (*L*), WIDTH (*W*), AND THICKNESS (*T*) DIRECTIONS. K(T) ALONG THE *W*- OR *T*-DIRECTIONS WAS MEASURED USING STACKING SAMPLES IN WHICH SEVERAL DI-BSCCO TAPES WERE SOLDERED. K(T) CURVES ALONG THE *L*- AND *W*-DIRECTIONS ALMOST COINCIDED WITH EACH OTHER. ABSOLUTE VALUES ALONG BOTH DIRECTIONS WERE ABOUT 2300 MW/CMK AT 77 K. THESE RESULTS INDICATE THAT THE CONTRIBUTION OF THE BI2223 CORE REGION TO THE THERMAL TRANSPORT IS VERY SMALL AND THE APPLIED HEAT MAINLY FLOWS THROUGH THE SILVER SHEATH. ON THE OTHER HAND, THE ABSOLUTE VALUE OF K(T) ALONG THE *T*-DIRECTION WAS APPROXIMATELY 170 MW/CMK AT 77 K. THIS SMALL VALUE OF K(T) ORIGINATES FROM THE FACT THAT THE SMALL AMOUNT OF APPLIED HEAT FLOWS ALONG THE *C*-AXIS OF THE BI2223 FILAMENTS. WE DISCUSS THE ANISOTROPIC THERMAL CONDUCTIVITY OF DI-BSCCO TAPES USING AN EQUIVALENT HEAT CURRENT CIRCUIT.

3MP1F-06**INCREASE THE CRITICAL CURRENT OF BI-2223/AG SUPERCONDUCTING TAPES BY USING MELTING ASSISTED HIP PROCESS** ***T. QU**[1], K. HUANG[1], C. GU[1], Z. HAN[1], X. SONG[2], P. ZENG[1];* [1]TSINGHUA UNIVERSITY, BEIJING 100084, CHINA, [2]INNOVA SUPERCONDUCTOR TECHNOLOGY CO.,LTD., BEIJING, CHINA. — AFTER NORMAL PRESSURE HEAT TREATMENTS, THERE WERE STILL MANY CRACKS AND HOLES IN CERAMIC FILAMENTS OF BI-2223/AG SUPERCONDUCTING TAPES, WHICH WERE GREAT OBSTACLES FOR ACHIEVING HIGH CRITICAL CURRENTS. THE HOT ISOSTATIC PRESSURE (HIP) PROCESS WAS PROVED TO BE AN EFFECTIVE METHOD FOR PRODUCING HIGH QUALITY TAPES. HERMETICALLY SEALED SAMPLES ARE REQUIRED FOR HIP EXPERIMENTS. OTHERWISE THE HIGH PRESSURE GAS MIGHT PENETRATE INTO THE INNER SAMPLE AND PRODUCE LARGE SIZE CRACKS. IN OUR PREVIOUS WORK, THE CRACK-HEALING PROCESS (CHP) WAS SUCCESSFULLY INTRODUCED BEFORE HIP. THIS ADDITIONAL PROCESS CAN HELP TO GROW SOME LIQUID PHASE TO HEAL SMALL CRACKS AND HOLES IN FILAMENTS. THUS IT COULD PRODUCE A SELF-SEALING EFFECT TO MAKE THE SUBSEQUENT HIGH PRESSURE PROCESS EFFECTIVE. BUT WHATEVER, THIS ADDITIONAL CHP PROCESS IS NOT SO FAVORABLE. IN THIS WORK, CHP WAS COMBINED WITH THE SUBSEQUENT HIP PROCESS. THE IDEA IS TO HEAT UP THE SAMPLE TO A HIGH TEMPERATURE. AFTER THE APPEARANCE OF SOME LIQUID PHASE, THE HIGH PRESSURE GAS IS DIRECTED ADDED ONTO THE SAMPLE AT THIS HIGH TEMPERATURE. IT WAS FOUND THAT THE DWELLING TIME BEFORE HIGH PRESSURE COULD BE RELATED TO THE FINAL CRITICAL CURRENT. MORE THAN 25% IMPROVEMENT WAS ACHIEVED BY USING THIS TECHNIQUE. MUCH HIGHER CRITICAL CURRENT MAY BE EXPECTED AFTER SYSTEMATIC OPTIMIZATION WORK IN THE FUTURE.

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3MP1F-07

INFLUENCE OF MELTING TEMPERATURE AND TIME ON THE NUCLEATION, GRAIN GROWTH, AND CRITICAL CURRENT DENSITY OF AG-BI2212 MULTIFILAMENTARY ROUND WIRE ***T. SHEN**, J. JIANG, F. KAMETANI, U. TROCIEWITZ, D. LARBALESTIER, E. HELLSTROM;* FLORIDA STATE UNIVERSITY. — THE MELT-PROCESSING OF PIT AG-BI2212 MULTIFILAMENTARY ROUND WIRE TO DEVELOP CRITICAL CURRENT DENSITY > 10^5 A/CM^2 IN MAGNETIC FIELDS UP TO 45 T IS COMPLEX. RECENTLY WE HAVE BEEN DECONSTRUCTING LATER STAGES OF THE PROCESS, CONCENTRATING ON THE NEED TO OVERDOPE THE 2212 PHASE [1] AND TO PROVIDE 2212 FILAMENT TO FILAMENT CONNECTIONS [2] TO GET THE HIGHEST J_C. HERE WE TURN TO THE MELT-SOLIDIFICATION STEPS WHICH DEVELOP THE 2212 GRAIN STRUCTURE, AND WHICH HISTORICALLY HAVE BEEN FOUND TO YIELD AN OPTIMUM J_C ONLY WITHIN A NARROW PROCESSING WINDOW, WHICH MAKES UNIFORM HEAT TREATMENT OF LARGE COILS WITH LARGE THERMAL MASS DIFFICULT. USING THROUGH-PROCESS QUENCHING TO REVEAL THE HIGH-TEMPERATURE MICROSTRUCTURES AND ELECTROMAGNETIC PROPERTIES PRODUCED BY PROCESSING AT VARIOUS SOAKING TIMES AT VARIOUS PEAK TEMPERATURES T_{MAX}, WE FOUND THAT RAISING T_{MAX} ABOVE THE OPTIMUM CAUSED A DECREASE IN 2212 NUCLEATION TEMPERATURE AND SMALLER 2212 GRAINS ON SUBSEQUENT COOLING. KEEPING ALL OTHER PARAMETERS CONSTANT, WE FOUND A CLEAR CORRELATION BETWEEN DECREASED 2212 FORMATION KINETICS, FINER 2212 GRAIN STRUCTURE AND LOWER J_C. THESE RESULTS AMPLIFY THE BROAD FINDINGS FROM OUR RECENT WORK THAT CONTROL OF 2212 GRAIN SIZE AND CONNECTIVITY IS KEY TO ACHIEVE HIGH J_C IN PRESENT ROUND WIRES OF BI-2212.[1] T. SHEN *ET AL*. APPLI.PHYS. LETT., **95**, 152516 (2009)[2] T. SHEN *ET AL*. SUPERCON. SCI. AND TECH. **23**, 025009 (2010)

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3MP1F-08**INTERPRETATION OF THE MECHANICAL BEHAVIOR OF BI2SR2CACU2OX/AGMG ROUND WIRES USING FRACTAL CHARACTERIZATION OF THE ROUGH SURFACES OF INDIVIDUAL FILAMENTS** ***X. GOU**[1], J. SCHWARTZ[2];* [1]NC STATE UNIVERSITY, US & HOHAI UNIVERSITY, CHINA, [2]NC STATE UNIVERSITY, US. — CROSS-SECTIONAL SEM OF MULTIFILAMENTARY BI2SR2CACU2OX (BI2212) ROUND WIRES AND MULTI-ANGLE SEM ON A SINGLE FILAMENTS FROM THIS WIRE SHOW THAT ITS MICROSTRUCTURE IS VERY COMPLICATED. SPECIFICALLY, AFTER HEAT TREATMENT THE FILAMENT SURFACES ARE VERY IRREGULAR AND OUTGROWS FORM BRIDGES BETWEEN FILAMENTS. FUNDAMENTAL QUESTIONS ARISE REGARDING WHICH MICROSTRUCTURAL FEATURES ENHANCE TRANSPORT CURRENT FLOW AND HOW THEY INFLUENCE ELECTROMECHANICAL LIMITS DURING MECHANICAL LOADING OR QUENCHING (THERMAL LOADING).

TO ADDRESS THESE QUESTIONS THEORETICALLY, THE MATHEMATICAL CHARACTERIZATION OF THE ROUGH FILAMENT SURFACES IN BI2212 ROUND WIRE IS STUDIED. IN THIS PAPER, FROM THE ORIGINAL SEM IMAGES OF SINGLE FILAMENT, THE IRREGULAR EDGE OF FILAMENT SURFACE IS ABSTRACTED BY MEANS OF IMAGE PROCESSING. ON THIS BASIS, FRACTAL AND MULTI-FRACTAL METHODS ARE USED TO CHARACTERIZE THE EDGE CURVE. RESULTS SHOW THAT THE ROUGH FILAMENT SURFACES CAN BE CHARACTERIZED BY FRACTAL AND MULTI-FRACTAL THEORY, AND THE KEY FRACTAL PARAMETERS, I.E., THE FRACTAL DIMENSION (FOR SIMPLE FRACTAL) AND MULTI-FRACTAL SPECTRUM (FOR MULTI-FRACTAL), ARE OBTAINED. THE WELL-CHARACTERIZED FRACTAL AND MULTI-FRACTAL GEOMETRIC BEHAVIORS OF THE SURFACE ARE THEN LINKED TO THE ELECTROMECHANICAL BEHAVIOR TO BETTER UNDERSTAND BI2212 BEHAVIOR.

THIS WORK PARTIALLY SUPPORTED BY THE CSC, THE FL THROUGH THE NHMFL, AND THE DOE THROUGH SUPERCON INC. THE AUTHORS THANK F.KAMETANI FOR PROVIDING MICROGRAPHS, S.PRESTEMON AND D.ARBELAEZ OF THE LBNL AND W.K.CHAN OF FAMU AND NCSU FOR USEFUL DISCUSSIONS.

3MP1F-09

FABRICATION OF BI-2212 COATINGS USING THERMO-SPRAYING *M. C. MAYORAL[1], J. M. ANDRÉS[1],* ***L. A. ANGUREL[2];*** [1]INSTITUTO DE CARBOQUÍMICA, CSIC, SPAIN, [2]ICMA (CSIC-UNIVERSTITY OF ZARAGOZA), SPAIN. — THIS WORK PRESENTS THE CHARACTERISTICS OF BI-2212 COATINGS ON SILVER SUBSTRATES OBTAINED BY THERMO-SPRAYING. THE SYSTEM ALLOWS MOVING THE SUBSTRATE AND, IN CONSEQUENCE, IT HAS BEEN POSSIBLE TO OBTAIN COATINGS OVER SURFACES WITH A WIDTH OF 1 CM AND SEVERAL CENTIMETERS LONG. CONTROLLING THE THERMO-SPRAYING PARAMETERS AND THE SUBSTRATE SPEED IT IS POSSIBLE TO MODIFY THE SUPERCONDUCTING THICKNESS. THE PHASE DISTRIBUTION AND EVOLUTION DURING ANNEALING HAS BEEN MONITORED. AN IMPORTANT AMOUNT OF BI-2212 PHASE IS ON THE SAMPLE JUST AFTER THE THERMO-SPRAYING PROCESS. IN SOME CASES, A SECOND TEXTURING PROCESS USING A LASER ZONE MELTING TECHNIQUE HAS BEEN APPLIED. THE INFLUENCE OF ALL THESE PROCESSING PARAMETERS ON THE CRITICAL CURRENT DENSITY VALUES OF THE SUPERCONDUCTING COATING HAS BEEN MONITORED.

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3MP1F-10

ANGULAR, TEMPERATURE AND STRAIN DEPENDENCE OF THE CRITICAL CURRENT OF DI-BSCCO TAPES IN HIGH MAGNETIC FIELDS ***P. SUNWONG****, J. S. HIGGINS, D. P. HAMPSHIRE;* DURHAM UNIVERSITY. — HIGH CRITICAL CURRENT DENSITY (J_C) DI-BSCCO BI-2223 SUPERCONDUCTING TAPE HAS BEEN DEVELOPED BY SUMITOMO ELECTRIC INDUSTRIES USING THE CONTROLLED OVER-PRESSURE TECHNIQUE TO IMPROVE THE TEXTURING AND DENSIFICATION . FURTHER ENHANCEMENT OF THE MECHANICAL STRENGTH OF THE STANDARD TAPE HAS BEEN OBTAINED BY LAMINATION TECHNIQUES . WE HAVE INVESTIGATED THE EFFECT OF MAGNETIC FIELD AND FIELD ORIENTATION ON THE CRITICAL CURRENT OF A SERIES OF DI-BSCCO TAPES AT 77 K UNDER TENSILE AND COMPRESSIVE REVERSIBLE STRAIN LIMIT. THESE CRITICAL CURRENT DATA ARE STRONGLY INFLUENCED BY THE ANISOTROPY OF BI-2223, THE MAGNETIC HISTORY OF THE MAGNETIC FIELD, THE TEXTURING OF THE TAPE AND ITS ARCHITECTURE. THE MAGNETIC FIELD AND ANGULAR DEPENDENCE OF J_C AT 77 K CAN BE PARAMETERISED WITH A SIMPLE ANISOTROPIC EXPONENTIAL MODEL . IN ADDITION, THE MEASUREMENTS AT TEMPERATURES ABOVE 77 K HAVE BEEN PERFORMED BY THE USE OF AN INSULATOR CUP TO CREATE A VARIABLE-TEMPERATURE CRYOGENIC GAS ENVIRONMENT . WE WILL PRESENT OUR MOST RECENT RESULTS OF J_C MEASUREMENTS AS A FUNCTION OF MAGNETIC FIELD, FIELD ORIENTATION, TEMPERATURE AND BOTH COMPRESSIVE AND TENSILE STRAIN ON A SERIES OF DI-BSCCO TAPES.

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3MP2A-01

AC SUSCEPTIBILITY STUDIES OF ANISOTROPY IN SM-123 SUPERCONDUCTORS ***N. SAKAMOTO****, T. AKUNE;* KYUSHU-SANGYO UNIVERSITY. — THE MAIN CAUSE OF THE DEGRADATION IN THE OXIDE SUPERCONDUCTORS IS CONSIDERED TO ORIGINATE IN THE INTER-GRANULAR LINK REGION AMONG THE SUPERCONDUCTING GRAINS. FOR ANALYTICAL STUDY OF THE GRANULAR STRUCTURE, THE GRAINED BEAN MODEL IS PROPOSED, WHERE THE SUPERCONDUCTING GRAINS ARE IMMERSED IN THE INTERCONNECTING LINK SUPERCONDUCTORS. DIFFERENCE OF THE SUPERCONDUCTING CHARACTERISTICS OF THE GRAIN AND THE LINK, PINNING PENETRATION DEPTHS BPG, BPL AND GRAIN VOLUME FACTOR FG, INTRODUCES A VARIETY OF DEFORMATION ON THE AC SUSCEPTIBILITY CURVES, SUCH AS DOUBLE PEAKS IN THE IMAGINARY PART AND PLATEAUS IN THE REAL PART. FROM THE DEPENDENCE OF X_N' AND X_N'' COMPONENTS OF N-TH HARMONICS OF AC SUSCEPTIBILITY ON TEMPERATURES T AND DC MAGNETIC FIELDS B_{DC} IN GRAIN-ALIGNED SM-123 SUPERCONDUCTORS, CRITICAL CURRENT DENSITIES, GRAIN SIZES AND THEIR ANISOTROPIC NATURE CAN BE ESTIMATED AND DISCUSSED COMPARING WITH THE EXISTING DATA.

3MP2A-02

EFFECTS OF NEUTRON IRRADIATION ON AN ISOLATED GRAIN BOUNDARY IN MOD COATED CONDUCTORS ***T. D. WITHNELL[1]****, H. W. WEBER[1], M. WEIGAND[2], J. H. DURRELL[2], S. C. SPELLER[3], G. M. HUGHES[3], C. R. M. GROVENOR[3];* [1]ATOMINSTITUT, VIENNA UNIVERSITY OF TECHNOLOGY, [2]DEPT. MATERIAL SCIENCE, UNIVERSITY OF CAMBRIDGE, [3]DEPARTMENT OF MATERIALS, UNIVERSITY OF OXFORD. — THE ACHIEVABLE TRANSPORT CRITICAL CURRENT DENSITIES IN COATED CONDUCTORS ARE LIMITED IN PART BY LOW ANGLE GRAIN BOUNDARIES. A COMBINATION OF ELECTRON BACK

SCATTERED DIFFRACTION (EBSD) AND FOCUSED ION BEAM (FIB) MILLING WERE USED IN COMBINATION TO IDENTIFY AND ISOLATE AN INDIVIDUAL GRAIN BOUNDARY. THE INFLUENCE OF NEUTRON IRRADIATION, A PROVEN METHOD FOR INCREASING MAGNETIC AND CURRENT CARRYING PROPERTIES, ON THESE EFFECTS WAS INVESTIGATED IN THIS WORK. GRAIN BOUNDARIES IN AN YBCO COATED CONDUCTOR SAMPLE, PRODUCED USING THE METAL-ORGANIC DEPOSITION (MOD) METHOD, WERE ISOLATED AND BOTH TRANSITION TEMPERATURE AND TRANSPORT CURRENT MEASUREMENTS WERE PERFORMED USING A 2-AXIS GONIOMETER. THE SAMPLE WAS ROTATED AT VARYING TEMPERATURE IN AN APPLIED MAGNETIC FIELD OF UP TO 6 T. THE ANGULAR DEPENDENCE OF THE CRITICAL DENSITY WAS DETERMINED BEFORE AND AFTER NEUTRON IRRADIATION IN THE TRIGA MARK II REACTOR IN VIENNA. THIS PRESENTATION SHOWS HOW THE DATA OBTAINED COMPARES WITH THAT FROM MEASUREMENTS ON THE UN-IRRADIATED FILM.

T.D. WITHNELL ACKNOWLEDGES THE NESPA PROJECT FOR PROVIDING FUNDING

3MP2A-04

OBSERVATION OF PERIODIC RESISTANCE PEAKS IN $BI_2SR_2CACU_2O_{8+D}$ (BI-2212) STACKS ***S. KIM***; JEJU NATIONAL UNIVERSITY. — COUPLED STACKED JOSEPHSON JUNCTIONS (SJJS) IN HIGH- SUPERCONDUCTING (HTS) $BI_2SR_2CACU_2O_{8+D}$ (BI-2212) ARE FABRICATED WITH A REFINED COUPLING CONFIGURATION OF A HOLE. TWO STACKS WITH A COMPLETELY PERFORATED HOLE OF 0.2 μM×0.4 μM WERE FABRICATED USING A 3-D FOCUSED ION BEAM (FIB) ETCHING METHOD. WHEN A CONSTANT EXTERNAL MAGNETIC FIELDS H_E VALUE OF 1 T AND A BIAS CURRENT I_B VALUE OF 1 μA WERE APPLIED TO THE SAMPLE WITH CHANGING EXTERNAL FIELD ANGLE Θ_I, UNSPECIFIED EQUIDISTANT AND PERIODIC PEAK STRUCTURES IN THE SJJS WERE INDUCED. THE PERIODIC PEAKS OF R_J SHOWS THE SWITCHING TRANSITION FROM ZERO VOLTAGE STATE TO THE RESISTIVE STATE. WE ASSIGN THE ORIGIN OF THE PEAKS TO THE INTERRELATIONS BETWEEN THE PERIODIC MECHANICAL VIBRATIONS OF SAMPLE STAGE AND THE QUANTIZED FLUX BEHAVIORS AROUND A SUBMICROMETER HOLE.

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3MP2A-05

THE MAGNETIC PROPERTIES OF SIC-MGB_2 COMPOSITE SUPERCONDUCTOR ***K. SONG***[1]*, S. KANG*[1]*, R. KO*[2]*, C. PARK*[3]*;* [1]CHONBUK NATIONAL UNIVERSITY, [2]KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE, [3]SEOUL NATIONAL UNIVERSITY. — WE INVESTIGATED THE EFFECT OF NANOPARTICLE ADDITIONS ON THE MAGNETIC PROPERTIES OF MGB_2 SUPERCONDUCTOR. THE NANOPARTICLE-MGB_2 COMPOSITE SUPERCONDUCTING SAMPLE, $(SIC)_{4WT.\%}(MGB_2)_{96WT.\%}$, CONTAINING SIC NANOPOWDERS OF 130NM DIAMETERS WAS PREPARED BY A SIMPLE SOLID-STATE REACTION ROUTE AND COLD PRESS INTO A PELLET FORM. THE MEASUREMENT OF ISOTHERMAL MAGNETIZATION M(H), FOR THE PREPARED SAMPLES SUCH AS SIC-MGB_2, PURE-MGB_2 AND ANNEALED PURE-MGB_2, WAS CARRIED OUT AT TEMPERATURES BETWEEN 5 AND 50 K IN FIELDS UP TO 8.5 T, USING A PPMS-9 (WITH ACMS OPTION, QUANTUM DESIGN). THE CRITICAL CURRENT DENSITY (J_C) VALUES HAVE BEEN OBTAINED FROM THE M(H) DATA, USING BEAN MODEL. THERE ARE STEP STRUCTURES AS A DYNAMICAL CHANGE IN THE J_C CURVES. THE J_C VALUES ARE DECREASING SLOWLY AT BOTH LOW FIELD AND HIGH FIELD REGIONS. IN THE MIDDLE FIELD REGIONS, HOWEVER, THE J_C VALUES ARE DECREASING FAST FOR ALL SAMPLES. BOTH PURE-MGB_2 AND SIC-MGB_2 SUPERCONDUCTORS SHOW ALMOST THE SAME DECREASING RATES OF J_C VALUES FOR ENTIRE FIELD REGIONS SUCH AS LOW, MIDDLE, AND HIGH FIELDS, RESPECTIVELY. THESE AND OTHER RESULTS WILL BE DISCUSSED.

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3MP2A-06

MAGNETIC SHIELDING PROPERTIES OF MGB2 BULK SAMPLES OF DIFFERENT GEOMETRIES *R. GERBALDO*[1]*, G. GHIGO*[1]*, L. GOZZELINO*[1]*, F. LAVIANO*[1]*, G. LOPARDO*[1]*,* ***B. MINETTI***[1]*, A. AGOSTINO*[2]*, E. MEZZETTI*[1]*;* [1]DEPARTMENT OF PHYSICS, POLITECNICO DI TORINO, TORINO, ITALY, [2]DEPARTMENT OF GENERAL AND ORGANIC CHEMISTRY, UNIVERSITÀ DI TORINO, TORINO, ITALY. — MITIGATION OF MAGNETIC FIELDS BY MGB2 BULK SAMPLES WITH DIFFERENT GEOMETRIES IS EXPERIMENTALLY STUDIED. THIS COMPOUND IS LESS BRITTLE AND LESS AFFECTED BY WEAK-LINK PRESENCE THAN HIGH-TC CUPRATE SUPERCONDUCTORS AND ITS WORKING TEMPERATURE IS EASILY ATTAINABLE BY SINGLE STAGE CRYOCOOLER. THESE PROPERTIES MAKE IT VERY SUITABLE FOR THE FABRICATION OF MAGNETIC SHIELDS WHERE, AS IN THE MEDICAL SECTOR, CONTROLLED MAGNETIC SHIELDING AND LOW MAGNETIC FIELD BACKGROUND ARE REQUIRED. A DEDICATED CRYOGENIC INSERT, EQUIPPED BY A MOVING SAMPLE HOLDER, WHERE A GAAS HALL PROBE ARRAY WAS MOUNTED, WAS DESIGNED IN ORDER TO OBTAIN 3D MAPS OF THE MAGNETIC FIELD DISTRIBUTION WITH MICROMETRIC SPATIAL RESOLUTION. PASSIVE MAGNETIC SHIELDING PROPERTIES OF HOMOGENEOUS SAMPLES WITH ELEMENTARY GEOMETRIES (DISK, TUBE, CUP) IS INVESTIGATED WITH PARTICULAR EMPHASIS ON THE SHIELDING PROPERTIES OF INTERCONNECTION JUNCTIONS BETWEEN SUPERCONDUCTING ELEMENTS OF SINGLE COMPONENTS. EXPERIMENTAL SPATIAL DISTRIBUTIONS OF THE MAGNETIC FIELD ARE THEN COMPARED WITH THE PREDICTED ONES [E.H.BRANDT, PHYS. REV. B 54 (1996) 4246, A.SANCHEZ ET AL., PHYS. REV. B 64 (2001) 214506, S.DENIS ET AL., SUPERCOND. SCI. TECHNOL. 20 (2007) 192] AIMING AT A SUITABLE RESCALING TO REAL EQUIPMENTS.

WORK SUPPORTED BY MIUR UNDER PRIN PROJECT NO.2007AW2K4Y “MITIGATION OF MAGNETIC FIELDS PRODUCED BY MRI: SHIELDING SOLUTIONS BY SUPERCONDUCTIVE AND TRADITIONAL ELEMENTS”

3MP2A-07

EFFECTS OF SINTERING TEMPERATURE ON SUPERCONDUCTING PROPERTIES OF MG_2SI DOPED MGB_2 WIRES ***G. LIANG****, H. FANG, .. NEELEY, J. HILL, J. BURK;* SAM HOUSTON STATE UNIVERSITY. — THE EFFECTS OF SINTERING TEMPERATURE ON THE SUPERCONDUCTING PROPERTIES OF TI-SHEATHED, MG_2SI DOPED MGB_2 WIRES HAVE BEEN STUDIED FOR THE FIRST TIME. THE WIRES WERE FABRICATED BY IN SITU POWDER-IN-TUBE (PIT) METHOD AND CHARACTERIZED BY X-RAY DIFFRACTION, MAGNETIZATION AND TRANSPORT MEASUREMENTS. SAMPLES WERE SINTERED FOR 30 MINUTES AT THE FOLLOWING TEMPERATURES: 650 °C, 750 °C, 800 °C, 850°C, AND 950°C. IT IS FOUND THAT EXCEPT FOR THE SAMPLE SINTERED AT 950°C, THE CORES OF THESE WIRES ARE ALMOST IN PURE MGB_2 PHASE, INDICATING THAT THE TI-SHEATH DOES NOT REACT WITH MG OR B. THE CRITICAL CURRENT DENSITY J_C PEAKS UP FOR SAMPLES SINTERED AT AROUND 750 °C. THE CORRELATIONS BETWEEN THE J_C, T_C, AND SINTERING TEMPERATURE WILL BE DISCUSSED IN DETAIL FOR THESE MG_2SI DOPED MGB_2 WIRES.

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3MP2A-08

OPTIMIZATION OF HEAT TREATMENT PROFILES APPLIED TO NANOMETRIC-SCALE NB_3SN WIRES WITH CU-SN ARTIFICIAL PINNING CENTERS ***D. RODRIGUES JR.****, L. B. S. DA SILVA, C. A. RODRIGUES, N. F. OLIVEIRA JR., C. B. NUNES;* ENGINEERING SCHOOL OF LORENA - UNIVERSITY OF SÃO PAULO. — NB_3SN IS ONE OF THE MOST USED SUPERCONDUCTING MATERIALS FOR APPLICATIONS IN HIGH MAGNETIC FIELDS. THE IMPROVEMENT OF THE CRITICAL CURRENT DENSITIES (J_C) IS IMPORTANT, AND MUST BE ANALYZED TOGETHER WITH THE OPTIMIZATION OF THE FLUX PINNING ACTING IN THE MATERIAL. FOR NB_3SN, IT IS KNOWN THAT THE GRAIN BOUNDARIES ARE THE MOST EFFECTIVE PINNING CENTERS. HOWEVER, THE INTRODUCTION OF ARTIFICIAL PINNING CENTERS (APCS) WITH DIFFERENT SUPERCONDUCTING PROPERTIES HAS BEEN PROVED TO BE BENEFICIAL FOR J_C. AS THESE APCS ARE NORMALLY IN THE NANOMETRIC-SCALE, THE CONVENTIONAL HEAT TREATMENT PROFILES USED FOR NB_3SN WIRES CANNOT BE DIRECTLY APPLIED, LEADING TO EXCESSIVE GRAIN GROWTH AND/OR INCREASE OF THE APCS CROSS SECTIONS. IN THIS WORK, THE HEAT TREATMENT PROFILES FOR NB_3SN SUPERCONDUCTOR WIRES WITH CU(SN) ARTIFICIAL PINNING CENTERS IN NANOMETRIC-SCALE WERE ANALYZED IN AN ATTEMPT TO IMPROVE J_C. IT IS DESCRIBED A METHODOLOGY TO OPTIMIZE THE HEAT TREATMENT PROFILES IN RESPECT TO DIFFUSION, REACTION AND FORMATION OF THE SUPERCONDUCTING PHASES. MICROSTRUCTURAL, TRANSPORT AND MAGNETIC CHARACTERIZATION WERE PERFORMED IN AN ATTEMPT TO FIND THE PINNING MECHANISMS ACTING IN THE SAMPLES. IT WAS CONCLUDED THAT THE MAXIMUM CURRENT DENSITIES WERE FOUND WHEN NORMAL PHASES (DUE TO THE INTRODUCTION OF THE APCS) ARE ACTING AS MAIN PINNING CENTERS IN THE GLOBAL BEHAVIOR OF THE NB_3SN SUPERCONDUCTING WIRE.

THE AUTHORS WISH TO THANK THE INSTITUTE OF PHYSICS, USP, BRAZIL, FOR THE USE OF THE 17T MAGNET; LME-LNLS, CAMPINAS, BRAZIL, FOR THE USE OF FEG-SEM; AND TO CNPQ AND CAPES, BRAZIL, FOR THE FINANCIAL SUPPORT. DRJ, CBN, AND NFOJ ARE CNPQ RESEARCHERS.

3MP2A-09

INVESTIGATION OF THE STRAIN EFFECTS ON THE SUPERCONDUCTING PROPERTIES OF NBTI WIRES IN HYDROSTATIC PRESSURES UP TO 1 GPA ***J. M. S. ORR****, D. P. HAMPSHIRE;* DURHAM UNIVERSITY. — NIOBIUM TITANIUM IS USED IN SUPERCONDUCTING APPLICATIONS IN FIELDS UP TO ~ 10 T. IT IS WELL KNOWN THAT DIFFERENTIAL THERMAL CONTRACTION IN THE COPPER-NBTI COMPOSITE AND THE LORENTZ FORCES PRODUCED DURING HIGH-FIELD OPERATION ACT ON THE NBTI FILAMENTS TO REDUCE THE CRITICAL PARAMETERS. THE DELETERIOUS EFFECT OF ONE-DIMENSIONAL STRAIN ON SUPERCONDUCTING MATERIALS IS WELL KNOWN , BUT IN ORDER TO ACCOUNT FULLY FOR THEIR PERFORMANCE UNDER OPERATING CONDITIONS THE THREE-DIMENSIONAL STRAIN STATE MUST BE CONSIDERED . WE PRESENT A STUDY OF THE EFFECTS OF HYDROSTATIC PRESSURE ON NBTI TECHNOLOGICAL WIRES. A PROCESS OF WIRE DRAWING AND CHEMICAL WET ETCHING IS USED TO PRODUCE SAMPLES WITH VERY LOW CROSS-SECTIONAL AREAS AND CRITICAL CURRENTS. THIS ALLOWS US TO PERFORM CRITICAL CURRENT MEASUREMENTS ON THE NBTI WIRE INSIDE A CUBE HIGH-PRESSURE CELL, USING A HELIUM PRESSURE MEDIUM UP TO 1 GPA, WITHOUT THE NEED TO INTRODUCE LARGE CURRENTS. THE MEASUREMENTS ARE PERFORMED AT 4.2 K IN A HORIZONTAL SPLIT-PAIR MAGNET (IN A TRANSVERSE MAGNETIC FIELD) AT FIELDS UP TO 15 T. THE $J_C(B,4.2K,\Theta)$ DATA ACQUIRED IN THIS EXPERIMENT ARE COMPARED WITH KNOWN CRITICAL CURRENT SCALING LAWS FOR UNIAXIAL STRAIN .

WE ACKNOWLEGE THE SUPPORT OF EPSRC

3MP2A-10

SYNTHESIS AND CHARACTERISTICS OF MGB_2 BULKS WITH DIFFERENT DENSITIES ***R. ZENG****;* UNIVERSITY OF WOLLONGONG. — DIFFERENT DENSITIES PURE MGB_2 BULKS ARE SYNTHESIZED BY THE DEVELOPED DIRECT MG-DIFFUSION METHOD, THE PRESSED BORON BULKS ARE SEPARATELY PACKED IN SEALED IRON TUBES WITH FILLED MAGNESIUM POWDER. IT IS FOUND THAT THE CONNECTIVITY SIGNIFICANTLY IMPROVED SINCE THE EFFECTIVE AREA (A_F) FROM 0.2 (CONVENTIONAL IN-SITU) TO 0.42 (DIFFUSION), HENCE THE SELF-FIELD CRITICAL CURRENT DENSITY, JC, IS SIGNIFICANTLY IMPROVED COMPARING WITH CONVENTIONAL POROUS MGB_2 BULKS MADE BY IN-SITU METHOD. A SAMPLE REACTED AT 850 °C FOR 10 HRS EXHIBITED J_C OF 1.2 MA/CM^2 AT 20 K IN SELF-FIELD.

3MP2B-01

ON THE STUDY OF THE MATCHING FIELDS IN PATTERNED YBCO THIN FILM ***A. K. GHOSH***[1]*, E. HOLLMANN*[2]*, R. WORDENWEBER*[2]*;* [1]DEPARTMENT OF PHYSICS, JADAVPUR UNIVERSITY, KOLKATA 700032, INDIA, [2]INSTITUTE FOR BIO AND NANOSYSTEM II, FORSCHUNSZENTRUM JULICH, 52425 JUILCH, GERMANY. — THE CRITICAL CURRENT AROUND THE MATCHING FIELD EXHIBITS NOVEL VARIATION IN PRESENCE ORDERED MICROHOLES. SUPERCONDUCTING YBCO THIN FILMS HAVE BEEN PREPARED MAINLY BY THE PULSED LASER DEPOSITION (PLD) TECHNIQUE. THE 60 NM THICK FILMS HAVE BEEN PATTERNED BY ANTIDOT LATTICES. THE OPTICAL LITHOGRAPHY TECHNIQUE HAS BEEN USED TO GET THE REQUIRED PATTERNS. WE HAVE STUDIED THE VARIATION OF THE CRITICAL CURRENT WITH MAGNETIC FIELD IN YBCO FILM WITH A KAGOME TYPE OF ANTIDOT LATTICE. THE LONGITUDINAL CRITICAL CURRENT EXHIBITS JUMPS WHICH ARE FOUND TO BE ASYMMETRICALLY POSITIONED IN MAGNETIC FIELD. AROUND THE ZERO FIELD LIMIT THE CRITICAL CURRENT REMAINS INDEPENDENT OF MAGNETIC FIELD. IN ANOTHER PATTERN HAVING TWO ROWS OF ANTIDOTS WE HAVE STUDIED THE HALL VOLTAGE CLOSE TO THE MATCHING FIELD. NOVEL VARIATION IN THE CRITICAL CURRENT HAS BEEN OBSERVED. THE COMPETITION BETWEEN THE ANHARMONIC HALL EFFECT AND GUIDANCE OF VORTICES INDUCES NOVEL FEATURES IN HALL VOLTAGE AND CRITICAL CURRENTS. THE IMPACT OF THE DC CURRENT AND RF-SUPERPOSITION IN CONTROLLING THE VORTEX MOTION IN PATTERNED FILM WILL BE DISCUSSED.

AKG WOULD LIKE TO ACKNOWLEDGE CSIR. INDIA AND EUROPEAN SCIENCE FOUNDATION (ESF) FOR AN AWARD TO PURSUE RESEARCH IN GERMANY.

3MP2B-02

NEUTRON IRRADIATION EFFECTS OF HIGH TEMPERATURE SUPERCONDUCTORS ***T. AOKI***[1]*, H. UEDA*[1]*, A. ISHIYAMA*[1]*, N. MIYAHARA*[2]*, N. KASHIMA*[3]*, S. NAGAYA*[3]*;* [1]WASEDA UNIVERSITY, [2]NATIONAL INSTITUTE OF RADIOLOGICAL SCIENCES, [3]CHUBU ELECTRIC POWER COMPANY. — IN RECENT YEARS, THE QUALITY OF HIGH TEMPERATURE SUPERCONDUCTORS (HTSS) IS IMPROVING RAPIDLY. WE ARE CARRYING OUT A FEASIBILITY STUDY ON APPLICATION OF HTS COIL TO MEDICAL ACCELERATOR SYSTEM FOR PARTICLE CANCER THERAPY. IN THIS APPLICATION, HTSS ARE EXPOSED TO RADIATION. AS A RESULT, HTS CONDUCTORS BECOME RADIOACTIVE MAKING THE OPERATION AND MAINTENANCE OF THE REACTORS OR ACCELERATORS DIFFICULT; THIS ALSO LEADS TO AN INCREASE IN THE AMOUNT OF NUCLEAR WASTE GENERATED. FURTHERMORE, THE SUPERCONDUCTING PROPERTIES MIGHT BE AFFECTED TO RADIATION. THEREFORE, IT IS NECESSARY TO INVESTIGATE THE RADIATION EFFECTS OF HTSS. IN THIS STUDY, WE CARRIED OUT THE EXPERIMENTS OF THE 14-MEV NEUTRON IRRADIATION OF 77-KGY TO YBCO AND BI2223 TAPES AT ROOM TEMPERATURE. AND WE MADE RADIOACTIVE ANALYSES ON HTS TAPES AND MEASURED THE I-V CURVES IN A LIQUID NITROGEN (LN_2) BATH BEFORE AND AFTER THE IRRADIATION. WE ALSO INVESTIGATED THE I-V CURVES OF HTS TAPES SUBJECTED TO BENDING STRAIN.

THIS RESEARCH WAS SUPPORTED BY THE MINISTRY OF EDUCATION, SCIENCE, SPORTS AND CULTURE, GRANT-IN-AID FOR SCIENTIFIC RESEARCH (B), 20360130, 2008.

3MP2B-03

ENHANCEMENT OF INTRAGRAIN CRITICAL CURRENT DENSITY IN BI-BASED SUPERCONDUCTOR BY SELF-ASSEMBLED TWO-DIMENSIONAL NANOPLANE DEFECTS ***H. TANAKA***[1]*, H. YOSHIKAWA*[2]*, C. TSURUTA*[2]*, Y. MATSUI*[2]*, S. KISHIDA*[3]*;* [1]YONAGO NATIONAL COLLEGE OF TECHNOLOGY, [2]NATIONAL INSTITUTE FOR MATERIALS SCIENCE, [3]TOTTORI UNIVERSITY. — WE GREW BI-BASED SUPERCONDUCTING WHISKERS WITH VARIOUS SUBSTITUTION RATIOS OF CA^{2+} IONS FOR SR^{2+} SITES (:CA/SR SUBSTITUTION RATIOS) BY AN AL_2O_3-SEEDED GLASSY QUENCHED PLATELET METHOD. WE FOUND THAT THE CRITICAL CURRENT DENSITY (J_C) OF THE BI-BASED SUPERCONDUCTING WHISKERS IS WIDELY CONTROLLABLE BY JUST CHANGING CA/SR SUBSTITUTION RATIOS. THE J_C INCREASES BY A FACTOR OF 200. THE BI-BASED SUPERCONDUCTING WHISKER WITH THE CA/SR SUBSTITUTION RATIO OF ABOUT 25 % SHOWS A HIGH J_C OF $2\times10^5 A/CM^2$ AT 40 K IN SELF-FIELD. FROM THE ANALYSIS BY X-RAY PHOTOEMISSION SPECTROSCOPY USING SYNCHROTRON RADIATION AND HIGH-RESOLUTION TRANSMISSION ELECTRON MICROSCOPY, WE FOUND THAT THE WHISKER HAS A STRONG PINNING CENTER. THE PINNING CENTER CONSISTS OF A STRUCTURAL DISTORTED TWO-DIMENSIONAL NANOPLANE DEFECT WHICH IS INTRODUCED BY CONTROLLING A STRAIN IN A SR-O LAYER.

3MP2B-04

ENHANCED FLUX PINNING IN YBCO THIN FILMS USING NB-BASED DOUBLE PEROVSKITE ***G. ERCOLANO****, M. BIANCHETTI, J. MACMANUS-DRISCOLL;* UNIVERSITY OF CAMBRIDGE. — THE WORK DESCRIBES THE SIMULTANEOUS INCORPORATION OF ADDITIONAL RANDOM AND CORRELATED DEFECTS, REALIZED WITH THE INTRODUCTION OF NOVEL NANO-SCALED SECOND PHASE PARTICLES IN YBCO FILMS. BOTH PURE YBCO AND YBCO COMPOSITE THIN FILM WERE DEPOSITED BY PULSED LASER DEPOSITION ABLATING A SINGLE TARGET, FILMS PRODUCED WERE CHARACTERIZED ADOPTING ADVANCED INVESTIGATION TECHNIQUES.THE ADDITION OF A NB-BASED DOUBLE PEROVSKITE PINNING PHASE TO YBCO THIN FILMS IS REPORTED. THE DOUBLE PEROVSKITE PHASE SELF-ASSEMBLES INTO STACKS OF ~10 NM SECOND PHASE PARTICLES, ALIGNED WITH THE C-AXIS OF THE YBCO. THE COMPOSITE THIN FILMS HAVE ENHANCED CRITICAL CURRENT BY A FACTOR OF 2 AT 1T (H||C) OVER THE PURE YBCO, WHILST MAINTAINING A HIGH TRANSITION TEMPERATURE. THE EFFECT OF THE PROCESSING PARAMETERS ON THE SUPERCONDUCTING PROPERTIES IS INVESTIGATED.

THIS WORK CARRIED OUT AT CAMBRIDGE UNIVERSITY IS PART OF NESPA, NANO-ENGINEERED SUPERCONDUCTORS FOR POWER APPLICATION, A FRAMEWORK OF THE MARIE CURIE

RESEARCH TRAINING NETWORK, FUNDED WITHIN THE EU'S 6° FRAMEWORK PROGRAM.

3MP2B-05

IN-FIELD CURRENT TRANSPORT PROPERTIES OF 600A-CLASS $GDBA_2CU_3O_{7-\Delta}$ COATED CONDUCTOR UTILIZING IBAD-MGO TEMPLATE ***M. INOUE***[1], *R. MIYOSHI*[1], *R. FUGER*[1], *K. HIGASHIKAWA*[1], *T. KISS*[1], *S. AWAJI*[2], *M. NAMBA*[2], *K. WATANABE*[2], *Y. IIJIMA*[3], *T. SAITOH*[3], *T. IZUMI*[4]; [1]KYUSHU UNIVERSITY, [2]TOHOKU UNIVERSITY, [3]FUJIKURA LTD., [4]SUPERCONDUCTIVITY RESEARCH LABORATORY, ISTEC. — WE HAVE INVESTIGATED CRITICAL CURRENT (I_C) PROPERTIES OF 600 A/CM-CLASS $GDBA_2CU_3O_{7-\Delta}$ (GDBCO) COATED CONDUCTOR (CC) DEPOSITED ON IBAD-MGO TEMPLATE. 2.5 MM THICK GDBCO LAYER HAS BEEN OBTAINED BY PULSE LASER DEPOSITION WITHOUT DEGRADATION OF CRITICAL CURRENT DENSITY BY AN IMPROVED HEATING CONDITION IN REEL-TO-REEL DEPOSITION PROCESS. THIS ENABLES STABLE PRODUCTION OF 600 A/CM-W OF I_C (77 K, SELF-FIELD) IN 200 M LONG WIRES. WE HAVE CARRIED OUT DETAILED MEASUREMENTS ON CURRENT VS. VOLTAGE CHARACTERISTIC OF THESE SAMPLES BY THE FOUR-PROBE TRANSPORT METHOD AS A FUNCTION OF TEMPERATURE (T), MAGNETIC FIELD (B) AND FIELD ANGLE (Θ) OVER WIDE RANGE OF BIAS CONDITIONS: T=20 TO 83 K, B=S.F. TO 27 T, Θ =-20 TO 110 DEG. THESE RESULTS ARE USEFUL AS A FUNDAMENTAL DATA FOR DESIGN OF SUPERCONDUCTING DEVICES SUCH AS COIL WINDING AND MAGNET. IN-FIELD I_C OF THESE SAMPLE SHOWED PROMISING RESULTS; FOR EXAMPLE, 32 A/CM-W FOR 77 K, 3T, AND OVER 200 A/CM-W FOR 20 K, 25T. WE WILL ALSO DISCUSS THE PINNING PROPERTY BASED ON THE ANALYSIS WITHIN THE FRAMEWORK OF PERCOLATION MODEL.

THIS STUDY WAS SUPPORTED IN PART BY "NEDO AS THE PROJECT FOR DEVELOPMENT OF MATERIALS & POWER APPLICATION OF COATED CONDUCTORS: M-PACC" AND ALSO BY "JSPS: KAKENHI (20360143)".

3MP2B-07

FIELD ANGLE DEPENDENCE OF CRITICAL CURRENT DENSITY IN YGDBCO COATED CONDUCTORS ***M. KIUCHI***[1], *Y. TAKAHASHI*[1], *T. KOIDA*[1], *E. S. OTABE*[1], *T. MATSUSHITA*[1], *M. MIURA*[2], *T. IZUMI*[2], *Y. SHIOHARA*[2], *T. KATO*[3]; [1]KYUSHU INSTITUTE OF TECHNOLOGY, [2]SUPERCONDUCTIVITY RESEARCH LABORATORY, ISTEC, [3]JAPAN FINE CERAMICS CENTER. — IMPROVEMENT OF CRITICAL CURRENT DENSITY J_C IN MAGNETIC FIELD IS DESIRED FOR REBCO COATED CONDUCTORS. ESPECIALLY, THE FIELD-ANGLE ANISOTROPY OF THE CRITICAL CURRENT DENSITY IS DESIRED TO BE REDUCED FOR APPLICATIONS TO SUPERCONDUCTING POWER DEVICES SUCH AS TRANSFORMERS AND SMES. IT IS KNOWN THAT J_C OF REBCO THIN FILMS MADE BY TFA-MOD METHOD IN MAGNETIC FIELD IS GREATLY IMPROVED BY INTRODUCTION OF NANOPARTICLES OF NON-SUPERCONDUCTING PHASE AS ARTIFICIAL PINNING CENTERS. IN ADDITION, THE FIELD ANGLE ANISOTROPY COULD ALSO BE REDUCED BY ISOTROPIC FLUX PINNING INTERACTIONS OF NANO-PARTICLES. HOWEVER, DETAILED REPORT ON THE MECHANISM OF FLUX PINNING WITH QUANTITATIVE INVESTIGATION IN SUCH COATED CONDUCTORS HAS NOT BEEN GIVEN. IN THIS STUDY, THE FIELD ANGLE DEPENDENCE OF THE CRITICAL CURRENT DENSITY IS MEASURED FOR TFA-MOD-PROCESSED YGDBCO COATED CONDUCTOR WITH SUPERCONDUCTING LAYER OF 0.5 MM THICK, AND THE RESULTS ARE THEORETICALLY ANALYZED TO CLARIFY THE FLUX PINNING MECHANISM.

THIS WORK IS SUPPORTED BY THE NEW ENERGY AND INDUSTRIAL TECHNOLOGY DEVELOPMENT ORGANIZATION (NEDO) THROUGH INTERNATIONAL SUPERCONDUCTIVITY TECHNOLOGY CENTER (ISTEC).

3MP2B-08

LOW-TEMPERATURE PINNING BEHAVIOUR OF MOD YBCO COATED CONDUCTORS ***N. M. STRICKLAND***, *E. F. TALANTSEV, J. A. XIA, N. J. LONG, C. HOFFMANN;* INDUSTRIAL RESEARCH LTD. — MUCH RESEARCH HAS BEEN PRODUCED OVER THE LAST FEW YEARS TO IMPROVE THE DISTRIBUTION OF FLUX PINNING CENTERS IN YBCO COATED CONDUCTORS. IN MANY CASES THE PRINCIPAL METRIC HAS BEEN J_C(B) AT 77K, BEING A CONVENIENT TEMPERATURE FOR ROUTINE MEASUREMENTS. HOWEVER IT IS CLEAR THAT THE MAJORITY OF APPLICATIONS REQUIRING IN-FIELD OPERATION WILL IN FACT HAVE OPERATING TEMPERATURES WELL BELOW THIS POINT. WE COMPARE J_C(B) FOR TEMPERATURES IN THE RANGE 20-77K FOR YBCO FILMS GROWN BY THE TFA-MOD METHOD THAT ARE EITHER NOMINALLY UNDOPED OR INCORPORATE DY_2O_3 OR $BAZRO_3$ NANOPARTICLES, AND RELATE THE PINNING BEHAVIOUR TO MICROSTRUCTURE AND NANOPARTICLE DISTRIBUTION.

3MP2B-09

EFFECT OF OXYGEN DEPLETION ON THE PINNING STRENGTH OF $YBA_2CU_3O_X$ THIN FILMS WITH NANO-INCLUSIONS ***E. CIMPOIASU***[1], *J. FELDMANN*[1], *T. HAUGAN*[2], *C. VARANASI*[3], *G. LEVIN*[2], *P. BARNES*[2]; [1]US NAVAL ACADEMY, ANNAPOLIS, MD, [2]AIR FORCE RESEARCH LABORATORY, WRIGHT-PATTERSON AFB, OH, [3]US ARMY RESEARCH OFFICE, RESEARCH TRIANGLE, NC. — APPLICATIONS OF $YBA_2CU_3O_X$(YBCO) COATED CONDUCTORS REQUIRE LARGE TRANSPORT CRITICAL CURRENT DENSITIES OVER A LARGE RANGE OF TEMPERATURES, MAGNETIC FIELD VALUES, AND MAGNETIC FIELD ORIENTATIONS. THE INCORPORATION OF NANOPARTICLES AND NANORODS HAS GENERALLY RESULTED IN A SUBSTANTIAL INCREASE OF THE CRITICAL CURRENT DENSITY, A DIRECT RESULT OF IMPROVED PINNING IN THE FILM, BUT THE FULL MECHANISM OF PRODUCING THIS INCREASE IS NOT COMPLETELY UNDERSTOOD. THIS REPORT ADDRESSES THE ORIGIN OF THE ENHANCED PINNING THROUGH COMPARATIVE RESISTIVE MEASUREMENTS IN THE MIXED STATE OF THIN FILMS OF YBCO, YBCO DOPED WITH Y_2O_3 NANOPARTICLES, AND YBCO DOPED WITH $BASNO_3$ NANORODS. IN ORDER TO STUDY THE PINNING EFFECT IN MORE DETAIL, ALL THREE KINDS OF SAMPLES HAVE BEEN ANNEALED IN AIR AT 420 DEG C TO CHANGE THE OXYGEN CONTENT. WE HAVE EXTRACTED AND COMPARED THE IRREVERSIBILITY LINES AND THE VORTEX

ACTIVATION ENERGIES FOR ALL SAMPLES, BEFORE AND AFTER ANNEALING. OUR RESULTS INDICATE THAT WHILE THE NANO-INCLUSIONS IN THE FULLY OXYGENATED SAMPLES IMPROVE THE PINNING STRENGTH OVER THAT IN THE PURE YBCO SAMPLE, THE PINNING ENHANCEMENT ESSENTIALLY VANISHES UPON OXYGEN DEPLETION. THIS IS TRUE FOR BOTH PINNING STRUCTURES, THE NANORODS AND NANOPARTICLES. *THIS WORK WAS PARTIALLY SUPPORTED BY AFOSR AND THE AFRL PROPULSION DIRECTORATE.*

3MP2C-01

MICROSTRUCTURE OF MGB_2 WIRES RESULTING BY THE INFILTRATION PROCESS ***L. SAGLIETTI**, A. FIGINI ALBISETTI, E. PERINI, G. GIUNCHI;* EDISON SPA. — THE SINTERING OF THE MGB_2 MATERIALS REQUIRES SPECIAL ATTENTION IN ORDER TO PROMOTE A GOOD GRAIN CONNECTIVITY. IN THE CASE OF THE WIRES PRODUCTION, WHERE APPLICATION OF PRESSURE DURING SINTERING IS PRACTICALLY UNREALISTIC, THE "EX-SITU" METHODS GIVE A LOWER CONNECTIVITY WITH RESPECT TO THE "IN SITU" METHODS. TO FURTHER IMPROVE THE "IN SITU" PROCESSING TECHNOLOGY OF THE WIRES WE APPLY THE MG LIQUID INFILTRATION FROM THE INNER PART OF THE WIRES TO THE SURROUNDING B POWDERS. WE HAVE DONE A DETAILED MICROSTRUCTURAL ANALYSIS OF THE RESULTING MGB_2 MATERIALS OF THESE WIRES BY SEM AND AFM ANALYSIS AS A FUNCTION OF DIFFERENT B POWDERS, OF THE PRESENCE OF DOPANTS AND OF DIFFERENT OPERATIVE CONDITIONS OF THE REACTION. IN PARTICULAR WE DISCUSS THE USE, AS STARTING PRECURSOR MATERIALS, OF MIXTURES OF MICROCRYSTALLINE B POWDERS WITH MGB_2 FINE POWDERS TO INCREASE THE WIRES FILL FACTOR.

3MP2C-02

COMPARISON ON EFFECTS OF B_4C, AL_2O_3 AND SIC DOPING ON THE PERFORMANCE OF MGB_2 CONDUCTORS ***J. VILJAMAA**[1], P. KOVÁČ[1], M. KULICH[1], T. MELIŠEK[1], M. REISSNER[2];* [1]INSTITUTE OF ELECTRICAL ENGINEERING, SLOVAK ACADEMY OF SCIENCES, [2]INSTITUTE OF APPLIED AND TECHNICAL PHYSICS, VIENNA UNIVERSITY OF TECHNOLOGY. — MGB_2 MONOFILAMENTARY SAMPLES WERE PREPARED TO EVALUATE THE EFFECT OF DOPING THE COMPOUNDS B_4C, AL_2O_3 AND SIC HAVE ON J_C AND THE J_C DEPENDENCY OF B OF THE SAMPLE. ALL THE SAMPLES IN THIS STUDY HAD NB SHEATHS AND WERE MANUFACTURED USING *IN SITU* PRECURSOR POWDERS AND THE POWDER-IN-TUBE FABRICATION METHOD. THE AMOUNTS OF ADDED IMPURITIES WERE 10 WT.% FOR B_4C AND AL_2O_3, AND 3, 10 AND 20 WT.% FOR SIC. A REFERENCE SAMPLE WITHOUT ANY DOPING WAS ALSO PREPARED. ALL THE SAMPLES WERE HEAT TREATED BETWEEN 650 AND 800 °C FOR 30 MINUTES. THE TRANSPORT $J_C(B)$ CHARACTERISTICS WERE MEASURED AT 4.2 K AND THE MAGNETIC $J_C(B)$ BEHAVIOR WAS OBTAINED IN VARIED TEMPERATURES UP TO 25 K. THE CHANGES IN CONNECTIVITY, OR EFFECTIVE CROSS-SECTION, WERE ALSO EVALUATED BY PERFORMING RESISTIVITY MEASUREMENTS ON THE SAMPLES AFTER REMOVAL OF THE SHEATH. FURTHERMORE, THE PINNING FORCES OF THE SAMPLES WERE EVALUATED FROM THE MAGNETIC MEASUREMENTS.

THIS WORK WAS SUPPORTED BY THE EU FP6 CONTRACT MRTN-CT-2006-035619 AND THE SLOVAK RESEARCH AND DEVELOPMENT AGENCY PROJECT APVV-0398-07.

3MP2C-03

CHEMICAL STABILITY OF EX SITU MGB2 POWDER IN TUBE CONDUCTORS ***A. KARIO**[1], R. NAST[2], W. HÄßLER[1], C. RODIG[1], M. SCHUBERT[1], B. RINGSDORF[2], S. I. SCHLACHTER[2], W. GOLDACKER[2], M. HERRMANN[1], B. HOLZAPFEL[1], L. SCHULTZ[1];* [1]INSTITUTE FOR METALLIC MATERIALS, IFW DRESDEN, [2]KARLSRUHE INSTITUTE OF TECHNOLOGY, INSTITUTE FOR TECHNICAL PHYSICS. — DECOMPOSITION OF MGB2 IN POWDER IN TUBE CONDUCTORS WAS OBSERVED EVEN BELOW THE TEMPERATURE OF 1550°C REPORTED IN LITERATURE, WHICH IS QUITE CRUCIAL FOR THE SINTERING PROCESS USUALLY MADE IN A TEMPERATURE RANGE 900°C - 950°C. DUE TO THE CRUCIAL IMPORTANCE OF THAT DECOMPOSITION, WHICH HAS STRONG INFLUENCE ON THE SUPERCONDUCTING PROPERTIES OF THE FINAL CONDUCTOR, RE-EXAMINATION OF THE DECOMPOSITION TEMPERATURE IN DIFFERENT CONDUCTORS WITH DIFFERENT SHEATH MATERIAL WAS DONE.TWO TYPES OF PRECURSOR POWDER WERE INVESTIGATED: ALFA AESAR MGB2 AS RECEIVED, AND EX SITU POWDER DIRECTLY PREPARED FROM MG AND B ELEMENTAL POWDERS IN OWN LAB. THOSE POWDERS WERE USED TO PRODUCE CONDUCTORS WITH NB/CUNI, NB/MONEL AND TI/MONEL SHEATH MATERIALS IN DIFFERENT GEOMETRY (TAPE, WIRE, SQUARE WIRE). DIFFERENT TIME-TEMPERATURE HEAT TREATMENT CONDITIONS WERE APPLIED TO ANALYSE THE DECOMPOSITION. AFTER X-RAY DIFFRACTION MEASUREMENTS, PHASE ANALYSIS WAS CARRIED OUT ON EXTRACTED AND POWDERED SAMPLE CORES BY RIETVELD ANALYSIS. DIFFERENTIAL SCANNING CALORIMETRY WAS APPLIED TO MEASURE TEMPERATURE DEPENDENT REACTION KINETICS AND REVERSIBILITY OF REACTION. THE INFLUENCE OF DECOMPOSITION REACTION ON CRITICAL FIELDS (UP TO 9T) AND CRITICAL CURRENT DENSITY VS. FIELD (TRANSPORT MEASUREMENTS IN LHE) WAS ANALYSED.

3MP2C-04

IMPROVED CRITICAL CURRENT DENSITIES IN EX-SITU PROCESSED MGB_2 TAPES SHEATHED WITH VARIOUS METALS USING POWDERS TREATED IN ORGANIC ACID SOLUTIONS ***H. FUJII**, K. OZAWA, H. KUMAKURA;* NIMS. — MGB_2 TAPES ARE MAINLY FABRICATED BY THE POWDER-IN-TUBE (PIT) TECHNIQUE. WE HAVE ALREADY REPORTED THAT THE USE OF MGB_2 POWDER TREATED IN ORGANIC ACID SOLUTIONS IMPROVES THE J_C PROPERTY OF EX-SITU PROCESSED FE-SHEATHED TAPES IN THE HIGH-FIELD REGION. THIS IS MAINLY DUE TO THE SLIGHT CARBON SUBSTITUTION FROM THE SOLVENT. MICROSTRUCTURAL OBSERVATION OF THE FE-SHEATHED TAPE SAMPLES REVEALED THAT THE REACTION BETWEEN FE AND MGB_2 OCCURS. XRD ANALYSES INDICATED THAT FE_XB IS FORMED AT THE INTERFACE REGION. SUCH REACTION MUST SUPPRESS THE J_C ENHANCEMENT DUE TO THE DECREASE OF THE VOLUME FRACTION OF SUPERCONDUCTING PHASE AND WEAK GRAIN COUPLING. ON

THE OTHER HAND, THE USE OF TA-SHEATH IS EFFECTIVE IN AVOIDING THIS REACTION. MICROSTRUCTURAL OBSERVATION AND XRD ANALYSES REVEALED THAT NO REACTION LAYER IS OBSERVED AT THE INTERFACE FOR THE TA-SHEATHED TAPES. THEREFORE, FURTHER J_C ENHANCEMENT IS EXPECTED WHEN USING THE TA-SHEATH. THE J_C PROPERTY OF THE TAPES SHEATHED WITH TA AND OTHER METALS WILL BE REPORTED.

3MP2C-05

MICROSTRUCTURE IN HIGH-DENSITY MGB_2 WIRES PREPARED BY AN INTERNAL MG DIFFUSION METHOD ***Y. SHIMADA***[1]*, Y. KUBOTA*[1]*, S. HATA*[1]*, K. IKEDA*[1]*, H. NAKASHIMA*[1]*, A. MATSUMOTO*[2]*, K. TOGANO*[2]*, J. HUR*[2]*, H. KUMAKURA*[2]*;* [1]KYUSHU UNIVERSITY, [2]NATIONAL INSTITUTE FOR MATERIALS SCIENCE. — RECENTLY, REACTION-INDUCED DIFFUSION PROCESSES TO FABRICATE HIGH-DENSITY MGB_2 MATERIALS ARE DEVELOPED, AND CRITICAL CURRENT DENSITY (J_C) HAS BEEN NOTABLY ENHANCED. IN THIS STUDY, MICROSTRUCTURE IN HIGH-DENSITY MGB_2 WIRES FABRICATED BY AN INTERNAL MG DIFFUSION (IMD) PROCESS HAS BEEN INVESTIGATED.MG ROD WAS INSERTED IN TA TUBE, AND B AND SIC POWDERS WERE COMPRESSED IN THE SPACE BETWEEN THE INNER WALL OF TA TUBE AND THE MG ROD. MG ATOMS WERE INFILTRATED TOWARD B AND SIC POWDERS DURING HEAT TREATMENT AT 640°C FOR 1 H IN AN AR ATMOSPHERE. FOIL SPECIMENS FOR TRANSMISSION ELECTRON MICROSCOPY OBSERVATION WERE PREPARED WITH A FOCUSED ION BEAM MILL.THE INNER REACTED REGION OF THE WIRE SHOWS DENSE POLYCRYSTALLINE MGB_2 OF 20-200 NM IN GRAIN SIZES. FINE MGO AND MG_2SI PARTICLES OF 10-30 NM IN SIZES ARE DISPERSED IN THIS REGION. ON THE OTHER HAND, THE OUTER REGION NEAR THE TA SHEATH IS COMPOSED OF UNREACTED B AND SIC POWDERS, FINE MGO PARTICLES AND MANY SMALL VOIDS. THE RESULTS INDICATE THAT OXIDATION OF MG IN THE IMD PROCESS FORMS FINE DISPERSION OF MGO WHICH MAY BE EFFECTIVE FOR FLUX PINNING.

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3MP2C-06

PINNING AND CONNECTIVITY MGB2 THIN FILMS AND PIT STRANDS ***M. A. SUSNER****, M. D. SUMPTION, E. W. COLLINGS;* THE OHIO STATE UNIVERSITY. — MGB2 THIN FILMS WERE FABRICATED UTILIZING PULSED LASER DEPOSITION (PLD). MAGNETIZATION MEASUREMENTS WERE USED TO DETERMINE CRITICAL CURRENT DENSITIES VIA THE BEAN MODEL. THESE RESULTS WERE CONVERTED TO PINNING FORCE CURVES OVER THE ENTIRE B AND T SPACE. GRAIN SIZES WERE OBTAINED VIA ELECTRON MICROSCOPY (HR-SEM AND TEM) TO OBTAIN THE EFFICIENCY OF GRAIN BOUNDARY PINNING AND THE PROPORTIONALITY BETWEEN THE PINNING FORCE DENSITY (FP) AND INVERSE GRAIN SIZE. MAGNETIC BASED FP MEASUREMENTS WERE THEN MADE ON POWDER-IN-TUBE-PROCESSED (PIT) STRANDS, FOLLOWED BY ELECTRON OPTICS BASED STUDIES TO DETERMINE THE GRAIN SIZE. THE FUNCTIONAL FORM OF THE FP(B) CURVES WERE COMPARED FOR STRANDS AND FILMS. RESITIVITY MEASUREMENTS OF FILMS AND WIRES WERE PERFORMED TO EXTRACT THE INFLUENCE OF CONNECTIVITY ON THE FP(B) CURVES, AND TO ALLOW A MORE DIRECT COMPARISON BETWEEN THE FUNCTIONAL DEPENDENCE OF FP ON B AND T FOR FILMS AND PIT STRANDS.

3MP2C-07

EFFECT OF GRAIN SIZE ON THE PROPERTIES OF MGB_2 WIRES DOPED WITH CARBON ***H. FANG****, B. WIGGINS, T. NEELEY, J. HILL, G. LIANG;* SAM HOUSTON STATE UNIVERSITY. — CONSTITUENT MGB_2 GRAIN SIZE HAS STRONG EFFECT ON THE PROPERTIES OF MGB_2 BULKS AND WIRES. IN THIS RESEARCH, WE QUANTITATIVELY STUDY THE EFFECT OF GRAIN SIZE ON TI-SHEATHED MGB_2 WIRES DOPED WITH NANOSIZED CARBON. PRECURSOR POWDERS WITH DIFFERENT PARTICLE SIZE ARE PREPARED BY USING HIGH-ENERGY BALL MILLING. MGB_2 WIRES WITH DIFFERENT CONSTITUENT GRAIN SIZE ARE PREPARED BY USING DIFFERENT SIZED PRECURSOR POWDER AND TEMPERATURE PROGRAMMED HEAT TREATMENT. PARTICLE SIZE, GRAIN SIZE AND PHASE ARE CHARACTERIZED BY USING X-RAY DIFFRACTION, SEM AND EDS. CRITICAL TEMPERATURE IS MEASURED BY USING FOUR-PROBE METHOD IN THE TEMPERATURE RANGE FROM 300K TO 10K. CRITICAL CURRENT DENSITY IS MEASURED BY A SQUID. THE QUANTITATIVE RELATIONSHIP BETWEEN THE PROPERTIES OF MGB_2 WIRES AND CONSTITUENT GRAIN SIZE WILL BE ANALYZED AND PRESENTED.

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3MP2C-08

IN-FIELD CRITICAL CURRENT DENSITY OF MGB_2 WIRES DOPED WITH SIC AND RARE-EARTH OXIDE ***H. FANG****, B. WIGGINS, T. NEELEY, J. HILL, G. LIANG;* SAM HOUSTON STATE UNIVERSITY. — IT HAS BEEN DEMONSTRATED THAT THE CRITICAL CURRENT DENSITY OF MGB_2 IN THE PRESENCE OF MAGNETIC FIELD CAN BE DRAMATICALLY IMPROVED BY DOPING MGB_2 WITH CARBON, CARBON COMPOUND, AND RARE-EARTH OXIDES. HERE WE PRESENT A SYSTEMATIC STUDY ON TI-SHEATHED MGB_2 WIRE CO-DOPED WITH NANOSIZED SIC AND NANOSIZED RARE-EARTH OXIDE. PRECURSOR POWDERS ARE PREPARED BY USING HIGH-ENERGY BALL MILLING, AND MGB_2 WIRES ARE PREPARED BY THE POWDER-IN-TUBE (PIT) METHOD. GRAIN SIZE AND PHASE ARE CHARACTERIZED BY X-RAY DIFFRACTION AND SEM. CRITICAL CURRENT DENSITY IS MEASURED BY A SQUID. THE EFFECT OF DOPANT AMOUNT AND ANNEALING TEMPERATURE ON JC(B) WILL BE DISCUSSED AND PRESENTED

THIS RESEARCH IS SUPPORTED BY THE NSF GRANT NO. CHE-0718482, A GRANT FROM THE SHSU EGR PROGRAM, AND AN AWARD FROM RESEARCH CORPORATION.

3MP2C-09

EFFECTS OF THE SIZE OF THE DOPED SIC NANOPARTICLES ON THE CRITICAL CURRENT DENSITY OF THE TI-SHEATHED MGB_2 SUPERCONDUCTING WIRES ***G. LIANG****, H. FANG, S. KEITH, C. HOYT;* SAM HOUSTON STATE UNIVERSITY. — THE EFFECTS OF THE GRAIN SIZE OF THE DOPED SIC NANOPARTICLES ON THE MAGNETIC CRITICAL CURRENT DENSITY (J_C) OF THE TI-SHEATHED MGB_2 SUPERCONDUCTING WIRES WERE STUDIED. THE CONCENTRATION OF THE SIC DOPANT WAS 10% AND THE SIZES OF THE SIC PARTICLES WERE 20 NM, 45 NM, AND 123 NM. CONTRARY TO THE J_C RESULTS REPORTED ON THE SIC-DOPED FE-SHEATHED MGB_2 WIRES, WE FOUND THAT THE J_C FOR THE SIC-DOPED TI-SHEATHED MGB_2 WIRES DECREASES WITH THE PARTICLE SIZE OF THE SIC DOPANT. WE FOUND THAT ONLY FOR THE WIRES WITH 123 NM SIC SIZE, THE J_C IS GREATER THAN THAT OF THE UNDOPED MGB_2 WIRES. THIS UNUSUAL DEPENDENCE OF J_C ON THE SIZE OF THE SIC DOPANT IS DISCUSSED IN ASSOCIATION WITH THE RESULTS FROM THE MAGNETIZATION, ELECTRICAL RESISITIVITY, X-RAY DIFFRACTION AND SCANNING ELECTRON MICROSCOPY MEASUREMENTS.

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3MP2D-01

CABLING OPTIONS OF MGB2 FINE WIRES ***A. FIGINI ALBISETTI****[1], L. SAGLIETTI[1], G. RIPAMONTI[1], E. BASSANI[2], A. DI ZENOBIO[3], S. TURTÙ[3], A. DELLA CORTE[3], G. GIUNCHI[1];* [1]EDISON S.P.A., [2]CNR-IENI - LECCO, [3]ENEA - FRASCATI. — PROTOTYPES OF SUPERCONDUCTING MGB2 MULTIWIRES CABLES, TO BE USED FOR THE MANUFACTURING OF LARGE MAGNETS WITH A "REACT & WIND" PROCESS, HAVE BEEN PREPARED. THE ROUND WIRES PRECURSORS ARE ARRANGED WITH AN INTERNAL MG CORE TO OBTAIN THE SUPERCONDUCTING PHASE BY AN "IN SITU" REACTIVE MG LIQUID INFILTRATION PROCESS. THEY HAVE BEEN DRAWN TO SMALL DIAMETERS, OF THE ORDER OF HALF A MILLIMETRE, THEN THEY HAVE BEEN BRAIDED ACCORDING TO VARIOUS TRANSPOSITION GEOMETRIES TO REALIZE A PRECURSOR CABLE WITH MINIMIZED AC LOSSES. THIS PRECURSOR CABLE HAS BEEN THUS HEAT TREATED EITHER IN A BATCH WISE OR CONTINUOUSLY, IN A TUNNEL FURNACES, TO OBTAIN THE SUPERCONDUCTING PHASE. FINALLY, THE CABLE HAS BEEN THERMAL STABILIZED BY CLADDING IT WITH LOW MELTING METALS. THE MECHANICAL CHARACTERISTICS OF THE PRECURSOR CABLES, AT VARIOUS STAGES OF THE PROCESS, HAVE BEEN CHECKED. IN THIS PAPER, A CHARACTERIZATION OF THE SUPERCONDUCTING FEATURES AS WELL AS A MECHANICAL ANALYSIS OF THESE SAMPLES ARE REPORTED.

3MP2D-02

COMPARATIVE STUDY OF MGB_2 WIRES MADE FROM DIFFERENT BORON POWDERS ***J. KIM****[1], A. MATSUMOTO[2], S. CHOI[2], S. DOU[3], M. RINDFLESICH[4], M. TOMSIC[4], H. KUMAKURA[2];* [1]NATIONAL INSTITUTE FOR MATERIALS SCINECE, UNIVERSITY OF WOLLONGONG, [2]NATIONAL INSTITUTE FOR MATERIALS SCINECE, [3]UNIVERSITY OF WOLLONGONG, [4]HYPER TECH RESEARCH INCORPORATED. — WE EVALUATED THE EFFECTS OF DIFFERENT BORON (B) POWDERS, SUCH AS AMORPHOUS, CRYSTALLINE, AND CARBON COATED CRYSTALLINE BORON, ON THE CRITICAL CURRENT DENSITY (J_C) OF MGB_2 WIRES. WE FOUND THAT J_C OF THE WIRES MADE FROM THE AMORPHOUS B SHOWED THE BEST PERFORMANCE. THIS IS DUE TO UNSTABLE PHASE OF THE AMORPHOUS BORON, WHICH CAN CAUSE FULL REACTION BETWEEN STARTING MATERIALS EVEN AT LOW TEMPERATURE OF AROUND 600^{O}C. FROM TRANSMISSION ELECTRON MICROSCOPY (TEM) OBSERVATIONS, IT WAS CONFIRMED THAT THE CRYSTALLINE B POWDERS SUPPLIED BY DIFFERENT COMPANIES HAD A B-RHOMBOHEDRAL STRUCTURE AS A MAIN PHASE. THIS STRUCTURAL PHASE CAUSED POOR J_C IN THE MGB_2 CONDUCTORS. QUITE INTERESTINGLY, THESE POWDERS HAD NUMEROUS DEFECTS SUCH AS TWIN AND STACKING FAULT INSIDE POWDERS. ON THE OTHER HAND, USING CARBON COATED CRYSTALLINE BORON CAN ENHANCE THE J_C UNDER HIGH MAGNETIC FIELD. IN ADDITION, BALL-MILLING PROCESSING CAN INDUCE MORE DEFECTS INSIDE POWDER, WHICH CAN HELP TO PROMPT THE REACTIVITY BETWEEN STARTING MATERIALS. THESE STUDIES WILL PROVIDE A DEEPER INSIGHT FROM THE VIEWPOINT OF PRACTICAL APPLICATIONS.

THIS STUDY WAS SUPPORTED BY THE JAPAN SOCIETY FOR THE PROMOTION OF SCIENCE (JSPS) UNDER GRANT-IN-AID FOR JSPS FELLOWS AND NANOTECHNOLOGY NETWORK PROJECT OF THE MINISTRY OF EDUCATION, CULTURE, SPORTS, SCIENCE AND TECHNOLOGY (MEXT), JAPAN.

3MP2D-03

STUDY OF THE MGB_2 GRAIN SIZE ROLE IN EX-SITU MULTIFILAMENTARY WIRES WITH THIN FILAMENTS ***A. MALAGOLI****, V. BRACCINI, C. BERNINI, M. VIGNOLO, G. ROMANO, M. PUTTI, C. FERDEGHINI;* CNR-SPIN. — THE MGB_2 SUPERCONDUCTOR HAS ALREADY DEMONSTRATED ITS APPLICATIVE POTENTIAL, IN PARTICULAR FOR DC APPLICATIONS SUCH AS MRI MAGNETS, THANKS TO THE LOW COSTS OF THE RAW MATERIALS AND TO ITS SIMPLE PRODUCTION PROCESS. HOWEVER FURTHER EFFORTS HAVE STILL TO BE MADE IN ORDER TO BROADEN ITS EMPLOYMENT ALSO TOWARDS THE AC APPLICATIONS SUCH AS SFCL, MOTORS, TRANSFORMERS. THE MAIN ISSUES ARE RELATED TO THE REDUCTION OF THE AC LOSSES. SOME OF THESE CAN BE FACED BY OBTAINING MULTIFILAMENTARY CONDUCTORS WITH A LARGE NUMBER OF VERY FINE FILAMENTS AND, IN THIS CONTEXT, THE POWDERS GRANULOMETRY CAN PLAY A CRUCIAL ROLE.WE HAVE PREPARED MGB_2 STARTING POWDERS WITH DIFFERENT GRANULOMETRIES AND BY THE *EX-SITU* P.I.T METHOD WE HAVE REALIZED MULTIFILAMENTARY WIRES WITH A NUMBER OF FILAMENTS UP TO 361 AND AN AVERAGE SIZE OF EACH FILAMENT LOWERED DOWN TO 30 MM. IN PARTICULAR WE HAVE STUDIED THE RELATIONSHIP BETWEEN GRAIN AND FILAMENT SIZE IN TERMS OF TRANSPORT PROPERTIES AND SHOW THAT THE OPTIMIZATION OF THIS RATIO IS POSSIBLE IN ORDER TO

OBTAIN SUITABLE CONDUCTORS FOR AC INDUSTRIAL APPLICATIONS.

3MP2D-04

COMPARISON OF MGB2 WIRES PRODUCTION TECHNOLOGIES AND INFLUENCE OF DIFFERENT PRODUCTION CONDITIONS

O. TKACHENKO[1], *A. ZALESKI*[1], *A. J. MORAWSKI*[2], *T. CETNER*[2], *D. GAJDA*[3], *M. RINDFLEISCH*[4], *M. TOMSIC*[4], *M. CHUDY*[5], *M. EISTERER*[5], *H. WEBER*[5]; [1]INSTITUTE OF LOW TEMPERATURE AND STRUCTURE RESEARCH PAS, [2]INSTITUT OF HIGH PRESSURE PHYSICS PAS, [3]INTERNATIONAL LABORATORY OF HIGH MAGNETIC FIELDS AND LOW TEMPERATURE, [4]HYPERTECH RESEARCH, INC., [5]ATOMINSTITUTE, TU WIEN. — COMPARISON OF DIFFERENT PRODUCTION TECHNOLOGIES OF MGB2 SUPERCONDUCTING WIRES FOR TECHNICAL APPLICATION HAVE BEEN MADE, INFLUENCE OF DIFFEREN BARRIER TYPE TO THE ELECTRICAL PROPERTIES HAVE BEEN INVESTIGATED. SUCH MATERIALS AS CU, FE, GLIDCOP AND OTHER ALLOYS MATERIALS HAVE BEEN APPLIED AS OUTER SHEATH. DIFFERENT BARRIER MATERIALS SUCH AS NB, FE AND EX SITU MGB2 HAVE BEEN STUDIED, AS WELL AS DIFFERENT ADDITIONS SUCH AS SIC, NANO C, C4H6O3 TO IN SITU MGB2. MONOFILAMENT AND MULTIFILAMENT WIRES HAVE BEEN COMPARED. HIGH PRESSURE GAS TRAP SYSTEM (UP TO 1.5 GPA) HAVE BEEN APPLIED FOR WIRE PRODUCTION, INFLUENCE OF HIGH PRESSURES FOR DENSIFICATION OF MGB2 NANO POWDER IN WIRES BEFORE (COLD ISOSTATIC PRESSING) AND DURING (HOT ISOSTATIC PRESSING) HEATING PROCESS HAVE BEEN INVESTIGATED. SHORT PIECES AND COILS HAVE BEEN COMPARED IN MAGNETIC FIELDS UP TO 15 T, IN DIFFERENT TEMPERATURES UP TO 20 K. JC OVER 3 X 10 4 A/CM2 AT 4.2 K AND 14 T WAS MEASURED. INFLUENCE OF DIFFERENT PROCESSING CONDITIONS SUCH AS, TEMPERATURE, PRESSURE, TIME, BARRIER AND SHEATH MATERIAL, ADDITIONS HAVE BEEN INVESTIGATED FOR DIFFERENT WIRES WORKING CONDITIONS. CONCLUSIONS AND FUTURE PROGNOSIS FOR MGB2 SUPERCONDUCTING WIRES PRODUCTION TECHNOLOGIES HAVE BEEN MADE.

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3MP2D-05

JC ENHANCEMENT OF THE CU ADDITION MGB_2 MULTIFILAMENTARY WIRES SYNTHESIZED WITH LOW TEMPERATURE DIFFUSION PROCESS FOR FUSION APPLICATIONS

Y. HISHINUMA[1], *A. KIKUCHI*[2], *T. TAKEUCHI*[2], *S. YAMADA*[1], *A. SAGARA*[1]; [1]NATIONAL INSTITUTE FOR FUSION SCIENCE, [2]NATIONAL INSTITUTE FOR MATERIALS SCIENCE. — MGB_2 COMPOUND HAS A HIGHER T_C VALUE (39K) AND WILL BE CANDIATE MATERIALS UNDER HIGHER AMBIENT TEMPERATURE OPERATION AROUND 20 K. MGB_2 COMPOUND IS ALSO ONE OF THE "LOW ACTIVATION SUPERCONDUCTORS" BECAUSE THE DECAY TIME OF THE INDUCED RADIO-ACTIVITY ON THE MGB_2 SUPERCONDUCTORS IS MUCH SHORTER THAN THAT OF NB-BASED SUPERCONDUCTORS. HOWEVER, TRANSPORT CRITICAL CURRENT DENSITY (J_C) OF MGB_2 WIRE IS LOWER THAN NB-TI WIRE. SO, MGB_2 WIRE IS ALTERNATIVE MATERIAL OF NB-TI WIRE FOR D-T FUSION APPLICATION SUCH AS FEEDBACK COIL AND CURRENT FEEDER AROUND CORE PLASMA IF ITS J_C PROPERTY COULD BE IMPROVED. WE HAVE DEVELOPED THE "LOW TEMPERATURE DIFFUSION" OF THE MGB_2/TA/CU MULTIFILAMENTARY WIRE TO IMPROVE J_C PROPERTY UNDER BEYOND NB-TI WIRE. IN THE CASE OF THE FEEDBACK COIL AND CURRENT FEEDER AROUND D-T PLASMA, THE NUCLEAR HEAT GENERATION WILL BE CAUSED BY THE D-T NEUTRON IRRADIATION. THE HEAT LOAD WILL BE INCREASED BY THE NUCLEAR HEAT GENERATION, AND THE COOLANT TEMPERATURE WILL BE ELEVATED BY THE HEAT LOAD. THE TEMPERATURE MARGIN BETWEEN T_C VALUE AND OPERATION TEMPERATURE IS ONE OF THE IMPORTANT FACTORS TO SELECT SUPERCONDUCTING MATERIALS FOR FUSION APPLICATION. THEN, WE HAVE CARRIED OUT I_C-T-B MEASUREMENT. THE SAMPLES WERE COOLED BY HE GAS AND THE AMBIENT TEMPERATURE WAS CONTROLLED BY LIQUID HE AND EXTERNAL HEATER. FURTHERMORE, I_C DEGRADATION OF THE APPLYING BENDING STRAIN ON THE SAMPLES WAS ALSO INVESTIGATED.

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3MP2D-06

APPLICATIONS OF PRESSURE AND TEMPERATURE TREATMENT TO INCREASE CRITICAL CURRENT OF THE MGB2 WIRES AND TAPES AT HIGH MAGNETIC FIELDS

A. J. MORAWSKI[1], *T. CETNER*[1], *M. RINDFLEISCH*[2], *M. TOMSIC*[2], *A. ZALESKI*[3], *D. GAJDA*[4], *A. KARIO*[5], *O. TKACHENKO*[3]; [1]INSTITUT OF HIGH PRESSURE PHYSICS PAS, [2]HYPERTECH RESEARCH, INC., [3]INSTITUTE OF LOW TEMPERATURE AND STRUCTURE RESEARCH PAS, [4]INTERNATIONAL LABORATORY OF HIGH MAGNETIC FIELDS AND LOW TEMPERATURE, [5]LEIBNIZ INSTITUTE FOR SOLID STATE AND MATERIALS RESEARCH. — THE HIP (HOT ISOSTATIC PRESSING) PROCESSES HAVE BEEN APPLIED FOR DENSIFICATION OF THE INNER CORES OF IN SITU MGB2 SUPERCONDUCTORS IN VARIETY OF THE METAL BARRIERS APPLIED I.E. NB, FE AND EX SITU HOMO MGB2. THE PRESSURE UP TO 1.4 GPA AND TEMPERATURES FROM 600 TO 850 DEG. C HAVE BEEN APPLIED FOR HIP TREATMENT. ONE AND MULTIFILAMENT WIRES AND TAPES WERE INVESTIGATED. THE VARIOUS ADDITIVES HAVE BEEN USED: NC, NSIC AND C4H6O3 IN ORDER TO INCREASE AND COMPARE THE PINNING FORCES ESPECIALLY IN HIGHER MAGNETIC FIELDS APPLIED. THE HIP PROCESSES HAVE BEEN PERFORMED IN THE AR GAS MEDIUM OR/AND IN MIXED SALTS AT HIGH PRESSURE AS WELL AS BY HOT ROLLING OF THE CU OR CU COMPOSITE CLAD WIRES. THE NEW CONCEPT OF EASY HIGH PRESSURE TREATMENT FOR LARGE PRODUCTION OF LOW COSTS WIRES IS PROPOSED. THE AMELIORATE METHOD, IN WHICH VOLTAGE IS MEASURED DURING MAGNETIC FIELD RISE AT CONSTANT CURRENT APPLIED FOR SHORT SAMPLES JC MEASUREMENTS, IS PRESENTED. THE TC AND JC, PINNING FORCES PROPERTIES OF THE WIRES SAMPLES WERE MEASURED IN 4.2 K IN MAGNETIC FIELDS UP TO 16 T. THE DIFFERENCES OF THE STRUCTURE DEVELOPMENT ACCORDING TO THE P, T, T, Q CONDITIONS APPLIED WERE INVESTIGATED. THE HIGH PRESSURE DENSIFICATION AND GOOD GRAINS CONNECTIVITY DUE TO THE HP PROCESSES HAS VERY POSITIVE

EFFECT FOR JC INCREASING, ESPECIALLY IN HIGHER MAGNETIC FIELDS. JC OVER 3 X 10 4 A/CM2 AT 4.2 K AND 14 T WAS MEASURED. THIS IS GOOD PROGNOSTIC FOR ITS APPLICATION IN ITER COILS.

3MP2D-07

ENHANCEMENT OF THE CRITICAL CURRENT DENSITY IN MGB2 SUPERCONDUCTORS FABRICATED BY CUBIC ANVIL HOT PRESSING ***K. KISHIMOTO**, S. CHONO, O. MIURA;* TOKYO METROPLITAN UNIVERSITY. — ON THE CRITICAL CURRENT DENSITY IN MGB2 SUPERCONDUCTORS INCREASING THE CORE DENSITY IN SUPERCONDUCTING MGB2 TAPES IS VERY IMPORTANT FOR IMPROVEMENT OF THE CONNECTIVITY BETWEEN THE GRAINS. SO IN THIS PAPER, WE TRY TO INCREASE THE CORE DENSITY BY USING CUBIC ANVIL HOT PRESSING. IN THE EXPERIMENT, MGB2 SAMPLES WAS PREPARED BY THE POWDER-IN-TUBE (PIT) METHOD. MG POWDER (200MESH) AND B POWDER (300MESH) ARE USED. SUS316 TUBES OF 4MM INNER DIAMETER AND 6 MM OUTER DIAMETER WERE FILLED WITH MIXTURES OF MG POWDER AND B POWDER. FIRST, EACH SAMPLE WAS SEALED AND GROOVE-ROLLED INTO A ROD HAVING AN OUTER DIAMETER ABOUT 3.8 MM, AND FIRST-STAGE HEAT TREATMENT IN 750°C WAS CARRIED OUT. THEN THE RODS WERE FLAT-ROLLED INTO TAPES. SOME TAPES OF THEM WERE 1 M PASCAL ISOSTATIC PRESSED AND HEAT-TREATED FROM 750°C TO 900°C BY USING CUBIC ANVIL HOT PRESSING. FINALLY, WE MADE ELECTROMAGNETIC CHARACTERIZATION ON THE SAMPLES. MAGNETIZATION OF THEM WAS MEASURED BY FIELD-COOLED CONDITION IN A MAGNETIC FIELD OF FROM 0 T TO 1T IN 20K.CRITICAL CURRENT DENSITIES WERE ESTIMATED FROM THE MAGNETIZATION CURVES.

I HAVE HAD BENEFITED FROM PROF. SATO (TOKYO METROPOLITAN UNIVERSITY), WHO ALLOWED ME TO USE EXPERIMENT SYSTEM.

3MP2D-08

EFFECT OF THE POWDER STRAIN STATE ON THE MECHANICAL PROPERTIES OF MGB_2 TAPES ***M. MALACHEVSKY**[1], A. SERQUIS[1], G. SERRANO[1], J. MORALES ARIAS[1], G. GIUNCHI[2], E. PERINI[2];* [1]CENTRO ATOMICO BARILOCHE AND INSTITUTO BALSEIRO, 8400 BARILOCHE, ARGENTINA, [2]EDISON SPA, R&D DIVISION, 20121 MILAN, ITALY. — STARTING FROM COMMERCIAL 325 MESH MGB_2 POWDER, WE FURTHER REDUCED THE AGGLOMERATES BY ATTRITION MILLING IN NITROGEN ATMOSPHERE TO MINIMIZE OXIDATION. USING DIFFERENT MILLING MEDIA (TUNGSTEN CARBIDE, YTTRIA STABILIZED ZIRCONIUM OXIDE AND STAINLESS STEEL BALLS), WE STUDIED THE EVOLUTION OF THE STRAIN STATE AND CRYSTALLINITY OF THE POWDERS BY X-RAY DIFFRACTION. WE INVESTIGATED THE CHANGES IN THE SUPERCONDUCTING PROPERTIES WITH THE USE OF DIFFERENT MILLING MEDIA BY MEASURING THE MAGNETIC MOMENT AS A FUNCTION OF TEMPERATURE IN A SQUID MAGNETOMETER, AFTER ZERO FIELD COOLING. WE PREPARED STAINLESS STEEL SHEATHED SINGLE FILAMENT TAPES WITH THE OBTAINED POWDERS, AND HEAT TREATED THEM FOR 2.5 HOURS AT 850 C UNDER ARGON ATMOSPHERE. WE CHARACTERIZED THE SUPERCONDUCTING PROPERTIES BY DETERMINING THE MAGNETIC JC BY USING A SQUID MAGNETOMETER.THE MECHANICAL PROPERTIES OF THE TAPES WERE ANALYZED USING A 4-POINT BENDING MICRO-TESTS. SOME IN-SITU MONEL-SHEATHED HOLLOW WIRES AND TITANIUM-SHEATHED TAPES WERE MEASURED FOR COMPARATIVE PURPOSES. WE DISCUSS THE INFLUENCE OF DIFFERENT WIRE MANUFACTURING PROCEDURES AND OF THE METAL SHEATH ON THE STRESS-STRAIN CHARACTERISTICS OF THE TAPES.

3MP2E-01

PERFORMANCE CHARACTERIZATION OF RUSSIAN ITER NB_3SN STRANDS ***V. PANTSYRNYY**[1], A. VOROBYEVA[1], R. VASILYEV[1], N. KOZLENKOVA[1], A. NIJHUIS[2];* [1]BOCHVAR INSTITUTE OF INORGANIC MATERIALS (VNIINM), MOSCOW, RUSSIA, [2]UNIVERSITY OF TWENTE, ENSCHEDE, THE NETHERLANDS. — MAGNETIC FIELD, TEMPERATURE AND AXIAL STRAIN DEPENDENCIES OF CRITICAL CURRENT MUST BE DEFINED FOR ALL STRANDS INTENDED FOR THE PRODUCTION OF ITER TF WINDINGS. SUCH A CHARACTERIZATION WAS PERFORMED FOR THREE RUSSIAN BRONZE ROUTED STRANDS. THE DESIGN FEATURES OF THE STRANDS UNDER INVESTIGATION ARE GIVEN. THE MEASUREMENTS OF CRITICAL CURRENT WERE CARRIED OUT IN THE PACMAN FACILITY AT THE UNIVERSITY OF TWENTE OVER A RANGE OF MAGNETIC FIELD FROM 5 TO 14 T, TEMPERATURE FROM 4.2 TO 11.5 K AND APPLIED AXIAL STRAIN FROM -0.7 TO +0.7%. EXPERIMENTAL PROCEDURE AND DATA REDUCTION ARE DESCRIBED IN THE PAPER. ACHIEVED CRITICAL CURRENT DENSITY AT 4.2 K AND 12 T IS ON THE ORDER OF 800 A/MM^2. A STUDY ON IRREVERSIBILITY STRAIN LIMIT IS ALSO PERFORMED INDICATING THAT CRITICAL CURRENT DEGRADATION STARTS AT INTRINSIC STRAIN LEVEL ABOVE 0.5%. ALONG WITH CRITICAL CURRENT DATA DERIVED FROM VOLTAGE-CURRENT CURVES, A NUMBER OF VOLTAGE-TEMPERATURE CHARACTERISTICS WERE MEASURED AND USED FOR FURTHER ANALYSIS. THE DATA OBTAINED ALLOWS ONE TO MAKE CALCULATIONS OF ITER TF COIL PERFORMANCE AS WELL AS ANALYSIS OF SHORT CONDUCTOR SAMPLE TEST RESULTS.

3MP2E-02

3D MODEL OF NB_3SN WIRE AND STRAIN-BASED EXPLANATION OF THE SUPERCONDUCTING BEHAVIOR ***J. CHEN**, K. HAN;* NATIONAL HIGH MAGNETIC FIELD LABORATORY. — THE PERFORMANCE OF NB_3SN MULTIFILAMENT WIRES IS HIGHLY STRAIN-SENSITIVE. SINCE THE STRAIN IN EACH INDIVIDUAL NB_3SN FILAMENT DETERMINE THE SUPERCONDUCTING PROPERTIES, IT IS VERY IMPORTANT TO BUILD THE RELATION BETWEEN INTERNAL STRAIN (THE STRAIN IN EACH NB_3SN FILAMENT) AND APPLIED EXTERNAL LOAD. IN THIS STUDY, A 3D MODEL IS DEVELOPED TO ASSESS THE INTERNAL STRAIN. IT IS FOUND THAT THE CROSS-SECTION SHAPE OF THE FILAMENTS PLAYS A SIGNIFICANT ROLE IN THE STRESS/STRAIN STATE. BASED ON THE RESULTS OF THIS ANALYSIS, A INTERNAL-STRAIN-BASED EXPLANATION ON THE OBSERVED JC ~ STRAIN RELATION IS PROPOSED.

3MP2E-03

MICROSTRUCTURE AND MECHANICAL CHARACTERISTIC OF INDUSTRIAL TIN BRONZE FOR NB3SN SUPERCONDUCTING WIRES ***A. KIKUCHI***[1]*, H. TANIGUCHI*[2]*, Y. YOSHIDA*[1]*, S. SAEKI*[2]*, Y. MONJU*[2]*, Y. MIZUTA*[2]*, T. MIZUTA*[2]*;* [1]NATIONAL INSTITUTE FOR MATERIALS SCIENCE, [2]OSAKA ALLOYING WORKS CO. LTD.. — THE PRODUCTION OF CU-SN BRONZE FOR NB3SN SUPERCONDUCTING WIRE IS ONGOING AT OSAKA ALLOYING WORKS CO. LTD., JAPAN. THOSE ARE USED FOR RAW MATERIALS FOR THE PRACTICAL BRONZE PROCESSED NB3SN WIRES, WHICH IS THE DOMINANT HIGH FIELD CONDUCTORS FOR ITER AND NMR USES. THE MICROSTRUCTURE AND MECHANICAL PERFORMANCE DETAILS OF THE BRONZE ITSELF ARE VERY IMPORTANT FOR THE FABRICATION OF SUPERCONDUCTING COMPOSITE WIRES, AND WE INVESTIGATED THOSE OF INDUSTRIAL BRONZE HAVING 14, 15, 16WT%SN CONCENTRATIONS. TENSILE TESTS AT ROOM TEMPERATURE AS WELL AS ELEVATED TEMPERATURES UP TO 700 OC WERE PERFORMED. IN ADDITION, THE LIMIT OF CONTINUALLY COLD-DRAWABILITY AS A FUNCTION OF A FINAL INTERMEDIATE ANNEALING CONDITION WAS STUDIED. A COLD-DRAWABILITY EXCESSIVELY DEGRADED WITH A FINAL INTERMEDIATE ANNEALING OF 400 OC. WE FOUND THAT NUMEROUS FINE PRECIPITATES WERE APPEARED AT THE INTRA AND INTER ALPHA-GRAINS THOUGH A LOW TEMPERATURE ANNEALING. THE TRANSMISSION ELECTRON MICROSTRUCTURE ANALYSIS REVEALED THAT THOSE PRECIPITATES WERE THE DELTA PHASE (CU41SN11). IT MAY BE CONSIDERED THAT THEY BEHAVE AS A PINNING SITE OF THE SLIP MOTION FOR THE PLASTIC DEFORMATION.

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3MP2E-04

ELASTIC STRAIN AND CRITICAL CURRENT DEGRADATION UNDER TRANSVERSE COMPRESSION IN DIFFERENT NB_3SN STRAND TYPES *F. BUTA*[1]*, **C. SCHEUERLEIN***[2]*, M. DI MICHIEL*[3]*, B. SEEBER*[1]*, A. FERREIRA*[1]*, R. FLUKIGER*[1]*;* [1]UNIVERSITY OF GENEVA, GENEVA, SWITZERLAND, [2]EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH (CERN), GENEVA, SWITZERLAND, [3]EUROPEAN SYNCHROTRON RADIATION FACILITY (ESRF), GRENOBLE, FRANCE. — HIGH ENERGY AND HIGH RESOLUTION SYNCHROTRON X-RAY DIFFRACTION MEASUREMENTS AT 4.2 K WERE PERFORMED *IN-SITU* DURING THE TRANSVERSE COMPRESSION OF INDIVIDUAL, BARE (I.E. NOT IMPREGNATED) NB3SN WIRE SAMPLES. THREE TYPES OF STRANDS WERE STUDIED: POWDER IN TUBE (PIT), RESTACK ROD PROCESSED (RRP) INTERNAL SN AND BRONZE ROUTE. FOR THE RRP AND THE BRONZE ROUTE SAMPLES AT LOW STRESSES THE STRAIN SHOWS VERY LITTLE INCREASE WITH THE APPLIED STRESS UNTIL A CERTAIN THRESHOLD IS EXCEEDED, SUGGESTING THAT THE MATRIX MAY INITIALLY CUSHION THE FILAMENTS. UNDER THE EXTREME CONDITIONS OF THESE EXPERIMENTS ON INDIVIDUAL BARE WIRES, THE ELASTIC STRAIN IN THE NB_3SN FILAMENTS AT EQUIVALENT STRESSES ARE HIGHER IN THE PIT THAN IN THE RRP AND THE BRONZE ROUTE WIRES. THIS IS CONSISTENT WITH THE CRITICAL CURRENT MEASUREMENTS ON INDIVIDUAL BARE WIRES SHOWING STRONGER SENSITIVITY TO TRANSVERSE COMPRESSION FOR THE PIT STRANDS.

WE ACKNOWLEDGE THE EUROPEAN SYNCHROTRON RADIATION FACILITY (ESRF) FOR BEAM TIME ON THE ID15 BEAMLINE.

3MP2E-05

THREE-DIMENSIONAL STRAIN MODEL FOR VARIOUS KINDS OF NB3SN WIRES ***H. OGURO***[1]*, S. AWAJI*[2]*, K. WATANABE*[2]*, G. NISHIJIMA*[2]*, T. ISHIGAKI*[1]*;* [1]IBARAKI UNIVERSITY, [2]TOHOKU UNIVERSITY. — THREE-DIMENSIONAL STRAINS ARE NECESSARY TO UNDERSTAND THE STRAIN EFFECT OF SUPERCONDUCTING PROPERTIES FOR NB3SN WIRES. WE MADE THE THREE-DIMENSIONAL STRAIN MODEL BASED ON EXPERIMENTAL RESULTS OF BRONZE ROUTE NB3SN WIRES. WE DISCUSS WHETHER THIS MODEL CAN ESTIMATE OTHER KINDS OF NB3SN WIRES BY USING INTERNAL-TIN NB3SN WIRES OR NOT. THE RELATIONSHIP BETWEEN THREE-DIMENSIONAL STRAIN AND SUPERCONDUCTING PROPERTIES FOR INTERNAL-TIN WIRES WAS INVESTIGATED BY THE STRAIN DEPENDENCE OF BC2 AND RESIDUAL STRAINS MEASURED BY NEUTRON DIFFRACTION. IT WAS FOUND THAT THE THREE-DIMENSIONAL STRAIN MODEL CAN EXPLAIN EXPERIMENTAL RESULTS. THE SUPERCONDUCTING PROPERTIES FOR NB3SN WIRES ARE SUCCESSFULLY EXPLORED BY AXIAL AND LATERAL RESIDUAL STRAINS AND THE RATIO OF AXIAL AND LATERAL STRAINS (EFFECTIVE POISSON RATIO). THIS RESULT MEANS THAT ONLY THREE PARAMETERS CONTROL THE STRAIN EFFECT OF SUPERCONDUCTING PROPERTIES FOR VARIOUS KINDS OF NB3SN WIRES.

3MP2E-06

CRITICAL CURRENT PARAMETERIZATION OF NB_3SN STRAND FOR ITER TF MAGNETS ***S. PARK****, C. LEE, H. CHOI, W. PARK, S. OH, K. KIM;* NATIONAL FUSION RESEARCH INSTITUTE. — A FULL CHARACTERIZATION OF NB_3SN STRANDS IS REQUIRED AS PARTS OF THE MANUFACTURING PROCESS QUALIFICATION OF THE PROTOTYPE ITER TF CONDUCTOR. KOREAN DOMESTIC AGENCY (KODA) WHO IS RESPONSIBLE FOR PROCURING THE 20.18% OF ITER TF CONDUCTOR AND NB_3SN STRANDS FOR THE QUALIFICATION CONDUCTOR IS BEING PRODUCED BY ITS SUPPLIER KAT. KODA PERFORMED CRITICAL CURRENT MEASUREMENTS AS A FUNCTION OF TEMPERATURE, FIELD AND MECHANICAL STRAIN. THE STRAIN DEPENDENCE OF THE CRITICAL CURRENT IS MEASURED BY THE WALTER SPIRAL PROBE. RESULTS ARE ANALYZED WITH VARIOUS SCALING MODELS INCLUDING ITER ORGANIZATION'S OFFICIAL MODEL, AND THE SCALING MODEL BASED ON THE STRONG COUPLING THEORY.

3MP2E-08

FUNDAMENTAL EVALUATIONS OF TRANSVERSE LOAD EFFECTS OF NB3SN STRANDS USING FINITE ELEMENT ANALYSIS. ***T. WANG***[1]*, L. CHIESA*[1]*, M. TAKAYASU*[2]*;* [1]TUFTS UNIVERSITY, [2]MIT, PLASMA SCIENCE AND FUSION CENTER. — THE PERFORMANCES OF LARGE SUPERCONDUCTING CABLE-IN-CONDUIT CONDUCTORS (CICC) ARE AFFECTED BY VARIOUS MECHANICAL EFFECTS CAUSED BY THERMAL CONTRACTIONS DURING COOLDOWN AND THE INHERENT INTERACTION OF CURRENT AND FIELD DURING OPERATIONS. RECENT LARGE CICC CABLES AND MAGNETS SUCH AS ITER CONDUCTORS HAVE SHOWN SIGNIFICANT UNEXPECTED DEGRADATIONS. IN THIS PAPER THE TRANSVERSE LOAD EFFECT CAUSED BY THE LORENTZ LOAD IS STUDIED FOR A SINGLE STRAND AND A 3-STRAND CABLE, BASIC ELEMENTS OF A CICC. 2D FINITE ELEMENT MODELS OF NB3SN SINGLE STRAND AND 3-STRAND CABLE ARE DEVELOPED TO STUDY THE DEFORMATION AND CONTACT PRESSURE OF INDIVIDUAL STRAND UNDER EXTERNAL TRANSVERSE LOADS. THE STRAIN AND STRESS DISTRIBUTIONS OF EACH STRAND INSIDE A TRIPLET ARE INVESTIGATED CONSIDERING THE DIFFERENT POSITIONS OF A STRAND IN A TRIPLET TO SIMULATE A TWISTED CABLE. THE NUMERICAL RESULTS, COMBINED WITH THE SINGLE-STRAND EXPERIMENTAL RESULTS AND THEORY OF CONTACT MECHANICS, ARE APPLIED TO ESTIMATE THE PERFORMANCE OF A TWISTED 3-STRAND CABLE. THE BEHAVIOR OF THE 3-STRAND CONFIGURATION OBTAINED USING FINITE ELEMENT ANALYSIS (FEA) IS DISCUSSED AND COMPARED TO EXPERIMENTAL RESULTS AND EXISTING MODELS OF THE EFFECT OF CONTACT PRESSURES ON THE PERFORMANCE OF SUPERCONDUCTING CABLES.

3MP2F-01

MECHANICAL PROPERTIES OF DY123 LOW POROSITY BULK SUPERCONDUCTOR AT LIQUID NITROGEN TEMPERATURE ***A. MURAKAMI***[1]*, K. OTAKA*[1]*, T. MIURA*[1]*, A. IWAMOTO*[2]*;* [1]FACULTY OF SCIENCE AND TECHNOLOGY, HIROSAKI UNIVERSITY, [2]NATIONAL INSTITUTE FOR FUSION SCIENCE. — IN ORDER TO IMPROVE MECHANICAL PROPERTIES OF RARE-EARTH BASED SUPERCONDUCTING BULKS, ELIMINATION OF PORES HAS BEEN SUGGESTED. IN THE PRESENT STUDY, MECHANICAL PROPERTIES OF A DY123 LOW POROSITY BULK WHICH HAD FEW PORES IN THE WHOLE REGION OF IT WERE EVALUATED AT LIQUID NITROGEN TEMPERATURE (77 K) THROUGH BENDING TESTS OF SPECIMENS CUT FROM THE BULK. MECHANICAL PROPERTIES OF A CONVENTIONAL DY123 BULK WHICH HAD PORES IN THE INNER REGION OF IT WERE ALSO EVALUATED. WHILE THE CONVENTIONAL BULK WAS FABRICATED BY HEATING A PRECURSOR IN AIR, THE LOW POROSITY BULK WAS FABRICATED BY HEATING A PRECURSOR IN OXYGEN ATMOSPHERE. THE AVERAGE BENDING STRENGTH AT 77 K OF THE LOW POROSITY BULK WAS 114 MPA, WHICH WAS HIGHER THAN THAT AT ROOM TEMPERATURE OF A DY123 LOW POROSITY BULK TESTED IN THE PREVIOUS STUDY, 89 MPA. A REGION NEAR THE TOP SURFACE OF THE CONVENTIONAL BULK HAD EXCEPTIONALLY LOW POROSITY. THE BENDING STRENGTH AT 77 K OF A SPECIMEN CUT FROM THE LOW POROSITY REGION OF THE CONVENTIONAL BULK WAS 119 MPA, WHICH WAS SIMILAR TO THE AVERAGE BENDING STRENGTH OF THE LOW POROSITY BULK. THE AVERAGE BENDING STRENGTH AT 77 K OF THE OTHER SPECIMENS OF THE CONVENTIONAL BULK WAS 94 MPA.

3MP2F-02

EXPERIMENTAL STUDY OF TWISTING HTS TAPES ***J. PIENKOS****, B. FITZPATRICK, J. KEPHART, M. PYRYT, P. FERRARA;* NAVAL SURFACE WARFARE CENTER - CARDEROCK DIVISION. — THE USE OF HTS TAPES IS IDEAL FOR NAVAL SHIPBOARD IMPLEMENTATION DUE TO THE DECREASE IN SIZE AND WEIGHT OF CONDUCTORS. RECENTLY, THE US NAVY EXTENSIVELY TESTED HTS APPLICATIONS ON DEPLOYED SHIPS. THE NAVY SHIP IMPLEMENTATION STRATEGY IS TO EXAMINE THE ENTIRE HTS SYSTEM AND INSTALL COMPONENTS AS MODULES. ONE SUCH MODULE IS THE SUPERCONDUCTOR AND CRYOSTAT HOUSING THE SUPERCONDUCTOR.THE DEVELOPMENT OF FLEXIBLE CRYOSTATS IN LONG LENGTHS HAS CREATED ATTRACTIVE POSSIBILITIES FOR THE US NAVY. THE USE OF HTS TAPES COOLED VIA HELIUM GAS HAS BEEN PREVIOUSLY STUDIED AND THE COMBINATION WITH THE FLEXIBLE CRYOSTATS ALLOWS FOR A SIMPLIFICATION IN THE INSTALLATION PROCESS. WITH PROPER CABLING TECHNIQUES THE TAPES SHOULD NOT SUFFER ANY DEFECTS DURING THE INSTALLATION PROCESS OF THE CRYOSTAT. HOWEVER, AT THE END OF THE CRYOSTAT THE TAPES HAVE TO BE SECURED WHICH CAN BE PROBLEMATIC. AS THE CRYOSTAT IS INSTALLED, THE TAPE MAY BECOME TWISTED ALONG THE LENGTH OF THE AXIS.PREVIOUS STUDIES HAVE EXAMINED SPIRAL PITCH LENGTH OF HTS TAPES AROUND A FORMER WITHOUT MENTION OF THE END CONDITION. THIS STUDY EXAMINED THE EFFECTS OF ROTATING THE TAPE AROUND A FORMER WITH THE ENDS HAVING NO ANGLE OF ORIENTATION TO THE AXIS OF ROTATION. BY SECURING BOTH ENDS OF THE TAPE THE PITCH ANGLE, PITCH LENGTH, AND SLIGHT VARIATIONS ON THE ANGLE OF ORIENTATION OF THE TAPE ENDS ARE VARIED EXPERIMENTALLY AND THE CRITICAL CURRENT WILL BE TESTED.

THE AUTHORS WOULD LIKE TO ACKNOWLEDGE THE SUPPORT PROVIDED BY THE OFFICE OF NAVAL RESEARCH AND IN PARTICULAR, GEORGE STIMAK.

3MP2F-03

TRANSPORT PROPERTY AND BENDING STRAIN SENSITIVITY OF HTS TAPES DUE TO PUMPING AND PRESSURIZATION OF LIQUID NITROGEN ***H. SHIN****, M. J. DEDICATORIA;* ANDONG NATIONAL UNIVERSITY. — IN POWER CABLE APPLICATIONS, PRESSURIZED SUB-COOLED LIQUID NITROGEN IS PREFERRED TO AVOID THE EFFECT OF INCREASED TEMPERATURE ON THE TRANSPORT PROPERTY OF HTS TAPES. ON THE OTHER HAND, LIQUID NITROGEN IS OPERATED UNDER VACUUM STATE TO ACHIEVE 66 K IN SOME MAGNET APPLICATION. IN MOST OF APPLICATIONS HTS TAPES WILL BE SUBJECTED TO BENDING DEFORMATIONS DUE TO COILING. THEREFORE, IT IS ALSO IMPORTANT TO INVESTIGATE THE EXTENT OF THE DEPENDENCY OF THE TRANSPORT PROPERTY IN BENT HTS TAPES AT DIFFERENT TEMPERATURES WHICH WILL BE OBTAINED BY PUMPING AND PRESSURIZATION. IN THIS STUDY, THE TRANSPORT PROPERTY AND THE BENDING STRAIN

SENSITIVITY OF CRITICAL CURRENT IN HTS TAPES AT DIFFERENT TEMPERATURES HAVE BEEN INVESTIGATED. USING A DEVISED FRP MANDREL IT WAS POSSIBLE TO INDUCE DIFFERENT BENDING STRAIN VALUES ALONG THE GAUGE LENGTH OF HTS TAPES UNDER PRESSURIZED AND VACUUMED STATE. IN THE CASE OF COATED CONDUCTORS, THE CRITICAL CURRENT, I_C SHOWED REVERSIBILITY AFTER EACH PRESSURIZATION AND VACUUMING FOR BOTH YBCO AND SMBCO SAMPLES INVESTIGATED. SEVERAL THERMAL CYCLING HAS BEEN DONE TO INVESTIGATE THE RECOVERABILITY OF THE CRITICAL CURRENT AFTER EACH PRESSURIZATION TEST. THE TEMPERATURE EFFECT ON I_C IN BENT BSCCO TAPES HAS BEEN ALSO INVESTIGATED.

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3MP2F-04

STUDY ON NANO-MECHANICAL PROPERTIES OF HEAT-TREATED YBCO COATED CONDUCTORS (CCS) USING NANO-INDENTATION TECHNIQUE ***Y. CHOI***[1]*, J. LEE*[1]*, H. KIM*[1]*, D. YANG*[1]*, C. LEE*[2]*, S. KIM*[2]*, H. LEE*[1]*;* [1]KOREA UNIVERSITY, KOREA, [2]KOOKMIN UNIVERSITY, KOREA. — THE NANO-INDENTATION TECHNIQUE HAS BEEN ESTABLISHED AS A POWERFUL METHOD TO CHARACTERIZE THE NEAR NANO-SURFACE PROPERTIES SUCH AS NANO-MECHANICAL PROPERTIES OF MATERIALS. THE STRUCTURE AND SUPERCONDUCTING PROPERTIES OF A YBCO CHANGE DURING HEAT-TREATMENT IN ACCORDANCE WITH OXYGEN STOICHIOMETRY. OXYGEN DEFICIENCY CAUSES A PHASE TRANSITION FROM A SUPERCONDUCTING ORTHORHOMBIC TO A NON-SUPERCONDUCTING TETRAGONAL, AND AFFECTS ITS NANO-MECHANICAL PROPERTIES. IN THIS STUDY, NANO-MECHANICAL PROPERTIES INCLUDING THE HARDNESS AND ELASTIC MODULUS OF NEAR SURFACE OF THE HEAT-TREATED YBCO CCS WERE TESTED USING A TRIBOINDENTER SYSTEM TI900 (HYSITRON INC., MINNEAPOLIS, MN). FROM THESE TEST RESULTS WE EXAMINED THE RELATIONSHIP BETWEEN PHASE TRANSITION AND NANO-MECHANICAL PROPERTIES OF THE YBCO CC ACCORDING TO THE HEAT TREATMENT CONDITIONS AND TO THE INDENTING DEPTH.

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3MP2F-05

TENSILE TESTS OF BI-2212 AG ALLOY CLAD ROUND HIGH TC SUPERCONDUCTING WIRES ***R. P. WALSH***[1]*, U. P. TROCIEWITZ*[2]*, H. W. WEIJERS*[1]*, D. M. MCRAE*[1]*, D. MYERS*[2]*, Y. VIOUCHKOV*[1]*;* [1]NHMFL/FSU, [2]ASC/NHMFL. — COMMERCIALLY AVAILABLE BI-2212 AG-ALLOY CLAD ROUND WIRE IS BEING USED AT THE NHMFL FOR HIGH FIELD MAGNET DEVELOPMENT. IN SUPPORT OF THE COIL DESIGN AND TESTS, THE MECHANICAL PROPERTIES OF SHORT STRAIGHT WIRE SAMPLES HAVE BEEN MEASURED IN TENSILE TESTS AT 295 K, 77 K AND 4 K. A COMPOSITE TENSILE SPECIMEN WAS ALSO DEVELOPED WITH MULTIPLE WIRES AND THE INSULATION SYSTEM, TO MEASURE COMPOSITE TENSILE PROPERTIES THAT ARE APPLICABLE TO THE MAGNET DESIGN. IN ADDITION THE WIRE HAS BEEN SUPPLIED BY THE NHMFL AS A CANDIDATE MATERIAL FOR VAMAS ROUND-ROBIN HIGH TC SUPERCONDUCTING WIRE TENSILE TEST STANDARDS DEVELOPMENT. HERE WE REPORT ON THE MECHANICAL PROPERTIES OF THE WIRE AND THE TENSILE TEST METHODS USED. WE ALSO REPORT ON THE THERMAL EXPANSION OF UN-REACTED WIRES FROM 295 K TO 600 K.

3MP2G-01

RESIDUAL STRESS ANALYSIS OF INSULATION COATINGS FOR MAGNET TECHNOLOGIES ***D. GUNEY****;* YILDIZ TECHNICAL UNIVERSITY. — HIGH TEMPERATURE MGO-ZRO_2 INSULATION COATINGS WERE GROWN ON LONG-LENGTH STAINLESS-STEEL (SS) TAPES BY REEL-TO-REEL SOL-GEL METHOD FOR APPLICATIONS OF HTS/LTS COILS AND MAGNETS. COATING SOLUTIONS WERE PREPARED FROM MG AND ZR BASED PRECURSORS, SOLVENT AND CHELATING AGENT, THE COATING WERE FABRICATED ON SS SUBSTRATES USING REEL-TO-REEL SOL-GEL TECHNIQUE. THE RESIDUAL STRESSES WERE INVESTIGATED AT VARIOUS TEMPERATURE RANGES, 580 °C TO 25 °C (ROOM TEMPERATURE) AND -196 °C (LIQUID HELIUM TEMPERATURE), AND 630 °C TO 25 °C AND -196 °C FOR DIFFERENT THICKNESSES AS (13, 12, AND 7 MM) USING BOTH ANALYTICALLY AND NUMERICALLY. THE MAXIMUM STRESS VALUES WERE ANALYTICALLY OBTAINED TO BE 1.92 GPA IN TENSION FOR SS SUBSTRATE WITH THE 13 MM COATING AND -2.42 GPA IN COMPRESSION FOR THE 7 MM MGO-ZRO_2 COATING IN THE TEMPERATURE RANGE BETWEEN 630 °C AND LIQUID HELIUM TEMPERATURE. THE RESULTS OF BOTH METHODS WERE COMPARED. THE SURFACE MORPHOLOGIES AND MICROSTRUCTURE OF SAMPLE WERE ALSO CHARACTERIZED USING A SCANNING ELECTRON MICROSCOPE (SEM). SEM OBSERVATION REVEALED THAT MGO-ZRO_2 COATINGS HAVE A MOSAIC LIKE CRACK STRUCTURE.

3MP2G-02

MECHANICAL PROPERTIES OF NON-SUPERCONDUCTING COMPONENTS IN YBCO AND NB3SN COMPOSITES ***K. HAN****;* NATIONAL HIGH MAGNETIC FIELD LABORATORY. — IN BOTH YBCO AND NB_3SN COMPOSITES FOR MAGNET APPLICATIONS, THE NON-SUPERCONDUCTING MATERIALS ARE ESSENTIAL COMPONENTS. THE SURFACE OF THE COMPOSITES IS MADE OF PURE CU THAT IS REFERRED AS STABILIZER. THE SURFACE FINISH IS VERY IMPORTANT FOR THE APPLICATIONS, PARTICULARLY IN THE CASE WHERE THIN LAYERS OF INSULATIONS ARE REQUIRED. THE STABILIZER USUALLY OCCUPIES MORE THAN 50% OF THE VOLUME FRACTION OF THE COMPOSITES, THUS MAKING AN IMPORTANT CONTRIBUTION TO THE MECHANICAL PROPERTIES OF THE COMPOSITES. THE OTHER COMPONENTS, SUCH AS CU-SN IN NB_3SN CONDUCTORS AND SUBSTRATES IN YBCO CONDUCTORS CONTRIBUTE TO OVERALL MECHANICAL STRENGTH. UNDERSTANDING THE PERFORMANCE OF THE NON-SUPERCONDUCTING COMPONENTS UNDER LOADING HELPS ONE TO MAKE GOOD USE OF THE COMPOSITES IN

MAGNETS AND TO MANUFACTURE CONDUCTORS TO MEET THE REQUIREMENTS OF THE MAGNETS, PARTICULARLY WHEN THE MAGNETIC STRESS REACHES THE LIMIT OF THE MECHANICAL STRENGTH OF THE CONDUCTORS. THE GOAL OF OUR RESEARCH IS TO UNDERSTAND THE MECHANICAL PROPERTIES OF NON-SUPERCONDUCTING COMPONENTS IN TWO TYPES OF COMPOSITE CONDUCTORS AND TO RELATE SUCH PROPERTIES TO DISLOCATION DENSITIES, PRECIPITATE FORMATIONS AND INTERFACE STRUCTURES. THIS PAPER ADDRESSES THE CORRELATION BETWEEN THE MECHANICAL PROPERTIES OF THE NON-SUPERCONDUCTING COMPONENTS AND THE COMPOSITES AT CRYOGENIC TEMPERATURES BY CONSIDERING VARIOUS MICROSTRUCTURE PARAMETERS.

3MP2G-03

NANOCOMPOSITE INSULATION FOR HTS DEVICES ***J. K. WALSH***[1]*, P. E. FABIAN*[1]*, M. W. HOOKER*[1]*, M. LIZOTTE*[1]*, E. TUNCER*[2]*, I. SAUERS*[2]*;* [1]COMPOSITE TECHNOLOGY DEVELOPMENT, [2]OAK RIDGE NATIONAL LABORATORY. — A CRITICAL NEED HAS EMERGED FOR DIELECTRIC MATERIALS THAT CAN BE USED AS INSULATION IN HTS POWER SYSTEMS, SUCH AS TERMINATIONS, FAULT CURRENT LIMITERS, TRANSFORMERS, AND MOTORS. TO ADDRESS THIS NEED, CTD IS CONSIDERING RESINS COMPRISED OF EPOXY AND BENZOXAZINE CHEMISTRIES WITH NANOMATERIAL ADDITIONS TO PRODUCE COMPOSITE INSULATION SYSTEMS. DEPENDING ON PART GEOMETRY, SOME PROCESSING METHODS ARE MORE EFFICIENT THAN OTHERS. FOR THIS REASON, CTD IS INVESTIGATING BOTH FIBER-REINFORCED AND FILLED RESIN SYSTEMS FOR USE IN THESE APPLICATIONS. EMPHASIS WAS PLACED ON DEVELOPING A LOW-VISCOSITY SYSTEM, WHICH IS PREFERABLE FOR PRODUCING LARGE-SCALE PARTS. MECHANICAL TESTING (SHORT BEAM SHEAR AND COMPRESSION) SHOWED THE CTD MATERIALS TO HAVE AS GOOD OR BETTER PERFORMANCE THAN THE INDUSTRY STANDARD, G10. IN ADDITION, A THOROUGH SET OF ELECTRICAL TESTING INCLUDING AC BREAKDOWN, BREAKDOWN AS A FUNCTION OF THICKNESS, PARTIAL DISCHARGE, AND FLASHOVER WILL BE DISCUSSED.

3MP2G-04

DESIGN AND TESTING OF CANDIDATE ITER TF COIL INSULATIONS ***M. HOOKER****, J. K. WALSH, N. A. MUNSHI;* CTD. — THE DESIGN OF THE ITER TOROIDAL FIELD (TF) COILS REQUIRES AN INSULATION SYSTEM THAT CAN PROVIDE RELIABLE ELECTRO-MECHANICAL PERFORMANCE AFTER RADIATION EXPOSURE, WHILE ALSO BEING AMENABLE TO THE VERY LARGE SCALE VACUUM IMPREGNATION PROCESSES PLANNED FOR THE CONSTRUCTION OF THESE DEVICES. REQUIREMENTS FOR THE TF COIL INSULATION INCLUDE A POT LIFE IN EXCESS OF 100 HOURS, A PROCESSING TEMPERATURE OF 50 TO 60C, AND GOOD COMPRESSION AND SHEAR STRENGTHS AFTER IRRADIATION. WHILE THE INSULATION USED IN THE TF COILS MUST MEET DEMANDING REQUIREMENTS, THE COST OF THESE MATERIALS MUST ALSO BE CONSIDERED. TO ADDRESS THIS NEED, CTD HAS DEVELOPED A LOWER-COST CYANATE ESTER/EPOXY INSULATION, CTD-425, THAT IS CURRENTLY BEING QUALIFIED BY ITER. THIS PRESENTATION WILL DISCUSS THE PROPERTIES OF THIS INSULATION AS RELATED TO THE REQUIREMENTS OF THE ITER TOROIDAL FIELD MAGNETS.

3MP2G-05

EFFECT OF SOLDERING DEFECTS ON STRENGTH OF HTS LAP JOINTS ***R. HOLTZ****;* NAVAL RESEARCH LABORATORY. — TO ACHIEVE ARBITRARILY LONG LENGTHS OF HTS CONDUCTOR IN EXCESS OF CONVENIENTLY MANUFACTURED LENGTHS, TAPES MUST BE SPLICED TOGETHER. THE MOST DIRECT METHOD OF SPLICING HTS TAPES IS A LAP JOINT. IN THIS METHOD, TAPES ARE OVERLAPPED AND SOLDERED. THE OVERLAP LENGTH IS MADE SUFFICIENTLY LONG TO REDUCE THE RESISTANCE TO ACCEPTABLE VALUES. ELECTRO-MECHANICAL BEHAVIOR OF SUCH LAP JOINTS HAS BEEN REPORTED FOR LONGITUDINAL TENSILE LOADING, SUCH AS IS DUE TO LORENTZ STRESS IN COILS. IN SOME APPLICATIONS, TENSION THROUGH THE THICKNESS OF THE TAPES AND SPLICES, OR C-AXIS TENSION, OCCURS. A LAP JOINT SPLICE UNDER THROUGH-THICKNESS TENSION IS POTENTIALLY SUBJECT TO FAILURE OF THE SOLDER OR SEPARATION OF THE SOLDER FROM THE HTS TAPES. SUCH FAILURES MAY BE TRIGGERED BY THE PRESENCE OF GAPS, BUBBLES, FOREIGN OBJECT DEBRIS, OR CORROSION PRODUCTS FROM FLUXES. IN PARTICULAR, UNDER CYCLIC FATIGUE LOADING, STRESS CONCENTRATIONS FROM DEFECTS COULD CAUSE SIGNIFICANT REDUCTION OF THE FATIGUE STRENGTH RELATIVE TO MONOTONIC STRENGTH. HERE, WE ANALYZE EFFECTS OF SOLDERING DEFECTS IN LAP JOINT SPLICES AND PRESENT STRENGTH AND FATIGUE MEASUREMENTS ON HTS SPLICES WITH VARIOUS DELIBERATELY INCLUDED DEFECTS.

3MP2G-06

MEASUREMENT OF 77K STRESS-STRAIN RESPONSE OF EPOXY-IMPREGNATED HTS STACKS ***R. HOLTZ****, P. PAO;* NAVAL RESEARCH LABORATORY. — VERY LITTLE EXPERIMENTAL DATA ARE AVAILABLE IN THE LITERATURE ON THE MECHANICAL PROPERTIES OF HTS COILS IN THEIR RADIAL DIRECTION; I.E. REPRESENTING THE CROSS-SECTION OF COILS. WHILE THE PROPERTIES OF COMMON EPOXY IMPREGNANTS ARE KNOWN, THE THROUGH-THICKNESS STRESS-STRAIN RESPONSE OF INDIVIDUAL HTS TAPES IS NOT WELL CHARACTERIZED, MAKING IT DIFFICULT TO ACCURATELY MODEL THE RADIAL RESPONSE OF COMPOSITE COILS. IN THIS PRESENTATION WE DESCRIBE A METHOD WE HAVE USED FOR MEASUREMENTS OF STRESS-STRAIN RESPONSE OF EPOXY-IMPREGNATED “STACKS” OF HTS TAPES. THE SPECIMENS, PROVIDED BY AMERICAN SUPERCONDUCTOR, WERE IN THE FORM OF RECTANGULAR BARS CUT FROM AN EPOXY-IMPREGNATED BLOCK OF STACKED HTS TAPES ARRANGED TO MIMIC A COIL CROSS-SECTION. ADDITIONAL BARS OF THE SAME GEOMETRY ARE PREPARED FROM EPOXY AND METALS FOR REFERENCE. STRAIN IS MEASURED WITH A CLIP-ON EXTENSOMETER CALIBRATED FOR BOTH ROOM TEMPERATURE AND 77K. NONLINEAR STRESS-STRAIN RESPONSE, THOUGHT TO BE DUE TO RESIDUAL STRAIN OR WARPAGE IN THE BARS, IS COMMONLY OBSERVED, BUT AN AVERAGING PROCEDURE USING TWO MEASUREMENTS WITH THE EXTENSOMETER ON

OPPOSING SIDES OF THE BARS YIELDS CONSISTENT VALUES FOR ELASTIC MODULUS. A BY PRODUCT OF THE METHOD IS THE TOTAL THERMAL CONTRACTION FROM ROOM TEMPERATURE TO 77K.

3MP3A-01

MINUTE DOPING OF $Y_{1-X}RE_XBA_2CU_3O_{7-\Delta}$ THIN FILMS WITH RE = TB AND ND ***J. N. REICHART***[1]*, E. L. THOMAS*[2]*, T. J. HAUGAN*[1]*, X. SONG*[3]*, P. N. BARNES*[1]*;* [1]AIR FORCE RESEARCH LABORATORY, [2]UNIVERSITY OF DAYTON, [3]WEST VIRGINIA UNIVERSITY. — DOPING OF YBCO HAS BECOME AN EFFECTIVE MEANS OF INCREASING THE FLUX PINNING AND CRITICAL CURRENT DENSITIES (JC) IN THIN FILM SUPERCONDUCTORS, WHILE MAINTAINING THE TRANSITION TEMPERATURE (TC). IN PREVIOUS RESEARCH EFFORTS, OUR GROUP SHOWED THAT DOPING (Y1-XREX)BCO WITH TYPICALLY DELETERIOUS RARE EARTH (RE) ELEMENTS CAN BE USED TO IMPROVE THE FILM'S JC VIA FLUX PINNING WHEN THE X MOLAR ADDITIONS ARE LESS THAN 1%. HOWEVER, DATA WAS ONLY PRESENTED FOR DIFFERENT ORDERS OF MAGNITUDE (X = 0.01%, 0.1%, 1%). THE RESEARCH PRESENTED HERE DEMONSTRATES THAT THE OPTIMIZATION OF DELETERIOUS RE ELEMENTS CAN VARY IN RANGE OF DOPING CONCENTRATION, IN ADDITION TO THE RELATIVE DOPING CONCENTRATION. RARE-EARTH ELEMENTS ND AND TB WERE COMPARED DUE TO THE DIFFERENCE IN DEGRADATION MECHANISMS: ND ADDITIONS RESULTS IN BA SITE SUBSTITUTION AND TB123 EXHIBITS POOR PHASE FORMATION. THIN FILMS OF ND AND TB DOPED YBCO FILMS WERE GROWN BY PLD USING STANDARD YBCO DEPOSITION PARAMETERS. THE COMPOSITIONS STUDIED WERE (Y1-XREX)BCO WHERE X = 0.001 TO 0.025 FOR ND AND X = 0.005 TO 0.015 FOR TB. ALL FILMS WERE CHARACTERIZED FOR JC AND TC BY VIBRATING SAMPLE MAGNETOMETRY. DATA FOR JC(H,T,THETA) AND TC WERE COMPARED TO UNDOPED YBCO FILMS PROCESSED UNDER THE SAME CONDITIONS. THE RESULTS SHOW A MEASURABLE INCREASE IN FLUX PINNING FOR BOTH DIFFERENT CONCENTRATIONS AND RANGE OF ND AND TB DOPING, WITH LITTLE DECREASE IN TC.

3MP3A-02

TRANSPORT CHARACTERIZATION OF $GDBA_2CU_3O_{7-\Delta}$ COATED CONDUCTORS DEPOSITED BY THE IN-PLUME PLD REEL-TO-REEL TECHNIQUE ***R. FUGER***[1]*, R. MIYOSHI*[1]*, T. KISS*[1]*, N. CHIKUMOTO*[2]*, S. LEE*[2]*, T. IZUMI*[2]*;* [1]KYUSHU UNIVERSITY, [2]SUPERCONDUCTIVITY RESEARCH LABORATORY, ISTEC. — IN-PLUME PULSED LASER DEPOSITION (PLD) PROCESS ALLOWS TO PRODUCE COATED CONDUCTORS (CC) WITH HIGH DEPOSITION RATES TOGETHER WITH SUPERIOR IN-FIELD PROPERTIES. WE INVESTIGATED SYSTEMATICALLY ON TEMPERATURE, MAGNETIC FIELD AND FIELD ANGULAR THE TRANSPORT PROPERTIES OF DIFFERENT $GDBA_2CU_3O_{7-\Delta}$ COATED CONDUCTOR PRODUCED BY AN IN-PLUME PLD MULTI-TURN REEL-TO-REEL PROCESS. THEREBY, HIGH SELF FIELD CRITICAL CURRENT DENSITIES (J_C) ($4.3X10^{10}$ A/M^2 AT 77 K) AND EXCELLENT IN FIELD BEHAVIOR WERE OBSERVED FOR THE BEST SAMPLES. THE ANGULAR RESOLVED J_C MEASUREMENTS SHOW A VERY EXTENSIVE STRUCTURE WHICH VARIES WITH TEMPERATURE AND APPLIED MAGNETIC FIELD. IN THE LOW FIELD REGION AN ASYMMETRIC BEHAVIOR ON THE DIRECTION OF THE CURRENT TO THE MAGNETIC FIELD (FIELD AND CURRENT WERE ALWAYS PERPENDICULAR TO EACH OTHER) WAS OBSERVED. THIS BEHAVIOR IS RELATED TO THE DIRECTION WHERE THE VORTICES ARE PUSHED, TO THE SUBSTRATE OR TO THE SURFACE, AND INDICATE AN ADDITIONAL SURFACE PINNING MECHANISM ON THE SUPERCONDUCTING TO BUFFER LAYER TRANSITION.

THIS STUDY WAS SUPPORTED IN PART BY "NEDO AS THE PROJECT FOR DEVELOPMENT OF MATERIALS & POWER APPLICATION OF COATED CONDUCTORS: M-PACC" AND ALSO BY "JSPS: KAKENHI (20360143) AND (2008795)".

3MP3A-04

IN-FIELD PROPERTIES OF SMBCO COATED CONDUCTOR ON IBAD_MGO METAL SUBSTRATES BY BATCH-TYPE REACTIVE CO-EVAPORATION ***R. KO***[1]*, S. JANG*[1]*, K. SONG*[2]*, S. OH*[1]*, C. PARK*[3]*, H. HA*[1]*, H. KIM*[1]*, D. HA*[1]*, S. KANG*[2]*, Y. KIM*[4]*;* [1]KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE, [2]CHONBUK NATIONAL UNIVERSITY, [3]SEOUL NATIONAL UNIVERSITY, [4]PUSAN NATIONAL UNIVERSITY. — WE HAVE REPORTED THE SUPERCONDUCTING PROPERTIES IN MAGNETIC FIELDS OF SMBCO COATED CONDUCTOR ON IBAD_MGO METAL SUBSTRATES FABRICATED BY BATCH-TYPE REACTIVE CO-EVAPORATION METHOD. OUR DEPOSITION SYSTEM WAS SPECIALLY DESIGNED AND WAS NAME EDDC(EVPORATION USING DRUM IN DUAL CHAMBER). THE SMBCO COATED CONDUCTOR BY EDDC-IBAD PROCESS WAS T_C=94 K, I_C=235 A/CM_WIDTH AND J_C=1.6 MA/CM^2 IN SELF-FIELD AT 77 K. THE J_C DEGRADATION AT 77 K FOR 1 T (B//C) AND IRREVERSIBILITY FIELD (B_{IRR}) AT 77 K WERE 0.4 MA/CM^2 AND 10.5 T RESPECTIVELY. IN-FIELD PROPERTIES OF SMBCO COATED CONDUCTOR WERE COMPARED TO THOSE OF COATED CONDUCTOR FABRICATED BY OTHER DEPOSITION PROCESS.

THIS RESEARCH WAS SUPPORTED BY A GRANT FROM CENTER FOR APPLIED SUPERCONDUCTIVITY TECHNOLOGY OF THE 21ST CENTURY FRONTIER R&D PROGRAM FUNDED BY THE MINISTRY OF SCIENCE AND TECHNOLOGY, REPUBLIC OF KOREA.

3MP3A-05

FABRICATION AND CHARACTERIZATION OF FILAMENTARY (ND,SM,GD)-BA-CU-O SUPERCONDUCTOR DOPED WITH COBALT AND NICKEL ***Y. IKEBE***[1]*, E. BAN*[1]*, G. NISHIJIMA*[2]*, K. WATANABE*[2]*;* [1]MEIJO UNIVESITY, [2]TOHOKU UNIVERSITY. — TERNARY $(ND_{0.33}SM_{0.33}GD_{0.33})_{1.18}BA_{2.12}CU_{3.09}O_Y$ (NSG123) FILAMENTS CHEMICALLY DOPED WITH NOMINAL CO AND NI CONCENTRATION BETWEEN 0 AND 0.5 AT% WERE PREPARED BY A SOLUTION SPINNING METHOD. PRECURSOR FILAMENTS WERE PARTIALLY MELTED AT 1050 °C FOR 30 MIN AND COOLED AT RAPID RATE OF 60 °C/H FROM 1050 TO 910 °C IN FLOWING $0.1\%O_2$+AR ATMOSPHERE GAS, AND THEN OXYGENATED IN PURE O_2 GAS. SAMPLES WITH SMALL AMOUNT OF 0.05 AT% CO AND NI SHOWED THE J_C VALUE OF 2.1×10^4 AND 8.6×10^3 A/CM^2 AT 77 K AND 0 T, CONTRAST TO LOW J_C VALUE OF 3.0×10^3 A/CM^2 FOR THE PURE SAMPLE.

FURTHERMORE, THE J_C MEASUREMENT WAS CARRIED OUT AT TEMPERATURE RANGING FROM 77 TO 90 K IN APPLIED MAGNETIC FIELDS UP TO 17 T BY ROTATING THE SAMPLE ALONG THE DIRECTION PERPENDICULAR TO THE FILAMENT. ANISOTROPIC BEHAVIOR WAS DETECTED FOR ALL FILAMENTARY SAMPLES FROM THE FIELD DEPENDENCE OF J_C VALUE. THE SAMPLE DOPED WITH 0.05 AT% CO MAINTAINED HIGH J_C VALUE OF 4.5×10^3 A/CM^2 IN MAGNETIC FIELD UP TO 17 T AT 77 K, WHILE THE SUPERCONDUCTIVITY DISAPPEARED AT AROUND 11 T FOR PURE NSG123 SAMPLE. OUR RESULTS CONFIRM THAT CO DOPING IS IMPORTANT IN ENHANCEMENT OF J_C IN AN APPLIED FIELD AS WELL AS SELF-FIELD. IN ADDITION, CO AND NI DOPED SAMPLES HAD A DENS MICROSTRUCTURE WITHOUT PORES AND LOW ELECTRICAL RESISTIVITY AT NORMAL STATE COMPARED WITH THOSE OF PURE SAMPLE.

3MP3A-06

CRITICAL CURRENT PROPERTIES IN MAGNETIC FIELD OF FILAMENTARY SM-BA-CU-O WITH METAL ADDITIONS ***E. BAN***[1]*, Y. IKEBE*[1]*, G. NISHIJIMA*[2]*, K. WATANABE*[2]*;* [1]MEIJO UNIVERSITY, [2]TOHOKU UNIVERSITY. — THE EFFECT OF ZR AND SN DOPING ON SUPERCONDUCTING PROPERTIES OF FILAMENTARY SM-BA-CU-O PREPARED BY A SOLUTION SPINNING METHOD HAS BEEN INVESTIGATED. SAMPLES ARE PARTIALLY MELTED IN FLOWING AR BASE-GAS CONTAINING O_2 CONCENTRATION RANGE OF 0.1% - 3% AND OXYGENATED IN PURE OXYGEN GAS. IN THE CASE OF ZR DOPOING TO SM123, SAMPLE WITH 0.2AT% ZR EXHIBITS A J_C VALUE OF 1.8×10^4 A/CM^2, CONTRAST TO THE PEAK J_C VALUES OF 2.5×10^4A/CM^2 FOR SM123 WITHOUT DOPING. FROM THE SEM OBSERVATION, A DENSE MICROSTRUCTURE WITH LITTLE PORES CAN BE SEEN IN ZR-DOPED SM123 SAMPLE, IN WHICH FINE SM211 PARTICLES ARE HOMOGENEOUSLY DISPERSED. THIS SAMPLE SHOWS J_C VALUE HIGHER THAN 10^3 A/CM^2 AND SUPERCONDUCTIVITY CAN BE MAINTAINED UP TO 8 T AND 12 T, RESPECTIVELY. FURTHERMORE, HIGH J_C VALUE OF 5.0×10^4A/CM^2 AT 77K , 0T WAS OBTAINED IN SM123+0.2AT%. IT IS ALSO FOUND THAT J_CS IN HIGH MAGNETIC FIELD AND THE IRREVERSIBILITY FIELD OF SM-BA-CU-O FILAMENTS ARE IMPROVED BY A SMALL AMOUNT OF ZR AND SN DOPING.

3MP3A-07

MAGNETIC PINNING IN YBCO ***S. C. WIMBUSH****, S. A. HARRINGTON, J. L. MACMANUS-DRISCOLL;* UNIVERSITY OF CAMBRIDGE. — MAGNETIC PINNING IS A PROMISING BUT HITHERTO LARGELY UNEXPLORED APPROACH TO ENHANCING THE ULTIMATE CRITICAL CURRENT DENSITY ACHIEVABLE IN SUPERCONDUCTORS OF TECHNOLOGICAL IMPORTANCE SUCH AS YBCO. WE HAVE PREVIOUSLY DEMONSTRATED THE FIRST SUCCESSFULLY INCORPORATED MAGNETIC PINNING ADDITION TO YBCO IN THE FORM OF THE WEAK FERROMAGNETIC OXIDE YFEO3, AND HAVE PRODUCED A MODEL OF THE INTERACTION THAT LEADS TO AN ENHANCED CRITICAL CURRENT IN SUCH FERROMAGNET-SUPERCONDUCTOR COMPOSITES, WHICH WE TERM THE LORENTZ FORCE REDUCTION MECHANISM. HERE, WE PRESENT OUR LATEST EXPERIMENTAL RESULTS AIMED AT THE INCORPORATION OF MORE STRONGLY FERROMAGNETIC PINNING MATERIALS INTO YBCO CONDUCTORS, WHERE THE INCREASED MAGNETIC INTERACTION BETWEEN PINNING CENTRE AND FLUX VORTEX DUE TO THE INCREASED MAGNETISATION OF THE FERROMAGNETIC COMPONENT IS EXPECTED TO YIELD AN EVEN GREATER ENHANCEMENT IN CRITICAL CURRENT, AND WHERE THE MAGNETIC PINNING EFFECT CAN BE EXPECTED TO BE SEEN MORE CLEARLY.

THIS WORK IS SUPPORTED BY THE LEVERHULME TRUST, WITH SUPPLEMENTARY FUNDING FROM THE ISAAC NEWTON TRUST.

3MP3A-08

VORTEX PATTERNS IN A MESOSCOPIC SUPERCONDUCTING ROD WITH A MAGNETIC DOT ***A. R. D. C. ROMAGUERA***[1]*, M. M. DORIA*[2]*, F. M. PEETERS*[3]*;* [1]UNIVERSIDADE FEDERAL RURAL DE PERNAMBUCO, [2]UNIVERSIDADE FEDERAL DO RIO DE JANEIRO, [3]UNIVERSITEIT ANTWERPEN. — WE STUDY A MESOSCOPIC SUPERCONDUCTING ROD WITH A MAGNETIC MOMENT ON ITS TOP ORIENTED ALONG THE AXIS OF SYMMETRY. WE STUDY THE DEPENDENCE OF THE VORTEX PATTERN WITH THE HEIGHT AND FIND THAT FOR VERY SHORT AND VERY LONG RODS, THE VORTEX PATTERN ACQUIRES A SIMPLE STRUCTURE, CONSISTING OF GIANT AND OF MULTI VORTEX STATES, RESPECTIVELY. IN THE LONG LIMIT THE MOST STABLE CONFIGURATION CONSISTS OF TWO VORTICES, THAT REACH THE LATERAL SURFACE OF THE ROD DIAMETRICALLY SYMMETRIC. THE LONG ROD ALSO SHOWS REENTRANT BEHAVIOR WITHIN SOME RANGE OF THE ROD'S GEOMETRICAL AND OF THE DOT'S MAGNETIC MOMENT INTENSITY. OUR RESULTS ARE OBTAINED WITHIN THE GINZBURG-LANDAU APPROACH IN THE LIMIT OF NO MAGNETIC SHIELDING.

FACEPE, FAPERJ, CNPQ

3MP3A-09

CHARACTERIZATION OF COMMERCIAL YBCO COATED CONDUCTORS AFTER FAST NEUTRON IRRADIATION ***M. CHUDÝ****, M. EISTERER, H. W. WEBER;* VIENNA UNIVERSITY OF TECHNOLOGY, ATOMINSTITUT. — IN VIEW OF THE SIGNIFICANT PROGRESS IN COATED CONDUCTOR PROCESSING TECHNOLOGIES, A WIDE VARIETY OF APPLICATIONS HAVE BECOME FEASIBLE. ONE OF THEM IS THE DESIGN OF SUPERCONDUCTING MAGNETS FOR FUSION DEVICES OPERATING IN THE LIQUID NITROGEN TEMPERATURE RANGE. IN THIS CASE, THE MATERIAL HAS TO WITHSTAND A SIGNIFICANT FLUENCE OF FAST NEUTRONS. SAMPLES OF THE LATEST GENERATION OF COATED CONDUCTORS PROVIDED BY A COMMERCIAL SUPPLIER WERE SEQUENTIALLY IRRADIATED IN A FISSION REACTOR AND CHARACTERIZED BY MAGNETIC AND DIRECT TRANSPORT MEASUREMENTS. IN ADDITION, ANGULAR RESOLVED TRANSPORT MEASUREMENTS WERE PERFORMED. WE WILL REPORT ON THE CHANGES IN J_C AFTER FAST NEUTRON IRRADIATION ASSESSED FOR THE TWO MAIN FIELD ORIENTATIONS IN MAGNETIC FIELDS OF UP TO 15 T AND AT VARIOUS TEMPERATURES. THE FLUX PINNING BEHAVIOR AND ITS EFFECT ON THE J_C ANISOTROPY AT VARIOUS FIELDS, TEMPERATURES AND LEVELS OF IRRADIATION WILL BE DISCUSSED.

THIS WORK WAS SUPPORTED BY NESPA (NANO ENGINEERED SUPERCONDUCTORS FOR POWER APPLICATIONS)

3MP3A-10

DYNAMIC GROWTH EFFECTS OF RARE EARTH NANOPARTICLES ON NANOROD FORMATION IN $YBA_2C_3O_X$ THIN FILMS ***F. BACA***[1]*, T. G. HOLESINGER*[1]*, B. MAIOROV*[1]*, L. CIVALE*[1]*, T. J. HAUGAN*[2]*, J. REICHART*[2]*, P. N. BARNES*[2]*, J. Z. WU*[3]*;* [1]LOS ALAMOS NATIONAL LABORATORY, [2]U. S. AIR FORCE RESEARCH LABORATORIES, [3]UNIVERSITY OF KANSAS. — TO MAINTAIN THE HIGH CURRENT-CARRYING PERFORMANCE OF $YBA_2CU_3O_X$ (YBCO) SUPERCONDUCTORS IN THE PRESENCE OF MAGNETIC FIELDS OF VARIED INTENSITY AND ORIENTATION, A TUNABLE VORTEX PINNING LANDSCAPE IS NECESSARY. WHILE SECOND-PHASE NANORODS AND NANOPARTICLES HAVE BEEN WELL ESTABLISHED AS A MEANS TO PROVIDE EFFECTIVE COLUMNAR PINNING STRUCTURES, CONTROL OF THEIR SELF-ASSEMBLY IS LIMITED DURING GROWTH. SINCE DYNAMIC EFFECTS HAVE BEEN SHOWN TO PLAY KEY A ROLE IN THE GROWTH AND SELF ASSEMBLY OF NANORODS IN THE YBCO MATRIX, WE EXAMINE THE ROLE OF NANOPARTICLES ON THE MICROSTRUCTURE AND FORMATION OF NANORODS GROWN BY PULSED LASER DEPOSITION UNDER VARIED DEPOSITION CONDITIONS. THROUGH TRANSMISSION ELECTRON MICROSCOPY STUDIES (TEM), WE HAVE FOUND THAT THE PRESENCE OF RARE EARTH OXIDE (RE_2O_3) NANOPARTICLES IN THE YBCO MATRIX DIRECTLY INFLUENCES THE GROWTH OF NANORODS, SUCH AS $BAZRO_3$. WITH VARIED GROWTH TEMPERATURE, CERTAIN NANOROD ATTRIBUTES, SUCH AS AVERAGE LENGTH AND SPLAY, VARY DISTINCTLY WHEN NANOPARTICLES ARE PRESENT. THIS INDICATES DYNAMIC EFFECTS, SUCH AS DIFFUSION, PLAY A SIGNIFICANT ROLE IN THE NANOROD FORMATION, AND WE EXAMINE THE ROLES OF BULK AND SURFACE DIFFUSION.

DEPARTMENT OF ENERGY, U. S. AIR FORCE OFFICE OF SCIENTIFIC RESEARCH, AIR FORCE RESEARCH LABORATORIES PROPULSION DIRECTORATE

3MP3A-11

EFFECTS OF NANOSCALE DEFECTS ON CRITICAL CURRENT DENSITY OF Y1-X EUXBA2CU3O7-X THIN FILMS ***R. GOSWAMI***[1]*, T. J. HAUGAN*[2]*, P. N. BARNES*[2]*, G. SPANOS*[3]*, R. L. HOLTZ*[3]*;* [1]SAIC/NAVAL RESEARCH LABORATORY, WASHINGTON DC, [2]AIR FORCE RESEARCH LABORATORY, OH 45433, [3]NAVAL RESEARCH LABORATORY, WASHINGTON DC. — IN PULSED LASER DEPOSITION OF YBA2CU3O7-Δ FILMS, DEFECT INTRODUCTION INTO THE FILMS TENDS TO ANISOTROPICALLY IMPROVE THE PINNING ALONG THE H//C DIRECTION DUE TO THE COLUMNAR GROWTH MODE OF THE PROCESS. IN EU-SUBSTITUTED SAMPLES, HOWEVER, EVEN THOUGH AN INCREASE IN CRITICAL CURRENT DENSITY (JC) IN THE H//C DIRECTION WAS OBSERVED FOR LOW FIELDS (H=0.2 T), THE IMPROVEMENT WAS MORE NOTABLE FOR THE H//AB-PLANE AT BOTH LOW AND HIGHER FIELDS. HEREIN WE PRESENT DETAILED TEM MICROSTRUCTURAL STUDIES TO UNDERSTAND THESE NEW TRENDS IN JC(H), WHICH ARE MARKEDLY DIFFERENT THAN FLUX PINNING INCREASES ACHIEVED WITH OTHER METHODS, FOR EXAMPLE, WITH NANOPARTICLE ADDITIONS. THREADING DISLOCATIONS, OBSERVED IN THE EU-SUBSTITUTED SAMPLES ALONG THE C-AXIS, ACCOUNT FOR JC ENHANCEMENT WITH H//C AT LOW FIELD. THE ENHANCED AB-PLANAR PINNING IN THE EU-SUBSTITUTED SAMPLES IS ATTRIBUTED TO THE EXTENSIVE BENDING OF THE {001} LATTICE PLANES THROUGHOUT THE FILM, AND THE CRYSTAL LATTICE DEFECTS WITH EXCESS CU-O PLANES, THAT WERE EFFECTIVE IN INCREASING THE JC FOR H//AB AT BOTH LOW AND HIGH FIELDS.

IT LOOKS GOOD.

3MP3B-01

COMPARISON OF CONTACT AND CONTACTLESS MEASUREMENTS OF THE CRITICAL CURRENT OF COATED CONDUCTORS ***I. RUDNEV****, S. POKROVSKI;* NATIONAL RESEARCH NUCLEAR UNIVERSITY, INTERNATIONAL LABORATORY OF HIGH MAGNETIC FIELDS AND LOW TEMPERATURES IN WROCLAW. — IN THIS REPORT WE PRESENT THE RESULTS OF COMPARISON OF DIRECT TRANSPORT MEASUREMENTS OF CRITICAL CURRENT OF COATED CONDUCTORS (MAGNETIC AND NONMAGNETIC SUBSTRATES) WITH DATA ONE OBTAINED FROM MEASUREMENTS OF MAGNETIZATION. TO DETERMINE THE DEPENDENCE OF TRANSPORT CRITICAL CURRENT ON THE MAGNETIC FIELD WE MEASURED A SET OF CURRENT-VOLTAGE CHARACTERISTICS IN THE RANGE OF MAGNETIC FIELD FROM 0 TO 8 T WITH THE ORIENTATION OF THE FIELD PERPENDICULAR TO THE TAPE AT T = 77 K. THE VALUES OF THE CRITICAL CURRENT WERE DETERMINED FROM THE I-V CHARACTERISTICS BY USE OF THE CRITERION OF 1 MKV /CM . AFTER TRANSPORT MEASUREMENTS WE HAVE CUT THE PART OF THE SAMPLES BETWEEN POTENTIAL CONTACTS FOR MEASUREMENTS OF MAGNETIZATION CURVES M(H). MAGNETIC MEASUREMENTS WERE DONE BY USE A VIBRATION MAGNETOMETER IN THE TEMPERATURE RANGE 4,2-77 K FOR MAGNETIC FIELDS UP TO 14 T. THE DEPENDENCIES OF CRITICAL CURRENT ON MAGNETIC FIELD WERE CALCULATED FROM THE M(H) BY USED THE CRITICAL-STATE MODEL COMPARISON OF FIELD DEPENDENCE OF CRITICAL CURRENT, OBTAINED BY CONTACT AND CONTACTLESS METHODS AT T = 77 K SHOWS THAT FOR BOTH SAMPLES IS OBSERVED COINCIDENCE OF THE CURVES AT LOW FIELDS AND A STRONG DIVERGENCE AT H> 1 TESLA. THUS, ONE CAN ASSUME THAT THE DEPENDENCIES OF IC(H), OBTAINED FROM THE MAGNETIZATION CURVES IN THE TEMPERATURE RANGE 4,2-77 K CORRECTLY MATCH TO TRANSPORT VALUES FOR FIELDS H <1 TESLA.

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3MP3B-02

NONLINEARITY OF THE CURRENT-VOLTAGE CHARACTERISTICS FOR $YBA_2CU_3O_{7-X}$ SINGLE CRYSTALS AND THE BEREZINSKII-KOSTERLITZ-THOULESS TRANSITION ***M. A. VASYUTIN****, N. D. KUZMICHEV;* MACHINE-BUILDING INSTITUTE. — THE NONLINEARITY OF THE CURRENT-VOLTAGE CHARACTERISTICS

FOR $YBA_2CU_3O_{7-X}$ SINGLE CRYSTALS IS INVESTIGATED IN THE VICINITY OF THE SUPERCONDUCTING TRANSITION TEMPERATURE T_C, AND THE MECHANISMS RESPONSIBLE FOR THE NONLINEARITY OF THE CURRENT-VOLTAGE CHARACTERISTICS ARE CONSIDERED. THE CURRENT-VOLTAGE CHARACTERISTICS AND THE AMPLITUDES OF THE HIGHER VOLTAGE HARMONICS FOR THE $YBA_2CU_3O_{7-X}$ SINGLE CRYSTALS ARE DIRECTLY MEASURED USING MODULATION FOURIER ANALYSIS. IT IS SHOWN THAT THE POSITIONS OF THE MAXIMA IN THE AMPLITUDES OF THE HIGHER VOLTAGE HARMONICS COINCIDE WITH THE BEREZINSKII-KOSTERLITZ-THOULESS TRANSITION TEMPERATURE T_{BKT}. THIS COINCIDENCE CAN PROVIDE A MEANS FOR DETERMINING THE TRANSITION TEMPERATURE T_{BKT}. A NUMBER OF PARAMETERS CHARACTERIZING THE $YBA_2CU_3O_{7-X}$ SINGLE CRYSTALS IN THE SUPERCONDUCTING STATE ARE ESTIMATED USING THE EXPERIMENTAL RESULTS AND THE MODEL OF A BEREZINSKII-KOSTERLITZ-THOULESS TRANSITION. THE PARAMETERS THUS ESTIMATED ARE IN GOOD AGREEMENT WITH THE DATA AVAILABLE IN THE LITERATURE.

3MP3B-03

VORTEX GLASS STATE IN SUPERCONDUCTORS CONTAINING FRACTAL CLUSTERS OF A NORMAL PHASE ***Y. I. KUZMIN;*** IOFFE PHYSICAL TECHNICAL INSTITUTE OF THE RUSSIAN ACADEMY OF SCIENCES. — THE EFFECT OF FRACTAL CLUSTERS OF A NORMAL PHASE ON VORTEX DYNAMICS IN PERCOLATIVE SUPERCONDUCTORS IS STUDIED. THE SUPERCONDUCTOR CONTAINS PERCOLATIVE SUPERCONDUCTING CLUSTER CARRYING A TRANSPORT CURRENT AND CLUSTERS OF NORMAL PHASE, WHICH ACT AS PINNING CENTERS. THE NORMAL-PHASE CLUSTERS HAVE FRACTAL BOUNDARIES AND THEIR DISTINCTIVE FEATURE IS THAT THE IRREGULARITIES OF THEIR STRUCTURE ARE IN THE WIDE RANGE OF GEOMETRIC SIZES. THE DIAMETER OF VORTEX CORE FALLS INTO THIS RANGE OF SIZES, SO THE VORTICES ARE TRAPPED INTENSIVELY IN SUCH CLUSTERS. ON THE OTHER HAND, THE FRACTAL CLUSTERS OF A NORMAL PHASE INTRODUCE A QUENCHED DISORDER INTO THE VORTEX SYSTEM. PINNING AND TRANSPORT OF VORTICES IN THE PRESENCE OF FRACTAL INTERFACE BETWEEN NORMAL AND SUPERCONDUCTING PHASES ARE STUDIED. IT IS REVEALED THAT A MIXED STATE OF THE VORTEX GLASS IS REALIZED IN THE SUPERCONDUCTORS INVOLVED. THE PHASE OF THE VORTEX GLASS CAN BE IDENTIFIED BY THE INITIAL PART OF CURRENT-VOLTAGE CHARACTERISTIC. GLASSY EXPONENT IS ESTIMATED AND ITS VALUE IS CONSISTENT WITH THE CONCEPT OF THE VORTEX BUNDLE PINNING. THE DEPENDENCE OF THE GLASSY EXPONENT ON THE FRACTAL DIMENSION OF THE CLUSTER BOUNDARY IS FOUND. THE ERGODICITY BREAKING IN THE VORTEX GLASS IS ANALYZED. THE RESULTS ARE APPLICABLE TO YBCO AND BSCCO COMPOSITES.

3MP3B-04

CRITICAL CURRENT MEASUREMENT OF HTS YBACUO RIBBONS ***T. LECREVISSE****, J. REY, J. GHELLER, O. LOUCHARD;* CEA SACLAY. — RECENT PROGRESSES IN YBACUO RIBBONS MANUFACTURING HAVE MADE RELEVANT USING THESE CONDUCTORS FOR HIGH FIELD MAGNET WITH LOWER CRYOGENICS NEED. IN ORDER TO PREPARE DESIGN EFFORTS OF SUPERCONDUCTING DEVICES THE CEA SACLAY HAS STARTED ELECTROMAGNETIC CHARACTERIZATION OF SOME YBACUO RIBBONS. THE RESULTS OF THE CRITICAL CURRENT MEASUREMENTS ARE PRESENTED HERE AND SOME CRITICAL CURRENT FITS HAVE BEEN DETERMINED. SOME PARTICULAR BEHAVIOR HAVE BEEN OBSERVED AND ARE PRESENTED HERE.

3MP3B-05

NUMERICAL INVESTIGATIONS ON EDGE EFFECTS OF SHIELDING CURRENT DENSITY IN HTS THICK FILM ***S. IKUNO****[1], T. TAKAYAMA[2], A. KAMITANI[2];* [1]TOKYO UNIVERSITY OF TECHNOLOGY, [2]YAMAGATA UNIVERSITY. — OHSHIMA ET AL. HAVE PROPOSED THE PERMANENT MAGNET METHOD FOR MEASURING THE CRITICAL CURRENT DENSITY. WHILE BRINGING A PERMANENT MAGNET CLOSER TO A HTS THIN FILM, THEY MEASURED THE ELECTROMAGNETIC FORCE ACTING ON THE FILM. AS A RESULT, THEY FOUND THAT THE MAXIMUM REPULSIVE FORCE IS APPROXIMATELY PROPORTIONAL TO THE CRITICAL CURRENT DENSITY. THIS TENDENCY IMPLIES THAT THE CRITICAL CURRENT DENSITY CAN BE DETERMINED BY MEASURING THE ELECTROMAGNETIC INTERACTION BETWEEN THE MAGNET AND THE HTS FILM. HOWEVER, THE DEGRADATION OF MEASUREMENT ACCURACY OCCURS BECAUSE OF THE EDGE EFFECT AND THE LOCATIONS OF MEASUREMENT ARE FURTHER AT A DISTANCE FROM THE EDGE OF HTS SO AS NOT TO RECEIVE THE INFLUENCE OF EDGE EFFECTS.THE PURPOSE OF THE PRESENT STUDY IS TO INVESTIGATE BEHAVIOR OF THE SHIELDING CURRENT DENSITY AT THE EDGE OF HTS NUMERICALLY AND TO NUMERICALLY EVALUATE THE INFLUENCE WHICH THE EDGE EFFECTS OF SHIELDING CURRENT DENSITY CAUSES TO THE MEASUREMENT OF CRITICAL CURRENT DENSITY BY MEANS OF THE PERMANENT MAGNET METHOD.

3MP3B-06

THE IC BEHAVIOR OF 2G YBCO TAPES UNDER DC MAGNETIC FIELD AT VARIOUS TEMPERATURES ***R. PEI****, Z. HONG, T. COOMBS;* CAMBRIDGE UNIVERSITY. — IN ORDER TO BE ABLE TO SUCCESSFULLY DESIGN HTS MACHINES WHICH ARE ABLE TO OPERATE SAFELY AND RELIABLY, STUDIES OF CHARACTERISATION OF 2G HTS TAPES ARE OF PARAMOUNT IMPORTANCE. THIS PAPER MAINLY PRESENTS CALCULATION AND MEASUREMENT OF CRITICAL CURRENT AS EXPERIENCED BY 2G HIGH TEMPERATURE SUPERCONDUCTOR (HTS) UNDER HIGH DC MAGNETIC FIELD (UP TO 5 TESLA) AS WELL AS VARIETIES OF TEMPERATURE RANGE FROM 25K TO 77K. THE 2G TAPE MEASURED IS SGS12050 COATED CONDUCTOR MADE BY SUPERPOWER COMPANY. THE CRITICAL CURRENT IS MEASURED BY FLUX VECTOR WITH REFERENCE TO WIDEST SAMPLE FACE FROM 0 TO 90 DEGREES AT 10 DEGREE STEPS. SMALLER STEPS WILL BE REQUIRED NEAR TO 0O. A VARIABLE TEMPERATURE INSERT (VTI) IS UTILIZED TO CONTROL TEMPERATURE CHANGE IN A MAGNETIC FIELD.AT FIRST, WE WILL GIVE A BRIEF INTRODUCTION TO THE BASIC DESIGN STRATEGY FOR SYNCHRONOUS MOTOR AND CHARACTERISTICS SPECIFICATION OF SUPERCONDUCTING

MATERIALS. THEN, THE BASIC PRINCIPLE AND ALGORITHM FOR CALCULATION AND MODELING OF IC UNDER HIGH MAGNETIC FIELD AT VARYING TEMPERATURE WILL BE EXPLAINED. SECONDLY, THE NOVEL MEASUREMENT SYSTEM USING VTI, A BOTTOM-LOADING VACUUM DEWAR AND DC MAGNETS IS PRESENTED. FINALLY, WE PRESENT AND ANALYZE CALCULATING AND EXPERIMENTAL RESULTS FOR 2G YBCO TAPE.

3MP3B-07

ELECTRICAL CHARACTERISTICS OF STACKS OF YBCO TAPES IN APPLIED MAGNETIC FIELD ***J. KIM****, C. KIM, J. KVITKOVIC, S. PAMIDI;* CENTER FOR ADVANCED POWER SYSTEMS. — SECOND GENERATION (2G) HIGH TEMPERATURE SUPERCONDUCTOR (HTS) IS BEING DEVELOPED FOR APPLICATION IN HTS POWER DEVICES SUCH AS POWER TRANSMISSION CABLES, TRANSFORMERS, SUPERCONDUCTING FAULT CURRENT LIMITER (SFCL), MOTORS, AND GENERATORS. FOR LARGE POWER CAPACITY OF HTS DEVICES, STACKED HTS TAPES NEED TO BE USED BECAUSE SINGLE HTS TAPE HAS A LIMITED CAPACITY IN CARRYING CURRENT. THE STACKED HTS TAPES HAVE DIFFERENT CHARACTERISTICS COMPARED WITH THE SINGLE HTS TAPE BECAUSE OF SCREENING EFFECT IN MAGNETIC FIELD. IN THIS STUDY, CRITICAL CURRENT MEASUREMENTS WERE PERFORMED ON RABITS AND IBAD 2G HTS TAPE STACKS IN THE TEMPERATURE RANGE OF 40 TO 77 K. TRANSPORT CHARACTERISTICS OF SEVERAL STACKS WERE MEASURED IN SELF FIELD AND EXTERNAL MAGNETIC FIELD APPLIED PERPENDICULAR AND PARALLEL TO THE TAPE SURFACE. CHARACTERISTICS OF THE STACKS FABRICATED WITH VARYING STAKING ARRANGEMENTS ARE COMPARED. THE EXPERIMENTAL RESULTS WILL BE RELATED TO IMPORTANT DESIGN CONSIDERATIONS OF HTS POWER DEVICES.

3MP3B-08

ANALYSIS OF LOCAL CURRENT DISTRIBUTION IN PATTERNED YBCO COATED CONDUCTORS USING LOW-TEMPERATURE SCANNING LASER MICROSCOPY ***S. PARK****, J. KIM, G. KIM, B. CHO, H. RI;* DEPT. OF PHYSICS, KYUNGPOOK NATIONAL UNIVERSITY. — DISTRIBUTION OF LOCAL TRANSPORT CURRENT IN PATTERNED YBCO COATED CONDUCTORS WERE INVESTIGATED USING LOW-TEMPERATURE SCANNING LASER MICROSCOPY (LTSLM). WE PREPARED YBCO COATED CONDUCTORS OF VARIOUS BRIDGE TYPES TO STUDY THE SPATIAL DISTRIBUTION OF TRANSPORT CURRENT IN SINGLE AND MULTI BRIDGES. WE ALSO ANALYZED THE EFFECT OF THE SCREENING CURRENT IN MULTI BRIDGES EXPOSED TO EXTERNAL MAGNETIC FIELDS. USING LTSLM, WE DIRECTLY VISUALIZED THE PATH OF CURRENT FLOW IN YBCO COATED CONDUCTORS OF VARIOUS PATTERNS.

THIS WORK WAS SUPPORTED BY THE NUCLEAR RESEARCH & DEVELOPMENT PROGRAM OF THE NRF GRANT AND THE R&D PROGRAM THROUGH THE NFRI FUNDED BY THE KOREAN GOVERNMENT MEST.

3MP3B-09

STUDY OF THE IRREVERSIBILITY LINE AND CRITICAL CURRENT OF BISCCO THIN FILMS WITH DIFFERENT SUPERCONDUCTING PHASES *A. MARIÑO CAMARGO,* ***M. B. LOPEZ SANTOS****, P. A. GARCÉS CONSTAIN;* UNIVERSIDAD NACIONAL DE COLOMBIA. — THE EFFECTS ON THE TRANSPORT PROPERTIES SUCH AS CRITICAL CURRENT DENSITY (JC), IRREVERSIBILITY LINE (IL) AND ACTIVATION ENERGY (EA) WERE STUDIED IN HIGHLY ORIENTED BSCCO THIN FILMS WITH DIFFERENT SUPERCONDUCTING PHASE RATIOS H-2223 (110K):L-2212 (85K) BY ZFC-FC METHOD IN RESISTIVITY MEASUREMENTS IN THE LOW MAGNETIC FIELD REGION (LESS THAN 0.1T). HIGHLY ORIENTED BSCCO SUPERCONDUCTING THIN FILMS WITH DIFFERENT SUPERCONDUCTING PHASES, AS DETERMINED BY X- RAY DIFFRACTION (XRD), WERE PRODUCED BY R.F. MAGNETRON SPUTTERING ON MGO (100) SUBSTRATES AND DIFFERENT POST-ANNEALING DURATION TIMES.THE CRITICAL CURRENT DENSITY (JC) AND THE ACTIVATION ENERGY (EA) WERE DETERMINED USING THE 10 MVOLT CRITERION AND FROM ARRHENIUS PLOTS OF RESISTANCE DATA RESPECTIVELY. BOTH DECREASED BY DECREASING THE PHASE RATIO. THIS BEHAVIOR HAS BEEN ATTRIBUTED TO AN INCREASING OF THE FILMS GRANULARITY. THE FILM GRANULARITY HAS BEEN ASSUMED AS ANY CRYSTAL LATTICE DEFECT, WHICH, CREATES A LOCAL DEPRESSION OF THE SUPERCONDUCTING ORDER PARAMETER.THE $T_{IRR}(H)$ DATA APPEAR DOMINATED BY THE INTERGRAIN JOSEPHSON FLUX. THEY EXHIBIT THE BEHAVIOR OF THE GRAIN COUPLING SYSTEMS (SIMILAR TO THAT DISPLAYED BY SPIN GLASSES) AND CAN BE WELL DESCRIBED BY A POWER LAW LIKE ALMEIDA-THOULES. ADDITIONALLY THE IRREVERSIBILITY LINE (IL) WAS SHIFTED TO LOWER TEMPERATURES BY DECREASING THE PHASE RATIO.

3MX-01

ELECTRO-MECHANICAL CHARACTERIZATION OF BI-2212 STRANDS ***X. F. LU***[1]*, N. CHEGGOUR*[1]*, T. C. STAUFFER*[1]*, C. C. CLICKNER*[1]*, U. TROCIEWITZ*[2]*, D. MYERS*[2]*, T. G. HOLESINGER*[3]*;* [1]NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY, BOULDER, CO 80305, [2]NATIONAL HIGH MAGNETIC FIELD LABORATORY, TALLAHASSEE, FL 32310, [3]LOS ALAMOS NATIONAL LABORATORY, LOS ALAMOS, NM 87545. — IMPORTANT NEW PHYSICS OPPORTUNITIES HAVE BEEN IDENTIFIED IN HIGH ENERGY PHYSICS AT MAGNETIC FIELDS ABOVE 20 TESLA (T) THAT ARE BEYOND THE REACH OF PRESENT NBTI AND NB_3SN MATERIALS. IN ADDITION, ULTRA-HIGH MAGNETIC FIELDS ARE DESIRABLE FOR OTHER APPLICATIONS SUCH AS NUCLEAR MAGNETIC RESONANCE MAGNETS (NMR). BI-2212 IS ONE OF THE PROMISING HTS CANDIDATES FOR MAKING HIGH FIELD MAGNETS DUE TO ITS VERY HIGH UPPER CRITICAL FIELD, AND BECAUSE IT CAN BE MADE IN A ROUND WIRE CONDUCTOR FORM. OWING TO THE BRITTLE NATURE OF BI-2212 CONDUCTOR, CHARACTERIZATION OF ITS ELECTRO-MECHANICAL PROPERTIES IS CRUCIAL FOR THE MAGNET DESIGN. WE WILL REPORT RESULTS ON AXIAL STRAIN AND MAGNETIC FIELD DEPENDENCE OF THE CRITICAL CURRENT FOR NEWLY DEVELOPED BI-2212 CONDUCTORS. THESE MEASUREMENTS WERE MADE AS A FUNCTION OF TENSILE AND COMPRESSIVE STRAIN IN MAGNETIC FIELDS AT 4 K. THE IRREVERSIBILITY

ASPECT OF I_C VERSUS STRAIN WILL BE DISCUSSED. WE HAVE ALSO MEASURED STRESS-STRAIN CHARACTERISTICS OF THESE BI-2212 STRANDS AND VARIOUS AG/AG-ALLOY MATERIALS AT ROOM AND LIQUID-NITROGEN TEMPERATURES TO IDENTIFY POSSIBLE MATERIALS THAT COULD BE USED FOR STRENGTHENING BI-2212 WIRES WITHOUT DEPRESSING THEIR SUPERCONDUCTING PROPERTIES.

THIS WORK IS PART OF THE U.S. VERY HIGH FIELD SUPERCONDUCTING MAGNET COLLABORATION (VHFSMC)

3MX-02

INFLUENCE OF THICKNESS OF SUPERCONDUCTING LAYER ON DOUBLE PEAK BEHAVIOR IN STRAIN EFFECT ON CRITICAL CURRENT UNDER MAGNETIC FIELD FOR YBCO COATED CONDUCTORS ***M. SUGANO***[1]*, K. SHIKIMACHI*[2]*, N. HIRANO*[2]*, S. NAGAYA*[2]*;* [1]KYOTO UNIVERSITY, [2]CHUBU ELECTRIC POWER CO.. — WE HAVE INVESTIGATED THE FUNDAMENTAL ELECTRO-MECHANICAL PROPERTIES OF YBCO COATED CONDUCTORS FOR THEIR APPLICATION TO SMES (SUPERCONDUCTING MAGNETIC ENERGY STORAGE). REVERSIBLE VARIATION OF CRITICAL CURRENT WITH STRAIN (IC(E)) HAS BEEN FOUND IN THE YBCO COATED CONDUCTORS AND THE IC(E) IN SELF FIELD SHOWS THE PARABOLIC STRAIN DEPENDENCE WITH ONE PEAK. ON THE OTHER HAND, THE DOUBLE PEAK BEHAVIOR HAS BEEN OBSERVED IN THE IC(E) UNDER MAGNETIC FIELD. THE PEAK WAS OBSERVED IN THE COMPRESSIVE STRAIN REGIONS AS WELL AS TENSILE ONE. SUCH DOUBLE PEAK IN THE IC(E) HAS NOT BEEN REPORTED IN OTHER SUPERCONDUCTING COMPOSITES AND IS UNIQUE TO THE YBCO COATED CONDUCTOR. IN THE PRESENT STUDY, THE IN-FIELD IC(E) WAS MEASURED FOR THE COATED CONDUCTORS WITH DIFFERENT THICKNESS OF THE YBCO LAYER USING 4-POINT BENDING METHOD AT THE TEMPERATURES HIGHER THAN 77 K. THE ORIGIN OF THE PEAKS IN THE IC(E) WILL BE DISCUSSED BASED ON THE MICROSTRUCTURE OF THE YBCO FILM.

THIS WORK WAS SUPPORTED BY THE NEW ENERGY AND INDUSTRIAL TECHNOLOGY DEVELOPMENT ORGANIZATION (NEDO) AS THE TECHNOLOGICAL DEVELOPMENT OF YTTRIUM-BASED SUPERCONDUCTING POWER EQUIPMENT.

3MX-03

MAGNETIC FIELD AND FIELD-ANGULAR DEPENDENCE OF THE EFFECT OF STRAIN ON CRITICAL CURRENT DENSITY AND FLUX PINNING IN $YBA_2CU_3O_{7-\Delta}$ COATED CONDUCTORS ***J. F. DOUGLAS***[1]*, D. C. VAN DER LAAN*[1]*, T. C. STAUFFER*[1]*, C. C. CLICKNER*[1]*, L. F. GOODRICH*[1]*, M. W. RUPICH*[2]*, Y. Y. XIE*[3]*, A. USOSKIN*[4]*, H. C. FREYHARDT*[5]*, V. SELVAMANICKAM*[5]*;* [1]NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY, [2]AMERICAN SUPERCONDUCTOR CORPORATION, [3]SUPERPOWER, INC., [4]BRUKER HTS, [5]UNIVERSITY OF HOUSTON. — A LARGE, MAGNETIC FIELD-DEPENDENT, REVERSIBLE REDUCTION IN CRITICAL CURRENT DENSITY WITH APPLIED AXIAL STRAIN HAS BEEN MEASURED IN $YBA_2CU_3O_{7-\Delta}$ COATED CONDUCTORS. THE DEGRADATION IN CRITICAL CURRENT WITH BOTH COMPRESSIVE AND TENSILE STRAIN IS FOUND TO GREATLY INCREASE WHEN AN EXTERNAL MAGNETIC FIELD IS APPLIED. BY MEASURING THIS EFFECT ON COATED CONDUCTORS WITH YBCO LAYERS THAT WERE DEPOSITED BY MOD, MOCVD, AND HR-PLD, AND BY VARYING THE ANGLE OF THE MAGNETIC FIELD WITH RESPECT TO THE CRYSTAL AXES, THE EFFECT OF STRAIN ON CORRELATED AND INTRINSIC PINNING SITES WAS STUDIED. THIS STUDY SHOWS THAT BOTH TYPES OF PINNING ARE AFFECTED BY STRAIN, BUT NOT BY THE SAME AMOUNT. WHILE THE MECHANISM IS NOT CLEARLY UNDERSTOOD, IT IS OBVIOUS THAT IT HAS MAJOR IMPLICATIONS FOR COATED CONDUCTOR APPLICATIONS THAT OPERATE IN A MAGNETIC FIELD. IT IS THEREFORE IMPORTANT TO MEASURE THE EFFECT OF STRAIN ON FLUX PINNING AND DETERMINE WHICH PINNING MECHANISM IS MOST EFFECTIVE UNDER THE CONDITIONS THAT THE COATED CONDUCTOR NEEDS TO OPERATE.

THIS WORK HAS BEEN SPONSORED IN PART BY THE DOE OFFICE OF ELECTRICITY DELIVERY AND ENERGY RELIABILITY

3MX-04

ORIGIN OF THE REVERSIBLE STRAIN EFFECT ON CRITICAL CURRENT DENSITY AND FLUX PINNING IN $BI_2SR_2CA_2CU_3O_X$ TAPES ***D. VAN DER LAAN***[1]*, F. DOUGLAS*[1]*, C. CLICKNER*[1]*, T. STAUFFER*[1]*, L. F. GOODRICH*[1]*, H. J. N. VAN ECK*[2]*;* [1]NIST, [2]FOM-INSTITUTE FOR PLASMA PHYSICS RIJNHUIZEN. — THE REVERSIBLE CHANGE IN THE PERFORMANCE OF HIGH-TEMPERATURE SUPERCONDUCTORS WITH STRAIN IS EXPECTED TO HAVE A SIGNIFICANT IMPACT ON CERTAIN APPLICATIONS. THE EFFECT, WHICH IS MOST PRONOUNCED IN $YBA_2CU_3O_{7-\Delta}$, IS STILL NOT COMPLETELY UNDERSTOOD DUE TO THE COMPLEX INTERACTION BETWEEN STRAIN AND THE MICROSTRUCTURE OF THE SUPERCONDUCTOR. WE WILL SHOW THAT, UNLIKE $YBA_2CU_3O_{7-\Delta}$, THIS INTERACTION IS FULLY UNDERSTOOD IN $BI_2SR_2CA_2CU_3O_X$. THE REVERSIBLE EFFECT OF STRAIN ON CRITICAL CURRENT DENSITY AND FLUX PINNING IN $BI_2SR_2CA_2CU_3O_X$ TAPES AT 65 K AND 76 K IS EXPLAINED ENTIRELY BY A CHANGE IN CRITICAL TEMPERATURE WITH PRESSURE. THIS NEW INSIGHT IS EXPECTED TO FORM THE BASIS OF A BETTER UNDERSTANDING OF THE REVERSIBLE STRAIN EFFECT IN OTHER HIGH-TEMPERATURE SUPERCONDUCTORS, SUCH AS $YBA_2CU_3O_{7-\Delta}$.

THIS WORK WAS SUPPORTED IN PART BY THE U.S. DEPARTMENT OF ENERGY, OFFICE OF ELECTRICITY DELIVERY AND ENERGY RELIABILITY.

3MX-05

UNUSUAL INTERNAL STRAIN BEHAVIOR EXERTED ON YBCO LAYER IN THE SURROUND CU STABILIZED YBCO COATED CONDUCTOR ***K. OSAMURA***[1]*, S. MACHIYA*[2]*, Y. TSUCHIYA*[3]*, S. HARJO*[4]*, H. SUZUKI*[4]*, T. SHOUBU*[4]*, K. KIRIYAMA*[4]*, M. SUGANO*[5]*;* [1]RESEARCH INSTITUTE FOR APPLIED SCIENCES, [2]DAIDO UNIVERSITY, [3]NATIONAL INSISTUTE FOR MATERIALS SCIENCE, [4]JAPAN ATOMIC ENERGY AGENCY, [5]KYOTO UNIVERSITY. — THE STRESS/STRAIN DEPENDENCES OF THE SURROUND CU STABILIZED YBCO COATED CONDUCTOR WERE PRECISELY INVESTIGATED BY MEANS OF WHITE X-RAY AT SPRING-8 AND

PULSED NEUTRONS AT J-PARC TAKUMI TOGETHER WITH THE CRITICAL CURRENT MEASUREMENTS. MULTIPLE DIFFRACTION PEAKS WERE OBSERVED ALONG LONGITUDINAL AND TRANSVERSE DIRECTIONS WITH THE TAPE AXIS AS A FUNCTION OF TENSILE LOAD IN ORDER TO EVALUATE IN DETAILS THE THREE DIMENSIONAL INTERNAL STRAINS. THE FOLLOWING UNUSUAL INTERNAL STRAIN BEHAVIORS EXERTED ON THE YBCO LAYER WERE ELUCIDATED. PAIRS OF (020) / (200) AND (040) / (400) WERE OBSERVED SIDE BY SIDE AND THEIR DIFFRACTION INTENSITY WAS ALMOST CONSTANT WITH INCREASING TENSILE LOAD. THE RATIO OF THE INTERNAL STRAIN OBTAINED FROM EACH LATTICE PLANE WITH THE MACROSCOPIC STRAIN BECAME LESS THAN UNITY AT ALL. THE DIFFRACTION ELASTIC CONSTANTS FROM (0K0) DIFFRACTION PEAKS WERE LARGER THAN ONES FROM (H00) PEAKS. THE FORCE FREE STRAIN, WHERE THE INTERNAL STRESS BECOMES ZERO IN THE YBCO LAYER WAS EVALUATED TO BE 0.19 - 0.21 % AT 77 K, WHILE THE CRITICAL CURRENT MAXIMUM WAS OBSERVED AT 0.035% STRAIN. IT IS STRONGLY SUGGESTED THAT THE MICRO TWIN STRUCTURE IS KEY NANOSTRUCTURE TO UNDERSTAND THEIR PRESENT UNUSUAL INTERNAL STRAIN BEHAVIOR AS WELL AS THEIR INFLUENCE TO THE STRAIN DEPENDENCE OF CRITICAL CURRENT.

3MX-06

HOOP STRESS TEST OF $GDBA_2CU_3O_Y$ COATED CONDUCTOR ***G. NISHIJIMA***[1], *K. MINEGISHI*[1], *S. AWAJI*[1], *K. WATANABE*[1], *T. IZUMI*[2], *Y. SHIOHARA*[2]; [1]INSTITUTE FOR MATERIALS RESEARCH, TOHOKU UNIVERSITY, [2]SUPERCONDUCTIVITY RESEARCH LABORATORY, INTERNATIONAL SUPERCONDUCTIVITY TECHNOLOGY CENTER. — HOOP STRESS TESTS HAVE BEEN PERFORMED FOR $GDBA_2CU_3O_Y$ COATED CONDUCTORS. THE CONDUCTORS WERE FABRICATED BY DEPOSITING GDBCO LAYER ON CEO_2 BUFFERED $LAMNO_3$/IBAD-MGO/GD-ZR-O/HASTELLOY C276 SUBSTRATE BY THE PLD METHOD. THE SUPERCONDUCTOR AND SUBSTRATE THICKNESS WERE 1.2 μM AND 100 μM, RESPECTIVELY. A 10-μM SILVER LAYER WAS DEPOSITED AS A STABILIZER.THE HOOP STRESS TEST COILS WERE FABRICATED BY WINDING THE 5-MM WIDTH CONDUCTOR ON A 270-MM DIAMETER GFRP BOBBIN BY 1.5 TURNS. TWO COILS WERE FABRICATED; THE HASTELLOY SUBSTRATE LOCATED OUTSIDE FOR ONE AND INSIDE FOR THE OTHER. STRAIN GAUGES WERE GLUED AND VOLTAGE TAPS WERE SOLDERED.THE HOOP STRESS TESTS WERE PERFORMED AT 4.2 K AND IN 11 T. THE MAXIMUM VALUE OF APPLIED HOOP STRESS, WHICH WAS DEDUCED FROM BJR (MAGNETIC FIELD, CURRENT DENSITY AND COIL RADIUS), WAS 1250 MPA AND 1100 MPA FOR HASTELLOY-OUTSIDE AND HASTELLOY INSIDE TEST COILS. THE MEASURED STRAIN VALUES WERE IN GOOD AGREEMENT AMONG THE FIVE STRAIN GAUGES. FURTHERMORE, THE OBTAINED STRESS (BJR)-STRAIN DATA SHOWED ELASTIC MODULUS OF 190 GPA, WHICH WAS IN GOOD AGREEMENT WITH SHORT SAMPLE MECHANICAL PROPERTY.

THIS WORK WAS SUPPORTED BY KAKENHI AND NEW ENERGY AND INDUSTRIAL TECHNOLOGY DEVELOPMENT ORGANIZATION.

3MX-07

INFLUENCE OF SHEAR STRAIN ON CURRENT CARRYING CAPABILITIES OF HTSC TAPES ***C. BARTH***, *K. WEISS, W. GOLDACKER;* KIT, INSTITUTE FOR TECHNICAL PHYSICS, GERMANY. — TO ACHIEVE HIGH CURRENTS SINGLE HTSC TAPES OR ROEBLE STRANDS MUST BE COMBINED INTO A CABLE. MANY CONCEPTS LIKE RUTHERFORD CABLE, COATED CABLE IN CONDUIT OR FULL SIZE CABLE MODEL OF ROEBEL STRANDS REQUIRE TWISTING OF THE HTSC TAPES. TWISTING OR TORSION EXERTS LONGITUDINAL AND SHEAR STRAIN ON THE TAPES WHICH DEGRADE THE CURRENT CARRYING CAPABILITIES. FINITE ELEMENT ANALYSIS WAS DONE TO EXPLAIN THIS BEHAVIOR. HOWEVER, THE INFLUENCE OF LONGITUDINAL STRAIN IN HTSC TAPES ON CRITICAL CURRENT IS WELL DOCUMENTED, BUT THERE IS NO EXPERIMENTAL DATA FOR PURE SHEAR STRAIN AVAILABLE. TO VERIFY THE FINITE ELEMENT ANALYSIS SHEAR STRAIN EXPERIMENTS ARE OF SIGNIFICANT INTEREST.WITH A THREE POINT BENDING METHOD SHEAR STRAIN CAN BE APPLIED TO A SINGLE HTSC TAPE. CRITICAL CURRENT MEASUREMENTS WITH VARYING SHEAR STRAIN ARE CONDUCTED FOR SEVERAL HTSC TAPES.WITH THE EXPERIMENTAL RESULTS AND THE LONGITUDINAL STRAIN DEPENDENCE A CORRELATION BETWEEN TORSION EXPERIMENTS AND FINITE ELEMENT ANALYSIS IS POSSIBLE.

3MX-08

FINITE ELEMENT ANALYSIS OF TORSION EXPERIMENTS ON HTSC TAPES ***K. WEISS***[1], *W. GOLDACKER*[1], *M. NANNINI*[2]; [1]KIT INSTITUTE FOR TECHNICAL PHYSIC, GERMANY, [2]CEA CADARACHE, FRANCE. — DURING THE PAST YEARS THE APPLICATION OF 2G HTSC MATERIAL IS GROWING. HOWEVER, TO ACHIEVE HIGH CURRENTS SINGLE HTSC TAPES MUST ASSEMBLED IN A ROEBEL-CABLE GEOMETRY. GOING TO EVEN LARGER CABLE CONCEPTS LIKE RUTHERFORD CABLES, TWISTING OF HTSC TAPES IS REQUIRED. TO EXAMINE THE INFLUENCE OF TWISTING OR TORSION ON CRITICAL CURRENT OF COATED CONDUCTOR TAPES OR ROEBEL STRANDS, SYSTEMATIC EXPERIMENTS WERE CARRIED OUT GIVING RESULTS FOR CRITICAL TWISTING LENGTHS. THE RESULTS HAVE TO BE EXAMINED CONSIDERING THE DIFFERENT STRAIN STATES WITHIN THE TAPE UNDER TORSION. ON ONE HAND LONGITUDINAL STRAIN PLAYS A ROLE, BUT ON THE OTHER HAND SHEAR STRAIN HAS TO BE ADDRESSED ALSO.TO UNDERSTAND THESE RESULTS THEORETICAL ASSESSMENT OF THE STRESS-STRAIN SITUATION WITHIN THE TAPE UNDER TORSION WAS PERFORMED. TOGETHER WITH FINITE ELEMENT ANALYSIS THE EFFECT OF LONGITUDINAL AND SHEAR STRAIN WAS SYSTEMATICALLY EXAMINED TO GIVE AN UNDERSTANDING OF THE CRITICAL CURRENT BEHAVIOR UNDER TORSION.

3MY-01

INFLUENCE OF HEAVY-ION IRRADIATION ON FLUX PINNING AND SUPERFLUID DENSITY IN SINGLE CRYSTALS OF 122 PNICTIDE SUPERCONDUCTORS ***R. PROZOROV***[1], *M. A. TANATAR*[1], *P. C. CANFIELD*[1], *U. WELP*[2], *W. K. KWOK*[2]; [1]AMES

LABORATORY, [2]ARGONNE NATIONAL LABORATORY. — SINGLE CRYSTALS OF BA(FE1−XTX)2AS2 (T=CO, NI) WERE IRRADIATED WITH 1.4 GEV PB IONS. MAGNETO-OPTICAL IMAGING HAS BEEN USED TO MAP THE DISTRIBUTION OF THE MAGNETIC INDUCTION IN THE IRRADIATED SAMPLES. THE RESULTS SHOW A SUBSTANTIAL AND UNIFORM ENHANCEMENT OF THE CRITICAL CURRENT DENSITY AT ALL TEMPERATURES. MAGNETO-OPTICAL OBSERVATIONS ARE SUPPORTED BY THE CONVENTIONAL MAGNETIC MEASUREMENTS REVEALING A LARGE INCREASE OF THE HYSTERETIC MAGNETIZATION. LONDON PENETRATION DEPTH, MEASURED BY USING TUNNEL-DIODE RESONATOR, HAS REVEALED A SYSTEMATIC VARIATION OF THE LOW - TEMPERATURE BEHAVIOR WITH THE INCREASED DEGREE OF DISORDER DUE TO IRRADIATION. THE RESULTS SUPPORT EXTENDED S_{+/-} PAIRING STATE IN THE PRESENCE OF SIGNIFICANT SCATTERING.

3MY-02

FLUX PINNING IN FE-BASED ARSENIDE OXIDES WITH THICK BLOCKING LAYERS ***J. SHIMOYAMA****, H. OGINO, N. KAWAGUCHI, S. SATO, Y. SHIMIZU, K. MACHIDA, A. YAMAMOTO, K. KISHIO;* UNIVERSITY OF TOKYO. — RECENTLY, WE HAVE DISCOVERED NEW FE-BASED ARSENIDE OXIDES HAVING PEROVSKITE-TYPE THICK BLOCKING LAYERS MORE THAN 1.5 NM, WHICH IS MUCH LARGER THAN THAT IN A HIGHLY ANISOTROPIC BI-BASED CUPRATES. AMONG THEM, SEVERAL COMPOUNDS EXHIBIT 40 K-CLASS SUPERCONDUCTIVITY. IN THE CUPRATE SUPERCONDUCTORS, BOTH IRREVERSIBILITY FIELDS AND PINNING FORCE DENSITY SYSTEMATICALLY DECREASE WITH AN INCREASE IN THICKNESS OF THE BLOCKING LAYER EXCEPT AT VERY LOW TEMPERATURES. SIMILAR TENDENCY CAN BE SUPPOSED IN THE FE-BASED PNICTIDE OXIDES.IN THE PRESENT STUDY, CRITICAL CURRENT PROPERTIES HAVE BEEN STUDIED FOR OF THE NEW 40 K-CLASS SUPERCONDUCTORS HAVING DIFFERENT INTERLAYER DISTANCE BETWEEN FE-LAYERS TO EVALUATE EFFECTS OF TWO-DIMENSIONALITY IN THE CRYSTAL STRUCTURE ON FLUX PINNING OF THE FE-BASED ARSENIDE OXIDES. THE IRREVERSIBILITY LINES OF THESE NEW SUPERCONDUCTORS WERE FOUND TO LOCATE MUCH LOWER FIELDS THAN THOSE OF FE-BASED 122 AND 1111 COMPOUNDS, SUGGESTING POOR FLUX PINNING NATURE IN THE HIGHLY ANISOTROPIC SUPERCONDUCTORS. FLUX PINNING PROPERTIES OF THE LAYERED FE-BASED ARSENIDE SYSTEM WILL BE DISCUSSED IN TERMS OF CRYSTAL STRUCTURE AND CONDUCTIVITY AT THE BLOCKING LAYERS.

THIS WORK WAS SUPPORTED BY JST-TRIP.

3MY-03

ENHANCED SUPERCONDUCTIVITY IN $FESE_{1-X}TE_X$ SYSTEM WITH LI DOPING ***C. YANG****[1], P. CHEN[1], S. HUANG[1], I. CHEN[1], X. QI[1], M. WU[2];* [1]DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING, NATIONAL CHENG KUNG UNIVERSITY, TAINAN, TAIWAN, [2]INSTITUTE OF PHYSICS, ACADEMIA SINICA, TAIPEI, TAIWAN. — IT HAS BEEN REPORTED THAT FESE BINARY IRON-BASED SUPERCONDUCTOR HAD TC~8K AND INCREASE TO 13K WHEN SE IS PARTIALLY SUBSTITUTED WITH TE AS $FESE_{1-X}TE_X$. THE DOPING EFFECT OF NON-TOXIC FESE WITHOUT CHALCOGENIDE (SUCH AS AS) ELEMENT SHOWS LOWER TC BUT CONSISTS OF SIMPLE CRYSTAL STRUCTURE THAT IS A SUITABLE SYSTEM TO STUDY THE DOPING MECHANISM IN IRON-BASED SUPERCONDUCTOR. IN THIS STUDY, THE CHEMICAL DOPING OF MONOVALENT LI IN FE(SE,TE) SYSTEM WAS STUDIED. FOR FESE SAMPLES, THE LI DOPING INDUCED PRECIPITATE WITH NIAS STRUCTURE PHASE AND REDUCED ITS SUPERCONDUCTIVITY. FOR $FESE_{1-X}TE_X$ ($1>X\geq0.6$) SAMPLES WITH 1 WT% LI DOPING, IT IS SHOWN THAT TC INCREASED ABOUT 1~1.5K TO ~ 15 K. MORE IMPORTANTLY, THIS LI DOPED $FESE_{1-X}TE_X$ SAMPLE SHOWS ENHANCED DIAMAGNETIC PROPERTY. BASED ON XRD AND RAMAN SHIFT RESULTS, IT IS PROPOSED THAT THE LI DOPING INDUCES THE $FESE_{1-X}TE_X$ ($1>X\geq0.6$) PHASE CHANGE FROM TETRAGONAL TO ORTHORHOMBIC AT FIRST AND THEN RECOVERED AS THE DOPING LEVEL IS FURTHER INCREASED. IT IS FOUND THAT TC BROADENING IS ASSOCIATED WITH THE ORTHORHOMBIC STRUCTURE FORMATION WITH A DISTORTED FE TETRAHEDRAL COORDINATION.

THIS STUDY WAS SUPPORTED BY THE NATIONAL SCIENCE COUNCIL, TAIWAN, REPUBLIC OF CHINA, UNDER CONTRACT NSC 96-2112-M-006-012-MY3.

3MY-04

(INVITED) **UPPER CRITICAL FIELD AND ROLE OF DISORDER ON FE BASED SUPERCONDUCTORS** ***M. PUTTI****[1], M. TROPEANO[1], I. PALLECCHI[2], G. LAMURA[2], C. FERDEGHINI[2], A. MARTINELLI[2], A. PALENZONA[1], R. CIMBERLE[3], C. TARANTINI[4], A. GUREVICH[4], D. LARBALESTIER[4], H. SHEN[5], N. NEWMAN[5], J. ROWELL[5], H. WEN[6];* [1]CNR-SPIN AND UNIVERSITY OF GENOVA, [2]CNR-SPIN, [3]CNR-IMEM, [4]APPLIED SUPERCONDUCTIVITY CENTER, NHMFL, FSU, [5]DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING, ASU, [6]INSTITUTE OF PHYSICS, NATIONAL LABORATORY OF CONDENSED MATTERPHYSICS, BEIJING. — WE COMPARE THE UPPER CRITICAL FIELD (H_{C2}) BEHAVIOUR OF FE BASED SUPERCONDUCTORS IN WHICH MAGNETIC AND NON MAGNETIC IMPURITIES HAVE BEEN INTRODUCED BY MEANS OF SUBSTITUTION AND IRRADIATION. IN $SMFEASO_{1-X}F_X$ COMPOUNDS F SUBSTITUTION OUT OF THE CONDUCTING LAYER DOES NOT AFFECT THE ELECTRON MEAN FREE PATH AND THE H_{C2} SLOPE SCALES WITH THE CRITICAL TEMPERATURE T_C AS EXPECTED FOR CLEAN SUPERCONDUCTORS. IN $SMFE_{1-X}RU_XASO_{0.85}F_{0.15}$ IN WHICH FE HAS BEEN SUBSTITUTED BY ISOELECTRONIC RU, T_C DECREASES, WHEREAS THE H_{C2} SLOPE REMAINS CONSTANT, INDICATING THAT THE SYSTEM PROGRESSIVELY MOVES FROM THE CLEAN TO THE DIRTY LIMIT. $FE_{1+Y}TE_XSE_{1-X}$ COMPOUNDS WITH INCREASING AMOUNT OF EXCESS FE AND A $NDFEASO_{0.7}F_{0.3}$ SINGLE CRYSTAL IRRADIATED WITH A-PARTICLES EXHIBIT A SIGNIFICANT KONDO-LIKE EXCESS RESISTANCE $\propto$ LNT AND NEGATIVE MAGNETORESISTANCE WHICH SUGGEST THAT TRANSPORT PROPERTIES ARE AFFECTED BY MAGNETIC IMPURITIES. THESE COMPOUNDS ALLOWED INVESTIGATION OF THE ROLE OF MAGNETIC IMPURITIES ON T_C AND H_{C2} WHICH COMES OUT TO BE PECULIAR OF FE BASED SUPERCONDUCTORS. VERY STRIKING IS THE RESULT THAT T_C IS HIGHLY RESISTANT TO DAMAGE EVEN IN THE PRESENCE OF STRONG MAGNETIC

SCATTERING, WHICH SUGGESTS A SIGNIFICANT MAGNETIC CONTRIBUTION TO THE PAIRING STATE.

THIS WORK IS PARTIALLY SUPPORTED BY ITALIAN FOREIGN AFFAIRS MINISTRY (MAE) - GENERAL DIRECTION FOR THE CULTURAL PROMOTION.

3MY-05

ENHANCED CRITICAL TEMPERATURE IN EPITAXIAL FESE0.5TE0.5 THIN FILMS WITH BIAXIAL COMPRESSIVE STRAIN ***C. FERDEGHINI**[1], E. BELLINGERI[1], R. BUZIO[1], A. GERBI[1], D. MARRÈ[2], I. PALLECCHI[1], M. PUTTI[2], A. PALENZONA[2], M. TROPEANO[1], M. CIMBERLE[3];* [1]CNR-SPIN, [2]CNR-SPIN AND UNIVERSITY OF GENOVA, [3]CNR-IMEM. — EPITAXIAL FESE0.5TE0.5 THIN FILMS WERE GROWN BY PULSED LASER ABLATION DEPOSITION ON DIFFERENT SUBSTRATES. HIGH PURITY PHASE AND FULLY EPITAXIAL GROWTH WERE OBTAINED. BY VARYING THE FILM THICKNESS, SUPERCONDUCTING TRANSITION TEMPERATURES UP TO 21K WERE OBSERVED, SIGNIFICANTLY LARGER THAN THE BULK VALUE 16.2 K. STRUCTURAL ANALYSES INDICATED THAT THE A AXIS CHANGES SIGNIFICANTLY WITH THE FILM THICKNESS AND IS LINEARLY RELATED TO THE CRITICAL TEMPERATURE WHILE THE C AXIS IS SMALLER THAN THE BULK VALUE BUT IT IS ALMOST INDEPENDENT ON THE FILM THICKNESS. THIS RESULT INDICATES THE IMPORTANT ROLE OF THE COMPRESSIVE STRAIN IN ENHANCING CRITICAL TEMPERATURE. TC IS ALSO RELATED TO BOTH THEFE-(SE,TE) BOND LENGTH AND FE-(SE,TE)-FE ANGLE, SUGGESTING THE POSSIBILITY OF FURTHER ENHANCEMENT.

3MY-06

J_C SCALING AND ANISOTROPY IN 122 AND 1111 PNICTIDE THIN FILMS ***J. HÄNISCH**, K. IIDA, M. KIDSZUN, S. HAINDL, T. D. THERSLEFF, A. KAUFFMANN, F. KURTH, L. SCHULTZ, B. HOLZAPFEL;* IFW DRESDEN, HELMHOLTZSTR. 20, 01069 DRESDEN, GERMANY. — WE HAVE SUCCESSFULLY GROWN EPITAXIAL, SUPERCONDUCTING FILMS IN TWO FAMILIES OF IRON PNICTIDES, $BA(FE_{1-X}CO_X)_2AS_2$ (122) [1] AND *RE*$FEAS(O_{1-X},F_X)$ (1111, *RE* RARE EARTH) [2]. DETAILED INVESTIGATIONS OF THEIR CRITICAL CURRENT DENSITY J_C WITH RESPECT TO TEMPERATURE AS WELL AS BOTH THE APPLIED MAGNETIC FIELD MAGNITUDE AND ORIENTATION WILL BE SHOWN IN THIS CONTRIBUTION. BOTH FILMS GROW VERY CLEAN AND WITHOUT OBSERVABLE CORRELATED DEFECTS PARALLEL TO THE C-AXIS, AS CONFIRMED BY TEM. THIS IS ALSO REFLECTED IN THE ABSENCE OF A C-AXIS PEAK IN $J_C(\Theta)$. IN CONTRAST TO CUPRATE HIGH-T_C SUPERCONDUCTORS SUCH AS YBCO OR EVEN BI2223, THE PNICTIDES HAVE VERY LOW ANISOTROPIES IN THEIR $J_C(\Theta)$ BEHAVIOUR AS WELL AS IN THEIR CHARACTERISTIC AND CRITICAL FIELDS, SUCH AS H_{IRR} AND H_{C2}. BOTH FAMILIES SHOW THE SAME ANISOTROPY BEHAVIOUR, 122 HAVING SLIGHTLY LOWER ANISOTROPIES [3]. CONSEQUENCES OF THE MULTI-BAND SUPERCONDUCTIVITY IN THESE MATERIALS ON THE J_C SCALING IN AN EXTENDED ANISOTROPIC GINZBURG-LANDAU DESCRIPTION WILL BE DISCUSSED.[1] K. IIDA ET AL., APPL. PHYS. LETT. 95, 192501 (2009).[2] M. KIDSZUN ET AL., SUPERCOND. SCI. AND TECHN. 23, 022002 (2010).[3] K. IIDA ET AL., COND-MAT ARXIV:1001.2505V3

3MY-07

HIGH CRITICAL CURRENTS AND STRONG PINNING IN LOW ANISOTROPY $BACO_XFE_{2-X}AS_2$ THIN FILMS DUE TO NATURALLY GROWN CORRELATED DEFECTS ***B. MAIOROV**[1], T. KATASE[2], H. HIRAMATSU[3], L. CIVALE[1], S. A. BAILY[1], T. G. HOLESINGER[1], H. HOSONO[4];* [1]LOS ALAMOS NATIONAL LABORATORY, [2]MATERIALS AND STRUCTURES LABORATORY, TOKYO INSTITUTE OF TECHNOLOGY, [3]FRONTIER RESEARCH CENTER, TOKYO INSTITUTE OF TECHNOLOGY, [4]FRONTIER RESEARCH CENTER AND MATERIALS AND STRUCTURES LABORATORY, TOKYO INSTITUTE OF TECHNOLOGY AND. — PNICTIDE SUPERCONDUCTORS OFFER A WIDE VARIETY OF POSSIBILITIES FOR APPLICATIONS AND VORTEX PHYSICS DUE TO RELATIVELY HIGH T_C, VERY HIGH UPPER CRITICAL FIELD (H_{C2}) AS WELL AS LOW-ANISOTROPY MULTI-BAND PROPERTIES.ALTHOUGH, EARLY WORKS IN FILMS AND POLYCRYSTALS SHOWED THAT THE CRITICAL CURRENT DENSITY (J_C) OF THESE MATERIALS IS GREATLY DEPRESSED BY GRAIN BOUNDARIES, RECENT WORK REPORTED THAT FILMS DEPOSITED ON $SRTIO_3$ CAN BE GROWN WITHOUT THE GRAIN BOUNDARY PROBLEMS.WE PRESENT J_C , H_M AND H_{C2} MEASUREMENTS AS A FUNCTION OF MAGNETIC FIELD STRENGTH AND ORIENTATION AT DIFFERENT TEMPERATURES FOR $BACO_XFE_{2-X}AS_2$ BIAXIALLY ORIENTED FILMS GROWN ON LSAT SINGLE CRYSTALS WITH $J_C > 1$ MA/CM^2 AT 4K AND *SELF-FIELD.* WE FIND EVIDENCE OF A HIGH DENSITY OF CORRELATED DEFECTS THAT GENERATE A VERY LARGE J_C PEAK AS A FUNCTION OF FIELD ORIENTATION CENTERED NEAR THE C-AXIS ORIENTATION. THE REDUCTION OF THE DISSIPATION IN THE VORTEX LIQUID STATE INDICATES THAT THESE CORRELATED DEFECTS ARE MORE EFFECTIVE THAN SIMILAR DEFECTS FOUND IN MORE ANISOTROPIC SUPERCONDUCTORS SUCH AS YBCO.

WORK AT LANL WAS SUPPORTED BY THE US DOE, OFFICE OF BASIC ENERGY SCIENCE (DIV. OF MATERIALS SCIENCES AND ENGINEERING) AND OFFICE OF ELECTRICITY DELIVERY & ENERGY RELIABILITY, BY NHMFL-UCGP AND BY THE US NSF.

4EA-01

(INVITED) **FUNDAMENTAL NOISE PROCESSES IN TES DEVICES** ***M. GALEAZZI**;* UNIVERSITY OF MIAMI. — IN ADDITION TO THE COMMONLY EXPECTED NOISE CONTRIBUTION TO MICROCALORIMETERS AND BOLOMETERS (JOHNSON NOISE AND PHONON NOISE), TES ARE SIGNIFICANTLY AFFECTED BY EXTRA NOISE, WHICH IS COMMONLY REFERRED TO AS "EXCESS NOISE". DIFFERENT FUNDAMENTAL NOISE PROCESSES HAVE BEEN INVESTIGATED TO EXPLAIN THE ORIGIN OF THIS EXCESS NOISE, NAMELY NEAR EQUILIBRIUM NON-LINEAR JOHNSON NOISE, FLUX-FLOW NOISE, PERCOLATION NOISE, AND INTERNAL THERMAL FLUCTUATION NOISE. EXPERIMENTS SHOW THAT ALL PROCESSES LIKELY CONTRIBUTE TO THE TES NOISE, HOWEVER DIFFERENT PROCESSES DOMINATE IN DIFFERENT REGIMES. THIS TALK WILL START WITH A HISTORICAL OVERVIEW OF THE EXCESS NOISE PROBLEM IN TES, THEN WILL FOCUS ON THE CHARACTERISTICS OF THE

DIFFERENT FUNDAMENTAL NOISE PROCESSES AND THEIR CONTRIBUTION TO TES PERFORMANCE.

4EA-02

ON THE EFFECT OF NON-UNIFORMITY IN TESES UNDER DC AND AC BIAS ***J. VAN DER KUUR****, L. GOTTARDI, P. DE KORTE, M. LINDEMAN, B. DIRKS, H. HOEVERS;* SRON NATIONAL INSTITUTE FOR SPACE RESEARCH. — TES-BASED DETECTOR ARRAYS ARE PROMISING CANDIDATES FOR APPLICATION IN THE FOCAL PLANE INSTRUMENTS OF SPACE-BASED TELESCOPES SUCH AS IXO AND SPICA. OPTIMAL DETECTOR SENSITIVITY IS VITAL FOR EFFICIENT USE OF THESE INSTRUMENTS. WITHIN THIS FRAMEWORK WE ARE OPTIMZING PIXEL PERFORMANCE UNDER BOTH DC AND AC BIAS ($0.5 < F < 6$MHZ).WE WILL PRESENT A MODEL WITH WHICH THE THE EFFECTS OF NON-UNIFORMITY IN THE TES ARE DEMONSTRATED, AND COMPARE THE RESULTS WITH EXPERIMENTAL DATA SINGLE PIXELS FROM DETECTOR ARRAYS. THE NON-UNIFORMITY LEADS TO EXCESS NOISE WITH RESPECT TO THE STANDARD NOISE MODELS. CRITERIA FOR MINIMIZING THE EFFECTS OF NON-UNIFORMITY WILL BE DERIVED.

4EA-03

THERMAL MODELS OF SUPERCONDUCTING TRANSITION-EDGE SENSORS ***I. MAASILTA****, K. KINNUNEN, M. PALOSAARI;* UNIVERSITY OF JYVASKYLA. — MICROCALORIMETERS AND BOLOMETERS BASED ON SUPERCONDUCTING TRANSITION-EDGE SENSORS (TES) HAVE BEEN UNDER INTENSE RESEARCH AND DEVELOPMENT DURING THE LAST DECADE. A TES CAN BE EMPLOYED IN A BROAD RANGE OF RADIATION DETECTION APPLICATIONS BY COUPLING IT TO A SUITABLE ABSORBER OF RADIATION FOR THE DESIRED ENERGY RANGE. EVEN THOUGH THEIR ENERGY RESOLUTION HAS STEADILY BEEN IMPROVING, TES-BASED DETECTORS STILL FAIL TO REACH THE THEORETICAL LIMITS.TES DEVICES OFTEN EXHIBIT EXCESS ELECTRICAL NOISE OF UNKNOWN ORIGIN WHICH LIMITS THEIR PERFORMANCE. THERE ARE SEVERAL THEORIES THAT TRY TO EXPLAIN THIS EXCESS NOISE, BUT NO GENERAL CONSENSUS ON A DEFINITE NOISE MECHANISM HAS BEEN REACHED SO FAR.BEFORE ONE CAN TALK OF EXCESS NOISE, WE FIRST NEED TO BE SURE THAT ALL THE CONVENTIONAL NOISE SOURCES ARE TAKEN INTO ACCOUNT. WE SHOW THAT BY CONSTRUCTING A SUITABLE THERMAL BLOCK MODEL, THE MEASURED NOISE CAN BE EXPLAINED IN MANY CASES IN TERMS OF ENERGY FLUCTUATIONS BETWEEN THE DIFFERENT PARTS. THE PROBLEM THEN IS IN CORRECTLY IDENTIFYING THE BLOCKS AND UNDERSTANDING THE THERMAL LINKS BETWEEN THEM. DATA FROM OUR DEVICES SUGGESTS THAT WE NEED A THREE-BODY MODEL TO EXPLAIN THE OBSERVED NOISE AND COMPLEX ELECTRICAL IMPEDANCE FEATURES. ALSO, IT SEEMS THAT THE HEAT CAPACITY IN THE SYSTEM IS LARGER THAN EXPECTED.

4EA-04

SURFACE CURRENT FLUCTUATIONS IN IR-TES SUPERCONDUCTING SURFACE SHEATH ***M. RIBEIRO GOMES***[1]*, M. GALEAZZI*[2]*;* [1]UNIVERSITY OF LISBON, CENTRE FOR NUCLEAR PHYSICS, [2]UNIVERSITY OF MIAMI. — THE PROBLEM OF SEPARATING BULK AND SURFACE EFFECTS IS UBIQUITOUS. IT IS WELL KNOWN THAT THE *1/F*-LIKE NOISE IN METALS CAN OCCUR FROM EITHER BULK OR SURFACE LOCALIZED SOURCES, OR THAT SURFACE VERSUS BULK EFFECTS IN DRIVEN NONLINEAR SYSTEMS SUCH AS VORTEX LATTICE IN SUPERCONDUCTORS, AND ITS EXTENSION TO THE ORIGIN OF THE FLUCTUATIONS ARE RESPONSIBLE FOR THEIR ELECTRONIC NOISE. IN ANY CASE, THE KEY QUESTION IS HOW TO DETERMINE THE RELEVANT SOURCES OF DISORDER. WE WILL REPORT THE MEASUREMENTS OF THE VOLTAGE NOISE IN THE SURFACE SUPERCONDUCTIVITY STATE OF IR-BASED THIN SUPERCONDUCTING FILMS. THESE FILMS WERE PRODUCED WITH THE SAME PHYSICAL AND CHEMICAL PROPRIETIES AS THE ONES USED FOR TRANSITION EDGE SENSORS IN THE FRAMEWORK OF THE MARE PROJECT. THE RESULTS WILL BE DISCUSSED IN TERMS OF CURRENT CONSERVATION IN A TWO-STAGE MECHANISM, INDICATING THAT SURFACE VORTICES GENERATE SURFACE CURRENT FLUCTUATIONS WHOSE MAGNITUDE CAN BE MODIFIED BY THE PINNING ABILITY OF THE SURFACE. EMPHASIS WILL BE MADE ON THE FUNDAMENTAL ROLE OF THE BOUNDARIES IN THE NONLINEAR RESPONSE OF VORTICES.

4EA-05

NOISE CHARACTERIZATION IN IR THIN FILMS ***Y. UPRETY***[1]*, D. BAGLIANI*[2]*, R. EGGENHOFFNER*[2]*, M. GALEAZZI*[1]*, F. GATTI*[2]*, M. R. GOMES*[3]*, K. PRASAI*[1]*;* [1]UNIVERSITY OF MIAMI, [2]UNIVERSITY OF GENOA, ITALY, [3]CENTRO DE FÍSICA NUCLEAR DA UNIVERSIDADE DE LISBOA, LISBOA, PORTUGAL. — WE HAVE CHARACTERIZED THE BEHAVIOR OF IR THIN FILMS DEPOSITED WITH RF SPUTTERING. WE FOCUSED IN PARTICULAR ON THE INTRINSIC NOISE OF THE FILM AT VARIOUS REGIMES (LOW POWER-HIGH POWER, LOW RESISTANCE-HIGH RESISTANCE). WE WILL DISCUSS THE RESULTS IN THE FRAMEWORK OF FLUX-FLOW NOISE, NEAR EQUILIBRIUM NON-LINEAR JOHNSON NOISE, PERCOLATION NOISE, AND INTERNAL THERMAL FLUCTUATION NOISE. WHILE ALL TERMS ARE EXPECTED TO CONTRIBUTE TO THE TOTAL NOISE, DIFFERENT TERMS DOMINATE AT DIFFERENT REGIMES.

4EA-06

NOISE STUDY OF LOW RESISTIVITY IR-BASED TES ***D. BAGLIANI***[1]*, F. BRUNETTO*[1]*, M. DELL'ANNA*[1]*, R. EGGENHÖFFNER*[2]*, F. GATTI*[1]*, M. GALEAZZI*[3]*, M. RIBEIRO GOMES*[4]*;* [1]UNIVERSITY AND INFN OF GENOA, [2]UNIVERSITY OF GENOA, [3]UNIVERSITY OF MIAMI, [4]UNIVERSITY OF LISBON, CENTRE FOR NUCLEAR PHYSICS. — NOISE PERFORMANCE OF IR-AU TES FOR RHENIUM MICROCALORIMETERS ARE OF FUNDAMENTAL IMPORTANCE FOR MAKING HIGH SPECTRAL RESOLUTION BETA SPECTROSCOPY BELOW 3KEV. WE HAVE ACQUIRED THE NOISE SPECTRAL CHARACTERISTICS OF IR AND IR-AU TES, WHICH ARE GROWN WITH LASER ABLATION METHOD ONTO SIN SUSPENDED MEMBRANE, AT THE TYPICAL OPERATING BIAS VOLTAGE AND BASE TEMPERATURES THAT ARE USED IN THE 187-RHENIUM BETA DECAY EXPERIMENT (MARE).THE SEARCH OF FEATURES OF AN EXCESS

CONTRIBUTION ARE STUDIED IN THE FRAMEWORK OF AVALANCHE AND PERCOLATIVE MODELS. FURTHERMORE, THESE ARE COMPARED TO THE ONES THAT ARE TAKEN AFTER THAT THE RHENIUM ABSORBER HAS BEEN COUPLED WITH THE TES, IN ORDER TO DISENTANGLE THE CONTRIBUTION OF THE INTERNAL FLUCTUATION NOISE OF THE WHOLE TES-RHENIUM SYSTEM.

4EB-01

DEVELOPMENT OF A CRYOCOOLER-BASED MULTI-CHANNEL HTS JOSEPHSON THZ DETECTOR ARRAY ***J. DU***[1], *A. D. HELLICAR*[2], *S. M. HANHAM*[2], *K. E. LESLIE*[1], *J. C. MACFARLANE*[1], *L. LI*[2], *N. NIKOLIC*[2], *C. P. FOLEY*[1]; [1]CSIRO CMSE, AUSTRALIA, [2]CSIRO ICT CENTRE, AUSTRALIA. — DUE TO ITS UNIQUE CHARACTERISTICS, THE TERAHERTZ (THZ) ELECTROMAGNETIC SPECTRUM OFFERS A WIDE RANGE OF POTENTIAL APPLICATIONS IN AREAS OF MATERIAL CHARACTERISATION, NON-DESTRUCTIVE TESTING, SECURITY SCREENING, MEDICAL IMAGING, AND BIOLOGICAL ANALYSIS. NOVEL COMPACT SOLID-STATE SOURCES AND DETECTORS ARE BEING SOUGHT FOR THZ RADIATION AND DETECTION. WE HAVE RECENTLY DEMONSTRATED A THZ IMAGER BASED ON A HIGH-TC SUPERCONDUCTING (HTS) STEP-EDGE JOSEPHSON JUNCTION DETECTOR OPERATING AT 77K [1, 2]. IN THIS WORK, WE REPORT OUR FURTHER DEVELOPMENT OF AN ARRAY OF JOSEPHSON THZ DETECTORS, THE ASSOCIATED ELECTRONICS, AND THE IMPLEMENTATION OF SUCH A MULTI-CHANNEL DETECTOR SYSTEM ON A PULSE-TUBE CRYOCOOLER. THE DESIGN AND CHARACTERISATION OF THE THZ DETECTOR ARRAY, THE ELECTRONICS, ISSUES RELATED TO THE OPERATION OF THE DETECTOR IN A CRYOCOOLER, AS WELL AS IMAGE ACQUISITION TECHNIQUE WILL BE DISCUSSED.REFERENCES1. J. DU, ET AL., “TERAHERTZ IMAGING USING A HIGH-TC SUPERCONDUCTING JOSEPHSON JUNCTION DETECTOR”, SUPERCOND. SCI. TECHNOL. 21 (2008) 125025.2. J. DU, ET AL., “TERAHERTZ IMAGING AT 77 K”, SUPERCOND. SCI. TECHNOL. 22 (2009) 114001.

4EB-02

TERAHERTZ CHARACTERIZATION OF EXTERNAL RESONANT SYSTEMS BY HIGH-T_C JOSEPHSON JUNCTIONS *V. N. GUBANKOV*[1], *I. I. GUNDAREVA*[1], *Y. Y. DIVIN*[2], ***V. V. PAVLOVSKIY***[1], *O. Y. VOLKOV*[1]; [1]KOTEL'NIKOV INSTITUTE OF RADIO ENGINEERING AND ELECTRONICS OF RAS, MOSCOW, 125009, RUSSIA, [2]FORSCHUNGSZENTRUM JÜLICH, D-52425 JÜLICH, GERMANY. — HIGH-T_C JOSEPHSON TECHNOLOGY LOOKS PROMISING FOR THZ APPLICATIONS [1]. ONE OF THE REMAINING PROBLEMS, IMPORTANT BOTH FOR DETECTION AND EMISSION OF THZ RADIATION, IS AN OPTIMUM COUPLING OF HIGH-T_C JUNCTIONS WITH ENVIRONMENT. RECENTLY [2], WE HAVE DEMONSTRATED A POSSIBILITY TO CHARACTERIZE ELECTROMAGNETIC SYSTEMS INTEGRATED WITH HIGH-T_C JUNCTIONS USING DC *I-V* CURVES OF THESE JUNCTIONS. HERE, WE REPORT IN DETAILS ON MODIFICATION OF THE DC *I-V* CURVES OF $YBA_2CU_3O_{7-X}$ BICRYSTAL JUNCTIONS, RELATED TO INTERACTION OF JOSEPHSON OSCILLATIONS WITH TERAHERTZ RESONANCE ANTENNAS. THIN-FILM LOG-PERIODIC ANTENNAS WITH VARIOUS RESONANCE STRUCTURES WERE FABRICATED ON THE SAME SUBSTRATE AS JOSEPHSON JUNCTIONS AND WERE EXCITED BY JOSEPHSON OSCILLATIONS. FREQUENCY-DEPENDENT ADMITTANCES OF THE ANTENNAS WERE DERIVED FROM FINE LOG-PERIODIC STRUCTURES ON THE DC *I-V* CURVES OF THE JUNCTIONS AND COMPARED WITH THE RESULTS OF NUMERICAL SIMULATIONS. DATA OBTAINED WERE USED FOR OPTIMIZATION OF COUPLING BETWEEN THE JUNCTIONS AND ANTENNAS.1. Y. DIVIN, U. POPPE, V.N. GUBANKOV, K. URBAN. IEEE SENSORS J., 2008, VOL. 8, PP.750-757.2. O.YU. VOLKOV ET AL. J. COMM. TECHNOL. ELECTRONICS, 2009, VOL. 54, PP. 1307-1311.

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4EB-03

MICROSPEC - A FULLY INTEGRATED HIGH PERFORMANCE TERAHERTZ SPECTROMETER ON A SINGLE WAFER ***S. H. MOSELEY***[1], *D. BENFORD*[1], *C. M. BRADFORD*[2], *A. BROWN*[1], *W. HSIEH*[1], *T. STEVENSON*[1], *K. U-YEN*[1], *E. WOLLACK*[1], *J. ZMUIDZINAS*[3]; [1]NASA/GSFC, [2]JPL, [3]CALTECH. — WE DESCRIBE THE μ-SPEC, AN EXTREMELY COMPACT HIGH PERFORMANCE SPECTROMETER FOR THE SUBMILLIMETER AND MILLIMETER SPECTRAL RANGES. USING LOW LOSS TRANSMISSION LINES, WE CAN PRODUCE A FULLY INTEGRATED SUBMILLIMETER SPECTROMETER WITH R~1500 ON A SINGLE FOUR INCH SI WAFER. THIS INSTRUMENT, IF SUCCESSFULLY REALIZED, CAN PROVIDE REVOLUTIONARY NEW CAPABILITIES FOR SPACE ASTROPHYSICS, AND CAN OFFER NEW CAPABILITIES FOR A WIDE RANGE OF APPLICATIONS.WE WILL PRESENT THE DESIGN OF THE INSTRUMENT, DESCRIBE ITS SCIENTIFIC POTENTIAL, AND PROVIDE A STATUS REPORT ON THE TESTS OF μ-SPEC COMPONENTS.

4EB-04

JOSEPHSON SPECTROSCOPY FOR IDENTIFICATION OF LIQUIDS *Y. DIVIN*[1], *M. LYATTI*[1], ***U. POPPE***[1], *K. URBAN*[1], *V. PAVLOVSKIY*[2]; [1]FORSCHUNGSZENTRUM JUELICH, [2]KOTELNIKOV INSTITUTE OF RADIO ENGINEERING AND ELECTRONICS. — ONE OF FUTURE PUBLIC SECURITY TECHNIQUES WILL BE RELATED WITH NON-INVASIVE, FAST AND RELIABLE DETECTION OF LIQUIDS. TO DISTINGUISH BETWEEN BENIGN AND THREAT LIQUIDS, WE HAVE SUGGESTED A CONCEPT BASED ON OUR HILBERT SPECTROSCOPY AND HIGH-TC JOSEPHSON DETECTORS [1]. THIS JOSEPHSON SPECTROSCOPY IS THE ONLY SPECTROSCOPIC TECHNIQUE, WHICH COVERS A FREQUENCY RANGE OF MAIN DISPERSIONS OF LIQUIDS FROM A FEW GHZ TO A FEW THZ. SEVERAL DEMONSTRATION LIQUID IDENTIFIERS, CONSISTING OF HILBERT SPECTROMETERS, INTEGRATED IN STIRLING COOLERS, AND POLYCHROMATIC RADIATION SOURCES, HAVE BEEN DEVELOPED AND CHARACTERIZED. REFLECTION POLYCHROMATIC SPECTRA OF VARIOUS LIQUIDS IN PLASTIC CONTAINERS HAVE BEEN MEASURED AT THE SPECTRAL RANGE OF 15 - 400 GHZ WITH TOTAL SCANNING TIME DOWN TO 0.2 SECOND [2]. EXAMPLES OF RELIABLE IDENTIFICATION OF LIQUIDS WILL BE PRESENTED.[1] Y. DIVIN, U. POPPE, V. GUBANKOV, K. URBAN. IEEE SENSORS J., V.8, PP.750-757

(2008).[2] M. LYATTI, Y. DIVIN, U. POPPE, K. URBAN. SUPERCOND. SCI. TECHNOL., V.22, 114005 (2009).

PARTIAL FINANCIAL FASI SUPPORT BY CONTRACT #02.740.11.5019 IS HIGHLY APPRECIATED.

4EB-05

MAGNETIC FIELD-TUNED SUPERCONDUCTING SPLIT-RING RESONATORS AT TERAHERTZ ***B. JIN***[1], *C. ZHANG*[1], *S. ENGELBRECHT*[2], *A. PIMENOV*[2], *Q. XU*[1], *C. CAO*[1], *J. CHEN*[1], *L. KANG*[1], *W. XU*[1], *P. WU*[1]; [1]RESERACH INSTITUTE OF SUPERCONDUCTOR ELECTRONICS, [2]EXPERIMENTELLE PHYSIK IV, UNIVERSITÄT WÜRZBURG, AM HUBLAND, D-97074 WÜRZBURG, GERMANY. — METAMATERIAL IS AN ARRANGEMENT OF ARTIFICIAL STRUCTURE ELEMENTS DESIGNED TO ACHIEVE ADVANTAGEOUS AND UNUSUAL PROPERTIES. THESE STRUCTURE ELEMENTS IN MANY CASES ARE RESONATORS MADE OF NORMAL METAL. AS THE NORMAL METAL IS REPLACED BY SUPERCONDUCTING THIN FILM, THE MAGNETIC FIELD TUNING CAN BE REALIZED SINCE THE MAGNETIC PENETRATION DEPTH IS DEPENDENT ON THE EXTERNAL MAGNETIC FIELD. IN THIS WORK, A TUNABLE TERAHERTZ METAMATERIAL IS DEMONSTRATED. A SQUARE SPLIT RING RESONATOR (SRR) ARRAY IS MADE FROM NB THIN FILM ON SILICON SUBSTRATE. UNDER THE EXTERNAL DC MAGNETIC FIELD (UP TO 0.7 TESLA), THE FIRST THREE MODES SHOW DIFFERENT FREQUENCY DEPENDENCE ON THE MAGNETIC FIELD. FOR THE FIRST MODE, THE FREQUENCY DECREASE WITH THE MAGNETIC FIELD. FOR THE SECOND MODE, THE FREQUENCY KEEPS ALMOST UNCHANGED, AND FOR THE THIRD MODE, THE FREQUENCY INCREASE OBVIOUSLY WITH THE MAGNETIC FIELD. THE DIFFERENT FREQUENCY DEPENDENCE ON THE FIELD CAN BE EXPLAINED AS FOLLOWS. AS THE FIELD INCREASE, THE PENETRATION DEPTH INCREASES, LEADING TO THE DECREASE OF THE RESONANT FREQUENCY. WHILE, THE COUPLING STRENGTH DECREASES SINCE THE CURRENT DISTRIBUTED MORE UNIFORMLY, LEADING TO THE INCREASE OF THE FREQUENCY. THESE TWO MECHANISMS COMPETE, GIVING DIFFERENT FREQUENCY DEPENDENCE ON THE FIELD. SO, SUPERCONDUCTING THZ METAMATERIAL HAS A FLEXIBLE AND EFFECTIVE TUNING METHOD.

THIS WORK IS SUPPORTED BY THE MOST 973 PROJECT (NO.2007CB310404), THE PROGRAM FOR NEW CENTURY EXCELLENT TALENTS IN UNIVERSITY (NCET-07-0414), AND QING LAN PROGRAM OF JIANGSU PROVINCE.

4EB-06

TUNABLE TERAHERTZ EMISSION FROM INTRINSIC JOSEPHSON JUNCTIONS ***H. WANG***[1], *S. GUENON*[2], *J. YUAN*[1], *Z. JIANG*[3], *Y. ZHONG*[3], *P. WU*[3], *A. ISHII*[1], *T. HATANO*[1], *B. GROSS*[2], *M. GRÜNZWEIG*[1], *D. KOELLE*[2], *R. KLEINER*[2]; [1]NATIONAL INSTITUTE FOR MATERIALS SCIENCE, [2]UNIVERSITAET TUEBINGEN, [3]NANJING UNIVERSITY. — AS IT HAS BEEN WELL KNOWN, LARGE STACKS OF INTRINSIC JOSEPHSON JUNCTIONS IN BI_2SR_2CACU_2O_8 CAN EMIT SYNCHRONOUS THZ RADIATION IN A LOW BIAS CURRENT REGIME, WITH FREQUENCIES INVERSELY PROPORTIONAL TO THE DIMENSION OF THE SHORT JUNCTION SIDE.^1 IN A HIGH BIAS CURRENT REGIME, THZ STANDING WAVES AND A HOTSPOT AREA (WHERE THE LOCAL TEMPERATURE CAN BE HIGHER THAN TC) HAVE BEEN IMAGED BY USING LOW TEMPERATURE SCANNING LASER MICROSCOPY INSIDE INTRINSIC JOSEPHSON JUNCTIONS.^2 WITH DIRECT ELECTROMAGNETIC WAVE DETECTION, WE FIND IN THE HIGH BIAS CURRENT REGIME, THZ EMISSIONS HAVE A DECENT (~20%) FREQUENCY TUNABILITY, HIGHER OUTPUT POWER, AND NARROWER LINEWIDTH. ALL THESE PROPERTIES INDICATE THE INTRINSIC JOSEPHSON JUNCTIONS MAY FIND THEMSELVES PRACTICAL APPLICATIONS AS COMPETITIVE SOLID STATE THZ SOURCES.REFERENCES[1]. L. OZYUZER, A. E. KOSHELEV, C. KURTER, N. GOPALSAMI, Q. LI, M. TACHIKI, K. KADOWAKI, T. YAMAMOTO, H. MINAMI, H. YAMAGUCHI, ET AL., SCIENCE 318, 1291 (2007).[2]. H. B. WANG, S. GUÉNON, J. YUAN, A. IISHI, S. ARISAWA, T. HATANO, T. YAMASHITA, D. KOELLE, AND R. KLEINER, PHYS. REV. LETT. 102, 017006 (2009).

THIS WORK HAS BEEN SUPPORTED BY THE STRATEGIC JAPANESE-GERMAN INTERNATIONAL COOPERATIVE PROGRAM FROM THE JST & DFG.

4EB-07

A ROAD TO HIGH POWER TERAHERTZ RADIATION FROM INTRINSC JOSEPHSON JUNCTIONS ***K. KADOWAKI***[1], *M. TSUJIMOTO*[1], *K. IVANOVIC*[1], *T. KOIKE*[1], *N. ORITA*[1], *K. DEGUCHI*[1], *R. NAKAYAMA*[1], *T. YAMAMOTO*[1], *T. KASHIWAGI*[1], *H. MINAMI*[1], *M. TACHIKI*[1], *R. A. KLEMM*[2]; [1]INSTITUTE OF MATERIALS SCIENCE, [2]UNIVERSITY OF CENTRAL FLORIDA. — AFTER DISCOVERY OF STRONG, CONTINUOUS AND COHERENT ELECTROMAGNETIC RADIATION FROM A LARGE MESA OF SINGLE CRYSTAL BI2SR2CACU2O8+D INTRINSIC JOSEPHSON JUNCTIONS, A GREAT DEAL OF ATTENTION HAS BEEN ATTRACTED NOT ONLY FOR THE FUNDAMENTAL INTEREST IN THE RADIATION MECHNISM BUT ALSO FOR A WIDE VARIETY OF APPLICATIONS TO BE EXPLORED. IN ORDER TO MAKE USE OF IT AS A SOURCE FOR VARIOUS PURPOSES, A POWER LEVEL AS HIGH AS A FEW MW IS AT LEAST REQUIRED. WE HAVE STUDIED AND ADJUSTED THE CONDITIONS FOR THIS PURPOSE BY CHANGING THE SHAPE OF THE MESA, THE DOPING, LEVEL, THE CONSTRUCTION OF THE MESA, ETC. AND HAVE REACHED 1 FEW TENS OF MICROWATT LEVEL. FURTHER MORE IT IS EXPECTED FROM AN ANALYSIS OF THE SPATIAL RADIATION INTENSITY DISTRIBUTION THAT IT MAY BE INCREASED BY ABOUT 100 TIMES BY MODIFYING THE STRUCTURE OF THE MESA. SOME PRELIMINARY RESULTS INDICATES THE TENDENCY AS PREDICTED. THESE RESULTS WILL BE SHOWN WITH EMPHASIS ON THE GRREAT ADVANTAGE OF PORTABLE, COMPACT AND HANDY TERAHERTZ DEVICES FOR APPLICATIONS.

THE AUTHORS THANK THE FINANCIAL SUPPORT FROM CREST, JST, JAPAN AND WPI MANA (NIMS).

4EB-08

SELF EMISSION FROM LARGE ARRAYS OF NIOBIUM JOSEPHSON JUNCTIONS ***F. SONG***[1], *A. SEMENOV*[2], *F. MÜLLER*[3],

R. BEHR[3], L. FANG[4], A. KLUSHIN[5]; [1]INSTITUTE OF BIO- AND NANOSYSTEMS AND JARA-FUNDAMENTALS OF FUTURE INFORMATION TECHNOLOGY; DEPARTMENT OF ELECTRONICS, NANKAI UNIVERSITY, 300071 TIANJIN, P. R. CHINA, [2]INSTITUTE OF PLANETARY RESEARCH, GERMAN AEROSPACE CENTER, 12489 BERLIN, GERMANY, [3]PHYSIKALISCH-TECHNISCHE BUNDESANSTALT, 38116 BRAUNSCHWEIG, GERMANY, [4]DEPARTMENT OF ELECTRONICS, NANKAI UNIVERSITY, 300071 TIANJIN, P. R. CHINA, [5]INSTITUTE OF BIO- AND NANOSYSTEMS AND JARA-FUNDAMENTALS OF FUTURE INFORMATION TECHNOLOGY. — JOSEPHSON JUNCTION ARRAYS COULD BE COMPETITIVE CANDIDATES FOR RADIATION SOURCES IN THE FREQUENCY RANGE FROM 0.5 TO 1.5 THZ, WHICH IS THE RANGE WHERE COMPACT SOLID-STATE CONTINUOUS WAVE SOURCES ARE MOST LACKING. RECENTLY WE REPORTED SELF EMISSION SEPARATELY FROM LARGE ARRAYS OF 7500 NIOBIUM JOSEPHSON JUNCTIONS AND 536 HIGH-TEMPERATURE SUPERCONDUCTOR BICRYSTAL JUNCTIONS EMBEDDED IN A QUASI-OPTICAL RESONATOR. AN ISOLATED SHARP EMISSION PEAK AROUND 76 GHZ AT 4.2 K FROM THE NIOBIUM JOSEPHSON JUNCTION ARRAY WAS OBSERVED, WHICH WAS LIMITED BY THE DETECTED BANDWIDTH OF OUR SUPERHETERODYNE RECEIVER FROM ABOUT 75 GHZ TO 80 GHZ WITH ACCEPTABLE SENSITIVITY. BY COUPLING TOGETHER THE RESONANT MODES OF THE EXTERNAL QUASI-OPTICAL RESONATOR AND ITS OWN SUBSTRATE SERVED AS A DIELECTRIC RESONATOR, THE EMISSION POWER WAS ENHANCED TO ABOUT 2MW.FURTHER INVESTIGATION WITH A DETECTOR OF THE SCHOTTKY DIODE IS EXHIBITED AT PRESENT. CONTINUOUS TUNABLE SELF EMISSION WAS OBSERVED IN A BROAD FREQUENCY RANGE FROM AROUND 50 GHZ TO 75 GHZ, WHICH AGREED WITH THE JOSEPHSON CURRENT-VOLTAGE RELATION. WITH REDUCED THE OPERATION TEMPERATURE, THE EMISSION COULD BE EXTENDED TO HIGHER FREQUENCY. IN THIS CASE, THE JOULE HEATING OF THE JUNCTIONS COULD BE LIMITED, WHICH WILL RESULT IN AN DECREASE OF THE AMPLITUDE OF JOSEPHSON OSCILLATIONS. THE RESULTS SUGGEST THAT IT IS PROMISING TO EXPAND THE FREQUENCY OF EMISSION INTO THE THZ RANGE.

THE AUTHOR FENGBIN SONG IS SUPPORTED BY THE STATE SCHOLARSHIP FUND ORGANIZED BY CSC (CHINA SCHOLARSHIP COUNCIL). THE AUTHORS WOULD LIKE TO THANK G. PANAITOV FOR THE HELP BY THE MODIFICATION OF THE SAMPLES AND M. HE FOR STIMULATING DISCUSSIONS.

4EPA-01

DESIGN AND IMPLEMENTATION OF MULTI-FLUX DRIVERS USING HIGH BETA_C JUNCTIONS ***D. OZAWA**, Y. NATSUME, Y. YAMANASHI, N. YOSHIKAWA;* YOKOHAMA NATIONAL UNIVERSITY. — THE LACK OF THE DRIVING ABILITY IS ONE OF WEAK POINTS OF SINGLE-FLUX-QUANTUM (SFQ) DEVICES. AT PRESENT, PULSE SPLITTERS, WHICH GENERATE DOUBLE OR TRIPLE FLUX QUANTA FROM AN SFQ INPUT, ARE USUALLY USED WHEN MULTIPLE-FLUX QUANTA (MFQ) ARE NECESSARY FROM AN SFQ INPUT. HOWEVER, VERY LARGE CIRCUIT AREA AND LONG LATENCY ARE REQUIRED IN THE SPLITTER-BASED MFQ DRIVER. IN ORDER TO OVERCOME THE PROBLEM, WE INVESTIGATED AN MFQ DRIVER USING HIGH BETA_C JUNCTIONS. THE ADVANTAGE OF THE PROPOSED MFQ DRIVER IS ITS CURRENT DRIVING ABILITY, WHICH CAN BE USED AS BIT-LINE DRIVERS OF SFQ MEMORIES AND OUTPUT DRIVERS OF SFQ CIRCUITS, WHERE LARGE GAINS ARE NECESSARY. THE PROPOSED MFQ DRIVER WAS IMPLEMENTED USING THE ISTEC 2.5 KA/CM^2 NB STANDARD PROCESS (STP2) AND ITS DRIVING ABILITY WAS TESTED. WE MEASURED A HISTOGRAM OF THE OUTPUT PULSE NUMBER OF THE MFQ DRIVER AS A FUNCTION OF THE BIAS CURRENT. IN ADDITION, WE EXAMINED THE PROPAGATION DELAY OF THE MFQ DRIVER BY CIRCUIT SIMULATIONS. THE RESULTS INDICATE THAT THE MFQ DRIVER CAN GENERATE MFQ FROM AN SFQ INPUT MORE RAPIDLY THAN THE SPLITTER-BASED MFQ DRIVERS.

NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY PARTIALLY CONTRIBUTED TO THE CIRCUIT FABRICATION.

4EPA-02

IMPLEMENTATION OF JOSEPHSON-CMOS HYBRID MEMORIES WITH BIT-SERIAL DATA INPUT/OUTPUT PORTS ***K. YAGUCHI[1], Y. OKAMOTO[1], H. JIN[1], H. PARK[1], Y. YAMANASHI[1], N. YOSHIKAWA[1], T. V. DUZER[2];* [1]YOKOHAMA NATIONAL UNIVERSITY, [2]UNIVERSITY OF CALIFORNIA, BERKELEY. — WE HAVE BEEN DEVELOPING A JOSEPHSON-CMOS HYBRID MEMORY, WHICH ENABLES SUB-NANOSECOND ACCESS TIME, FOR SINGLE-FLUX-QUANTUM (SFQ) DIGITAL SYSTEMS. IN OUR PREVIOUS STUDY, WE MEASURED THE ACCESS TIME OF A 64-KB HYBRID MEMORY USING 0.18 UM CMOS DEVICES BY AN SFQ DELAY MEASUREMENT CIRCUIT, AND OBTAINED THE ACCESS TIME OF ABOUT 1.4 NS FOR SINGLE-BIT DATA READOUT. IN THIS STUDY, WE IMPLEMENTED A HYBRID MEMORY WITH A BIT-SERIAL INPUT/OUTPUT PORTS FOR HIGH-SPEED READ-OUT AND WRITE-IN BIT-SERIAL DATA BY COMBINING SFQ SERIAL/PARALLEL CONVERTERS WITH THE HYBRID MEMORY. WE HAVE IMPLEMENTED A 64-KB HYBRID MEMORY WITH SFQ SERIAL/PARALLEL CONVERTERS, BY WHICH 20-GHZ INPUT/OUTPUT OF BIT-SERIAL DATA WILL BE POSSIBLE, USING THE CMOS 0.18 UM PROCESS AND THE ISTEC NB 2.5 KA/CM^2 STANDARD PROCESS (STP2). AT PRESENT A 64-KB HYBRID MEMORY WITH 8-BIT PARALLEL INPUT/OUTPUT PORTS AND 8-BIT SFQ SERIAL/PARALLEL CONVERTERS WERE TESTED INDIVIDUALLY AND THEIR CORRECT OPERATIONS WERE CONFIRMED. FULL SYSTEM OPERATION IS NOW UNDER INVESTIGATION. THE LATEST TEST RESULTS WILL BE SHOWN AT THE CONFERENCE.

NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY PARTIALLY CONTRIBUTED TO THE CIRCUIT FABRICATION.

4EPA-03

INTEGRATION OF OPTICAL WAVEGUIDES WITH SFQ CIRCUITS ***Y. ARITA**, N. YOSHIKAWA, T. BABA, Y. YAMANASHI;* YOKOHAMA NATIONAL UNIVERSITY. — SINGLE-FLUX-QUANTUM (SFQ) CIRCUITS AND OPTICAL CIRCUITS ARE EXPECTED FOR NEXT GENERATION'S INTEGRATED CIRCUITS.

SFQ CIRCUITS ARE SUITABLE FOR HIGH-SPEED DATA PROCESSING, WHEREAS OPTICAL CIRCUITS ARE APPROPRIATE FOR WIRING TO TRANSMIT HIGH-SPEED SIGNALS. IN THIS STUDY, OPTICAL CIRCUITS INTEGRATED WITH SFQ CIRCUITS WERE INVESTIGATED FOR MAKING THE BEST USE OF EACH ADVANTAGE. THE METAL CLADDING OPTICAL WAVEGUIDE WITH SIO_2 CORE AND NB CLADDING WAS FABRICATED USING THE ISTEC NB STANDARD PROCESS (STP2) AND INTEGRATED WITH SFQ CIRCUITS. WE CALCULATED AND MEASURED THE PROPAGATION CHARACTERISTICS OF THE WAVEGUIDE. THE CALCULATION RESULTS SHOW THAT THE PROPAGATION LOSS IS 21.2 DB/MM FOR THE CORE HEIGHT OF 1.2 UM. THE EXPERIMENTAL RESULTS REVEAL THAT THE LIGHT IS ABLE TO PROPAGATE ALONG THE WAVEGUIDE OF THE LENGTH OF 830 UM AT ROOM TEMPERATURE. LASER-LIGHT-IRRADIATION EFFECTS OF JOSEPHSON JUNCTIONS WERE ALSO MEASURED USING THE INTEGRATED OPTICAL WAVEGUIDE. IT WAS DEMONSTRATED THAT THE CRITICAL CURRENT OF THE JUNCTION WAS MODULATED BY THE IRRADIATION OF THE LASER LIGHT OF 1.55 UM, WHICH CAN BE USED AS AN O-E CONVERTOR. DIRECT INPUTS OF OPTICAL SIGNALS TO SFQ CIRCUITS THROUGH THE INTEGRATED OPTICAL WAVEGUIDE WILL BE SHOWN AT THE CONFERENCE.

NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY PARTIALLY CONTRIBUTED TO THE CIRCUIT FABRICATION.

4EPA-04

DEMONSTRATION OF 30 GBIT/S GENERATION OF SUPERCONDUCTIVE TRUE RANDOM NUMBER GENERATOR ***T. SUGIURA****, Y. YAMANASHI, N. YOSHIKAWA;* YOKOHAMA NATIONAL UNIVERSITY. — TRUE RANDOM NUMBER GENERATORS, WHICH EXTRACT ENTROPY FROM PHYSICAL PHENOMENA SUCH AS THERMAL AND ELECTRONIC NOISES, ARE WIDELY USED IN THE FIELD OF THE CRYPTOGRAPHIC COMMUNICATION SYSTEMS. WE HAVE BEEN DEVELOPING A SUPERCONDUCTIVE TRUE RANDOM NUMBER GENERATOR THAT CAN GENERATE SEQUENCES THAT ARE IMPOSSIBLE TO BE PREDICTED BY UTILIZING THE HIGH-SPEED OPERATION AND HIGH-SENSITIVITY OF SUPERCONDUCTIVE INTEGRATED CIRCUITS. IN THIS STUDY, STATISTICAL TESTS ARE PERFORMED USING THE NIST STATISTICAL TEST SUITE IN ORDER TO EVALUATE THE QUALITY OF THE RANDOMNESS OF SEQUENCES GENERATED BY THE SUPERCONDUCTIVE TRUE RANDOM NUMBER GENERATOR AT 30 GBIT/S. WE HAVE GENERATED 3.2 MBIT RANDOM NUMBER SEQUENCES USING THE SUPERCONDUCTIVE TRUE RANDOM NUMBER GENERATOR, FABRICATED BY THE ISTEC-SRL 2.5 KA/CM2 NB STANDARD PROCESSS. AS A RESULT OF NIST STATISTICAL TEST SUITE WHICH CONSISTS OF 16 KINDS OF STATISTICAL TESTS, 13 KINDS OF TESTS PASSED AND THE 3 KINDS OF TEST RESULT DID NOT COME OUT OF THEM. THIS IS BECAUSE THERE WAS LITTLE AMOUNT OF DATA. HOWEVER, IT WAS PROVED ENOUGH THAT A SUPERCONDUCTIVE TRUE RANDOM NUMBER GENERATOR CAN GENERATE HIGH QUALITY OF RANDOM NUMBERS AT 30 GBIT/S.

THIS PROJECT IS SUPPORTED BY MEXT'S PROGRAM “PROMOTION OF ENVIRONMENTAL IMPROVEMENT FOR INDEPENDENCE OF YOUNG RESEARCHERS”

4EPA-05

INVESTIGAION OF CHARACTERISTIC VARIATIONS OF HIGH-SPEED CRYO CMOS AMPLIFIERS FOR INTERFACE CIRCUITS OF THE JOSEPHSON/CMOS HYBRID MEMORIES. ***H. JIN****, Y. OKAMOTO, K. YAGUCHI, Y. YAMANASHI, N. YOSHIKAWA;* YOKOHAMA NATIONAL UNIVERSITY. — WE ARE DEVELOPING A JOSEPHSON/CMOS HYBRID MEMORY SYSTEM. ONE OF THE KEY COMPONENTS OF THE HYBRID MEMORY SYSTEM IS INTERFACE CIRCUITS, WHICH AMPLIFY SUB-MILIVOLT-LEVEL SIGNALS FROM SFQ CIRCUITS TO VOLT-LEVEL CMOS SIGNALS AT VERY HIGH SPEED. CRYO CMOS AMPLIFIERS ARE CANDIDATE FOR THE MAIN HIGH-SPEED AMPLIFIER FOR THE JOSEPHSON/CMOS INTERFACE CIRCUITS. WE PROPOSED TWO TYPES OF CMOS AMPLIFIERS. ONE IS A CASCADED CMOS DIFFERENTIAL AMPLIFIER AND THE OTHER IS A SOURCE-FOLLOWER-TYPE CMOS AMPLIFIER. SO FAR, A LOW-TEMPERATURE CMOS DEVICE MODEL WAS DEVELOPED AND SINGLE-BIT ACCESS TIME OF THE JOSEPHSON/CMOS HYBRID MEMORY USING THE CASCADED CMOS DIFFERENTIAL AMPLIFIER IS SUCCESSFULLY MEASURED. THE SOURCE FOLLOWER CMOS AMPLIFIER WAS COMPLETELY SIMULATED BY USING THE LOW-TEMPERATURE CMOS DEVICE MODEL AND IT WAS SUCCESSFULLY OPERATED AT LIQUID HELIUM TEMPERATURE. IN THIS STUDY, WE EXAMINED LOCAL CHARACTERISTIC VARIATIONS OF THE CMOS DIFFERENTIAL AMPLIFIERS TO VERIFY THE ROBUSTNESS OF THE AMPLIFIER AND TO REALIZE MULTI-CHANNEL DATA INPUTS FOR THE JOSEPHSON/CMOS HYBRID MEMORY SYSTEM.

THE AUTHORS WOULD LIKE TO THANK VLSI DESIGN EDUCATIONAL CENTER (VDEC) FOR SUPPORTING SIMULATION ENVIRONMENTS AND CHIP FABRICATIONS.

4EPA-06

DESIGN AND EXPERIMENTAL STUDY OF AN RSFQ WAVE-PIPELINED 8-BIT ALU AND KOGGE-STONE ADDER ***A. F. KIRICHENKO***[1]*, T. V. FILIPPOV*[1]*, O. A. MUKHANOV*[1]*, M. DOROJEVETS*[2]*, C. AYALA*[2]*;* [1]HYPRES, [2]STONY BROOK UNIVERSITY. — WE HAVE DESIGNED AND DEMONSTRATED A KOGGE-STONE ADDER AND AN ARITHMETIC-LOGIC UNIT (ALU) BASED ON RSFQ TECHNOLOGY AS CONSEQUENT STEPS TOWARD BUILDING AN 8-BIT RSFQ PROCESSOR DATAPATH. BOTH CIRCUITS WERE DESIGNED IN 4-BIT AND 8-BIT VERSIONS. THEY WERE DESIGNED FOR AND FABRICATED WITH STANDARD HYPRES’S 4.5 KA/CM^2 PROCESS AND OPERATE AT HIGHER THAN 20 GHZ CLOCK FREQUENCY. IN THIS PAPER, WE WILL PRESENT THE DESIGN AND TEST RESULTS OF THESE CIRCUITS. WE WILL ALSO DISCUSS ISSUES OF A LARGE CIRCUIT’S INTEGRATION.

THIS WORK HAS BEEN SUPPORTED THROUGH US ARO CONTRACT #W911NF-09-C-0036

4EPA-07

THE MULTIPLIER OF LARGE SCALE INTEGRATION SFQ CIRCUITS BASED ON THE BOOTH ENCODER ***R. NAKAMOTO****, S. SAKURABA, T. ONOMI, S. SATO, K. NAKAJIMA;* RESEARCH INSTITUTE OF ELECTRICAL COMMUNICATION, TOHOKU UNIVERSITY. — DRIVING TECHNOLOGIES WITH LOW POWER CONSUMPTION ARE REQUIRED AS THE WORLD TREND, BECAUSE HIGH INTEGRATION CAUSES THE INCREASE OF POWER DISSIPATION. SINGLE-FLUX-QUANTUM (SFQ) LOGIC CIRCUITS ATTRACT MUCH ATTENTION BECAUSE OF LOW POWER DISSIPATION AND HIGH THROUGHPUT. THOUGH THE SUPER CONDUCTIVE CIRCUITS NEED A REFRIGERATOR SYSTEM, SFQ CIRCUITS HAVE HIGHER ADVANTAGE COMPARED TO SEMICONDUCTOR CIRCUITS.WE EXAMINE FAST FOURIER TRANSFORMATION (FFT) WITH SFQ CIRCUITS. THE REDUCTION OF PARTIAL PRODUCTS IS REQUIRED FOR HIGHER-BIT MULTIPLICATION, BECAUSE THE ADDITION OF PARTIAL PRODUCTS STAGE OCCUPIES LARGE CIRCUIT AREA. TO REDUCE PARTIAL PRODUCTS, WE DESIGN 2-BIT BOOTH ENCODER WITH JOSEPHSON-TRANSMISSION-LINES (JTLS) AND THE PASSIVE-TRANSMISSION-LINES (PTLS) BY USING CELL-BASED TECHNIQUES AND TOOLS (CONNECT CELL LIBRARY). THE BOOTH ENCODING METHOD IS ONE OF THE ALGORITHMS TO OBTAIN PARTIAL PRODUCTS. IN THIS METHOD, A NUMBER OF PARTIAL PRODUCTS DECREASE DOWN TO THE HALF COMPARED TO AN AND ARRAY METHOD. IN THIS PAPER, A TEST CHIP FOR A MULTIPLIER WITH A 2-BIT BOOTH ENCODER WITH THE PTLS IS PRESENTED, AND IT HAS AN ESTIMATED PROCESSING FREQUENCY 20GHZ. THE MAXIMUM PROCESSING FREQUENCY OF THIS CIRCUIT IS 45GHZ WITH INCREASING A BIAS VOLTAGE BY 25% FROM 2.5V. THE CIRCUIT AREA OF A MULTIPLIER DESIGNED WITH THE BOOTH ENCODER METHOD IS ESTIMATED TO COMPARE TO THAT DESIGNED WITH THE AND ARRAY METHOD.

THIS WORK WAS SUPPORTED IN PART BY MEXT SFQ PROJECT, SCIENTIFIC RESEARCH ON PRIORITY AREAS ENTITLED "SINGLE-FLUX-QUANTUM INTEGRATED CIRCUITS BASED ON LOCALIZED ELECTROMAGNETIC WAVES,"

4EPB-01

DEVELOPMENT OF SUPERCONDUCTING NBTIN WAVEGUIDES FOR THE TERAHERTZ SIS MIXERS ***K. KUROIWA****[1], K. MAKISE[2], T. KOJIMA[1], Y. FUJII[3], M. KROUG[3], A. MIYACHI[3], Y. UZAWA[3], Z. WANG[2], H. OGAWA[1];* [1]OSAKA PREFECTURE UNIVERSITY, [2]NATIONAL INSTITUTE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY, [3]NATIONAL ASTRONOMICAL OBSERVATORY OF JAPAN. — SUPERCONDUCTING NBTIN FILMS HAVE BEEN DEPOSITED ON TERAHERTZ WAVEGUIDE STRUCTURES MADE OF COPPER TO REDUCE THEIR TRANSMISSION LOSSES DUE TO THE SURFACE RESISTANCE. THE SPLIT-BLOCK WAVEGUIDES WITH A SIZE OF 152 MICRONS BY 304 MICRONS WERE PREPARED. A REACTIVE DC MAGNETRON SPUTTERING WAS USED TO DEPOSIT A 500-NM-THICK NBTIN FILM ON THE COPPER WAVEGUIDES AT AN AMBIENT TEMPERATURE. THE DEPOSITION CONDITION WAS OPTIMIZED TO OBTAIN THE FILM WITH A 20-K RESISTIVITY < 90 MICRO-OHM-CM AND A CRITICAL TEMPERATURE > 14.5 K ON A FUSED QUARTZ SUBSTRATE. THE X-RAY DIFFRACTION PATTERNS OF THE NBTIN FILM ON THE COPPER SHOWED A STRONGER (200) PEAK COMPARED TO THAT OF THE FILM ON A FUSED QUARTZ SUBSTRATE. THE ENERGY DIPERSIVE X-RAY SPECTROMETRY (EDS) AND THE WAVELENGTH DISPERSIVE X-RAY SPECTROMETRY (WDS) REVEALED THAT THE CHEMICAL COMPOSITION OF THE FILM WAS NIOBIUM, TITANIUM, AND NITROGEN PROPERLY. THESE EVIDENCES SUGGEST THAT THE NBTIN ON THE COPPER WAVEGUIDE HAS A GOOD SUPERCONDUCTIVITY. THE RF PROPERTIES OF THE WAVEGUIDE ARE NOW UNDER TEST AND THE RESULTS WILL BE INCLUDED AT THE PRESENTATION.

4EPB-02

DESIGN AND ESTIMATION OF SUPERCONDUCTING BAND-PASS FILTERS USING HTS BULK RESONATORS ***A. SAITO****[1], H. TESHIMA[2], S. ONO[1], N. SEKIYA[3], M. TAKEDA[4], K. NAKAJIMA[1], S. OHSHIMA[1];* [1]YAMAGATA UNIVERSITY, [2]NIPPON STEEL CORPORATION, [3]UNIVERSITY OF YAMANASHI, [4]SHIZUOKA UNIVERSITY. — WE PRESENT THE DEVELOPED DESIGN AND ITS ESTIMATION OF SUPERCONDUCTING BAND-PASS FILTERS (BPFS) USING DISK-TYPE RESONATORS MADE BY HIGH-TEMPERATURE SUPERCONDUCTING (HTS) BULK SINGLE CRYSTALS. THE 2-POLE, 3-POLE, AND 4-POLE BPFS USING THE DISK RESONATORS, SEPARATED SUBSTRATES, AND MAGNETIC TRIMMING RODS WERE DESIGNED FOR MULTI-POLE BPFS WITH SHARP SKIRT PROPERTIES USING A 3-DIMENSIONAL EM SIMULATOR. THESE FILTERS SHOWED BPF PROPERTIES WITH A CENTER FREQUENCY OF 5 GHZ AND BANDWIDTH OF 100 MHZ. WE FOUND THAT THE FREQUENCY RESPONSES OF THE CONVENTIONAL 2-POLE, 3-POLE, AND 4-POLE BPFS WERE EASILY ADJUSTED USING MAGNETIC AND/OR DIELECTRIC TRIMMING RODS. WE TRIED TO DESIGN THE 3-POLE BPFS WITH RETURN STRUCTURE OF FILTER PATTERN AND OBTAINED BPF RESPONSES. THESE RESULTS INDICATE THAT WE CAN DESIGN MORE THAN 9-POLE FILTERS WITH RETURN STRUCTURE AND MAY BE USED AS TRANSMIT BPFS WITH SHARP SKIRT PROPERTIES AND HIGH POWER-HANDLING CAPABILITIES.

THIS WORK WAS SUPPORTED IN PART BY THE GRANT-IN-AID FOR YOUNG SCIENTISTS (B) (21760246) AND TELECOMMUNICATIONS ADVANCEMENT FOUNDATION. A PART OF THIS WORK WAS CARRIED OUT IN THE CLEAN ROOM OF YAMAGATA UNIVERSITY.

4EPB-03

MECHANISMS LIMITING THE PERFORMANCE OF MGB2 THIN-FILM MICROWAVE RESONATORS *G. GHIGO[1], R. GERBALDO[1], L. GOZZELINO[1], F. LAVIANO[1], G. LOPARDO[1], B. MINETTI[1], E. MONTICONE[2], C. PORTESI[2],* ***E. MEZZETTI****[1];* [1]DEPARTMENT OF PHYSICS, POLITECNICO DI TORINO, TORINO, ITALY, [2]NATIONAL INSTITUTE OF METROLOGICAL RESEARCH, TORINO, ITALY. — WE INVESTIGATE THE NONLINEAR BEHAVIOR OF MGB2 COPLANAR WAVEGUIDE RESONATORS, IN ORDER TO IDENTIFY THE MECHANISMS SETTING THE PERFORMANCE LIMIT OF POLYCRYSTALLINE MGB2 FILMS IN MICROWAVE APPLICATIONS. IN PARTICULAR, WE FOCUS ON THE SWITCHING RESPONSE OF THE DEVICES TO THE INCREASE OF RF CURRENTS ABOVE A GIVEN THRESHOLD [1]. A MODEL

BASED ON THE HEAT BALANCE EQUATION IS ABLE TO ACCOUNT FOR THE OBSERVED BEHAVIORS, INCLUDING THE PRESENCE OF A REGIME OF THERMAL BISTABILITY. IT ALSO REPRODUCES THE TEMPERATURE DEPENDENCE OF THE LIMITING CURRENTS. RESULTS ARE CONSISTENT WITH THE HYPOTHESIS THAT A HOT-SPOT IS FORMED DUE TO LOCAL JOULE HEATING IN CORRESPONDENCE TO A WEAK LINK. WEAK LINKS ARE MODELLED, IN THIS CASE, AS LONG S-N-S JUNCTIONS, ORIGINATING FROM THE TRANSITION TO THE NORMAL STATE OF ROWS OF ENTIRE MGB2 GRAINS. EFFECTS OF THIS THERMAL PROCESS AND POSSIBLE USES OF MGB2 FILMS IN NONLINEAR DEVICES EXPLOITING THE OBSERVED BEHAVIORS ARE FINALLY DISCUSSED.[1] G. GHIGO ET AL., APPL. PHYS. LETT. 94, 052505 (2009)

4EPB-04

TIME DOMAIN CHARACTERIZATION OF DISCRETE JOSEPHSON JUNCTION TRANSMISSION LINE ***M. KHOSHNEGAR**, H. MAJEDI;* INSTITUTE FOR QUANTUM COMPUTING, UNIVERSITY OF WATERLOO. — TIME DOMAIN ELECTRICAL RESPONSE OF YBCO BICRYSTAL BRAN BOUNDARY JOSEPHSON JUNCTIONS EMBEDDED WITHIN SUPERCONDUCTING TRANSMISSION LINES IS INVESTIGATED EXPERIMENTALLY. ALL YBCO HIGH CRITICAL CURRENT JJS AND THE HOSTING COPLANAR WAVEGUIDES (CPW) ARE GROWN ON STO BICRYSTAL SUBSTRATES. VARIOUS TOPOLOGICAL CONFIGURATIONS FOR TRANSMISSION LINES AND JJS ARE IMPLEMENTED IN ORDER TO FULLY EXAMINE THEIR TIME-RESOLVED TRANSIENTS. THESE CONFIGURATIONS INCLUDE LUMPED SINGLE OR SERIAL JJS LOCATED WITHIN COMPARATIVELY LONG CPWS. THESE STRUCTURES ARE ELEMENTAL BUILDING BLOCKS OF DISCRETE JOSEPHSON JUNCTION TRANSMISSION LINES (DJTL), WITH NICHE APPLICATIONS IN SUPERCONDUCTING MONOLITHIC MICROWAVE INTEGRATED CIRCUITS. WE EXCITED THE SAMPLES WITH UP TO 40 GHZ MICROWAVE GAUSSIAN PULSES AND MEASURED BOTH THE INTRINSIC JUNCTION AND CIRCUIT-CONNECTED FEEDTHROUGH RESPONSES SEPARATELY. WE HAVE ALSO REPORTED OUR EXPERIMENTS THROUGH A TIME DOMAIN SIMULATION BY MODELING TRANSMISSION LINES AND JOSEPHSON JUNCTIONS WITH THEIR EQUIVALENT CIRCUIT ELEMENTS. THESE MEASUREMENTS GIVE US AN INSIGHT TO THE NONLINEAR BEHAVIOR OF BOTH JJS AND CPW TRANSMISSION LINES ESPECIALLY FOR HIGHER DRIVEN CURRENTS.

4EPB-05

DESIGN OF SUPERCONDUCTING TRANSMIT FILTERS USING STRIPLINE STRUCTURE ***N. SEKIYA**[1], K. YAMAMOTO[1], S. KAKIO[1], A. SAITO[2], S. OHSHIMA[2];* [1]UNIVERSITY OF YAMANASHI, [2]YAMAGATA UNIVERSITY. — WE PRESENT THE DEVELOPED DESIGN OF SUPERCONDUCTING FILTER USING A STRIPLINE (SL) STRUCTURE FOR HIGH POWER HANDLING CAPABILITY. AN ELECTROMAGNETIC SIMULATOR WAS USED TO DESIGN AND ANALYZE THE FILTER, WHICH HAD A 5.0-GHZ CENTER FREQUENCY AND A 100-MHZ BANDWIDTH. THE FILTER IS COMPOSED OF 3-POLE HALF-WAVELENGTH STRAIGHT-LINE RESONATORS. SIMULATION RESULTS SHOWED THAT THE SPACING BETWEEN RESONATORS OF THE SL FILTER COULD BE MADE 20% THE SIZE OF A CONVENTIONAL MICROSTRIPLINE (MSL) FILTER BECAUSE OF THE WEAK COUPLING BETWEEN THE RESONATORS. HOWEVER, THE MAXIMUM SURFACE CURRENT OF THE SL FILTER WAS 1.3 TIMES HIGHER THAN THE MSL FILTER WITH THE SAME CHARACTERISTICS IMPEDANCE. TO DECREASE THE MAXIMUM SURFACE CURRENT OF THE SL FILTER, WE INCREASED THE SPACING BETWEEN RESONATORS AND USED WAVEGUIDES BETWEEN RESONATORS TO KEEP THE INITIAL COUPLING STRENGTH. THE MODIFIED SL FILTER WITH 65% THE SPACING BETWEEN RESONATORS OF THE MSL FILTER OBTAINED ALMOST THE SAME MAXIMUM SURFACE CURRENT OF THE MSL FILTER. THESE RESULTS INDICATE THAT THE SPACING BETWEEN RESONATORS IS IMPORTANT FACTOR TO DESIGN HIGH POWER HANDLING CAPABILITY OF THE SL FILTER AND THE SL FILTER CAN BE MADE SMALLER THAN THE MSL FILTER WITH THE SAME POWER HANDLING CAPABILTY.

THIS WORK WAS SUPPORTED IN PART BY CASIO SCIENCE PROMOTION FOUNDATION AND RESEARCH FOUNDATION FOR THE ELECTROTECHNOLOGY OF CHUBU.

4EPB-06

SIS JUNCTION USING AS A MICROWAVE NOISE SOURCE ***H. INOUE**[1], T. NOGUCHI[2], K. KOHNO[1];* [1]UNIVERSITY OF TOKYO, [2]NATIONAL ASTRONOMICAL OBSERVATORY OF JAPAN. — CRYOGENIC LOW NOISE AMPLIFIER (LNA) IS USED IN THE READOUT SYSTEM OFSEVERAL DETECTORS FOR RADIO ASTRONOMY LIKE, HETERODYNE RECEIVERS FORHIGH RESOLUTION SPECTROSCOPY AND KINETIC INDUCTANCE DETECTOR. THE NOISETEMPERATURE IS ONE OF THE MOST IMPORTANT PARAMETERS OF THE LNA BECAUSEIT GOVERNS THE OBSERVATION TIME. RECENTLY THE NOISE TEMPERATURE OF THESELNA REACHED TO A FEW K AND THE MEASUREMENT UNACCURACY COME TO BE APROBLEM. THE NOISE TEMPERATURE OF THE LNA IS USUALLY MEASURED BY NOISESOURCE. FOR ACCURATE MEASUREMENT, THE NOISE SOURCE SHOULD GENERATE NOISEWHOSE POWER LEVEL IS AS LOW AS THAT OF LNA NOISE TEMPERATURE. IN THECONVENTIONAL METHOD THE NOISE POWER IS GENERATED BY ATTENUATING THEOUTPUT OF THE AVALANCHE DIODE AT LOW TEMPERATURE. THIS METHODINEVITABLY INCLUDES A MEASUREMENT INACCURACY > 10 % DUE TO ERRORS OFLOSSES AT AN ATTENUATOR AND THE CABLE BETWEEN THE AVALANCHE DIODE ANDTHE LNA. SUPERCONDUCTOR-INSULATOR-SUPERCONDUCTOR (SIS)JUNCTION GENERATES SHOT NOISE THAT IS IN PROPOTION TO THE BIAS VOLTAGESO IT CAN BE USED AS A NOISE SOURCE FOR AN ACCURATE NOISE TEMPERATUREMEASUREMENT (~ A FEW %).CONSIDERING IMPEDANCE MATCHING, SIS JUNCTION AND ITS HOUSING WERE DESIGNED. THE FREQUENCY CHARACTERISTICS OF THE NOISE TEMPERATURE WASCOMPARED BETWEEN THE CONVENTIONAL METHOD AND SIS SHOT NOISE METHOD. TWORESULTS MATCHED WITHIN THE MEASUREMENT UNACCURACY.

4EPB-07

MICROWAVE PHASE AND AMPLITUDE MODULATOR FOR MICROWAVE PULSE GENERATION ***T. OHKI**[1], R. RAFIQUE[2];*

[1]BBN TECHNOLOGIES, [2]ST-ERICSSON. — WE PRESENT A MICROWAVE AMPLITUDE/PHASE MODULATION DEVICE BASED ON SUPERCONDUCTING RESONATOR AND SYNTHETIC TRANSMISSION LINE TECHNOLOGY. THE PRIMARY BENEFITS OF THIS DEVICE ARE AGILE FREQUENCY RESPONSE FOR MODULATION OVER A 2 GHZ BANDWIDTH, LOW POWER DISSIPATION AND POTENTIAL FOR INTEGRATION WITH HIGH-SPEED SFQ LOGIC. THIS DEVICE DEMONSTRATES THE PHASE MODULATION OF ≈ 60°, AND AMPLITUDE MODULATION OF ≈30DB IN A 2 GHZ LOCAL OSCILLATOR BANDWIDTH. THE TARGETED APPLICATION OF THIS TECHNOLOGY IS FOR LOW POWER MICROWAVE PULSE GENERATION FOR QUBIT APPLICATIONS. IN THIS PAPER WE PRESENT RESULTS FOR THE MODULATOR AND INTRODUCE POTENTIAL APPLICATIONS IN QUANTUM COMPUTING AND DIGITAL LOGIC I/O.

4EPB-08

THZ PROPAGATION WITHIN HTS PARALLEL PLATE WAVE GUIDES ***B. YOO***[1]*, D. CHUNG*[1]*, M. KWAK*[2]*, H. CHOI*[3]*, S. KANG*[2]*, S. KIM*[2]*, H. RYU*[2]*, M. PAEK*[2]*, K. KANG*[2]*;* [1]WOOSUK UNIV., [2]ETRI, [3]CHOSUN UNIV.. — IN THIS PAPER WE REPORT THE PROPAGATION CHARACTERISTICS OF TERAHERTZ WAVE WITHIN HIGH-TC SUPERCONDUCTING (HTS) PARALLEL PLATE WAVE GUIDES. PLANAR WAVE GUIDES ARE IMPORTANT COMPONENTS TO ESTABLISH INTEGRATION CIRCUITS OF FUTURE TERAHERTZ APPLICATION, LIKE HIGH SPEED COMMUNICATION SYSTEMS, BIOMEDICAL ENGINEERING, IMAGING AND SPECTROSCOPY SYSTEMS. WE INVESTIGATED EXPERIMENTAL RESULTS FOR THE PROPAGATION PROPERTIES OF THZ PULSES WITHIN HTS PARALLEL PLATE WAVE GUIDES WHICH WERE MADE OF HIGH-TC SUPERCONDUCTING (HTS) THIN FILMS. OUR WAVE GUIDES DESIGNED IN THIS WORK WAS FABRICATED USING AN YBCO SUPERCONDUCTING THIN FILM ON AN MGO SUBSTRATE, AND THE DESIGNED PROPAGATION FREQUENCY WAS 1 THZ. EXPERIMENTAL RESULTS COMPARED WITH NORMAL METAL COUNTERPART SHOWED THAT MAIN ATTENUATION IN A PLANAR WAVE GUIDE WAS DUE TO THE FINITE CONDUCTIVITY OF NORMAL METAL LIKE COPPER. HOWEVER THE GUIDED THZ PULSES IN OUR WAVE GUIDE DEMONSTRATED VERY LOW ATTENUATION AND GROUP VELOCITY DISPERSION.

4EPC-01

FABRICATION OF NANO-ANTENNAS FOR SUPERCONDUCTING INFRARED DETECTOR ***A. KAWAKAMI****, S. SAITO;* NICT. — TO IMPROVE THE PERFORMANCE OF SUPERCONDUCTING INFRARED DETECTOR, WE HAVE CONSIDERED A FABRICATION PROCESS OF NANO-ANTENNA. THE NANO-ANTENNA CONSISTS OF A DIPOLE ANTENNA AND AN NBN THIN FILM BRIDGE WHICH IS PLACED IN THE CENTER OF THE ANTENNA. IN ORDER TO EVALUATE THE ANTENNA CHARACTERISTICS USING FOURIER TRANSFORM INFRARED SPECTROSCOPY, WE FABRICATED 2-D-ARRAYS OF THE NANO-ANTENNA. THE ANTENNA LENGTH AND WIDTH WERE SET AROUND 2400 NM AND 400 NM, AND THE ANTENNAS WERE PLACED AT INTERVAL OF SEVERAL MICRO-METERS ALL OVER THE AREA OF 1MM2. ON THE EVALUATION OF SPECTRAL TRANSMISSION CHARACTERISTICS OF THE ANTENNA ARRAY, CLEAR ABSORPTION CAUSED BY ANTENNA EFFECTS WAS OBSERVED AT AROUND 1100 CM-1.

4EPC-02

NBTIN HOT ELECTRON BOLOMETER WAVEGUIDE MIXERS ON Si_3N_4 MEMBRANES AT THZ FREQUENCIES ***P. PÜTZ****, K. JACOBS, M. JUSTEN, F. SCHOMAKER, M. SCHULTZ, S. WULFF, C. E. HONINGH;* UNIVERSITÄT ZU KÖLN. — WE REPORT ON NBTIN HOT ELECTRON BOLOMETER MIXER DESIGN AND FABRICATION FOR THE 1.5, 1.9 AND 2.5 THZ FREQUENCY BANDS FOCUSED ON OUR CONTRIBUTION TO THE MULTI-BAND SINGLE-PIXEL RECEIVERS OF THE GERMAN RECEIVER FOR ASTRONOMY AT TERAHERTZ FREQUENCIES (GREAT), WHICH IS A FIRST LIGHT INSTRUMENT FOR THE AIRBORNE STRATOSPHERIC OBSERVATORY FOR INFRARED ASTRONOMY (SOFIA), AND THE FOCAL PLANE ARRAY RECEIVER ON THE BALLOON-BORNE STRATOSPHERIC TERAHERTZ OBSERVATORY (STO). WE MEASURE DEVICE NOISE AND GAIN ROLL-OFF VS. INTERMEDIATE FREQUENCY AND ANALYZE THE RECEIVER SYSTEM OUTPUT POWER STABILITY AND IF BAND RIPPLE WITH NEWLY DEVELOPED SIGE HBT CRYOGENIC LOW-NOISE AMPLIFIERS FROM THE S. WEINREB GROUP (CALTECH). THE MIXERS USE WAVEGUIDE TECHNOLOGY WITH THE DEVICE COUPLED TO A PROPAGATING WAVEGUIDE MODE VIA AN INTEGRATED PROBE ANTENNA. THE DEVICE IS ELECTRICALLY CONNECTED THROUGH BEAMLEADS, WHICH RELIABLY SUSPEND THE 2 μM THIN SI3N4 MEMBRANE WITH MICROMETER MOUNTING PRECISION. ELECTRON BEAM LITHOGRAPHY DEFINES THE 400 NM LONG AND 4 NM THICK NBTIN MICROBRIDGES AND A NOVEL DEEP REACTIVE-ION ETCH FOR SHAPING OF THE SUBSTRATES.

4EPC-03

A STUDY OF THE STABILITY OF THE QUASI-OPTICAL SUPERCONDUCTING NBTIN HOT-ELECTRON BOLOMETER MIXER AT 1.5 THZ FREQUENCY BAND ***H. MAEZAWA***[1]*, T. YAMAKURA*[2]*, S. YAMAMOTO*[3]*, T. SHIINO*[3]*, S. SHIBA*[3]*, A. MIZUNO*[1]*, N. NAKAI*[2]*;* [1]NAGOYA UNIVERSITY, [2]TSUKUBA UNIVERSITY, [3]UNIVERSITY OF TOKYO. — WE HAVE DEVELOPED QUASI-OPTICAL SUPERCONDUCTING HOT ELECTRON BOLOMETER (HEB) MIXERS COMBINED WITH A TWIN-SLOT ANTENNA AND A HYPER-HEMISPHERE LENS. THE MICRO-BRIDGE OF THE MIXER IS FORMED OF AN NBTIN THIN FILM DEPOSITED ON SI SUBSTRATE ON ALN BUFFER LAYER WITH A HELICON PLASMA SPUTTERING TECHNIQUE. THE MIXER IS COOLED TO 4 K WITH A MECHANICAL PULSED TUBE REFRIGERATOR. THE MECHANICAL VIBRATION AND TEMPERATURE FLUCTUATION AT THE MIXER POSITION ARE REDUCED TO BETTER THAN 3 MICRON AND 2 MK, RESPECTIVELY. AT 1.5 THZ FREQUENCY BAND ALLAN VARIANCE OF THE INTERMEDIATE FREQUENCY (IF) SIGNAL OUTPUT FROM THE MIXER WAS INVESTIGATED SWEEPING A LOCAL OSCILLATOR POWER WITH THE BIAS VOLTAGE FIXED. WE FOUND THAT IF POWER HAS A PEAK MAXIMUM AS A FUNCTION OF BIAS CURRENTS. THE IF SIGNAL WAS MOST STABLE AT AROUND THE MAXIMUM REGION GIVING OPTIMUM RECEIVER NOISE TEMPERATURE. WE WILL REPORT THE PRELIMINARY RESULTS.

4EPC-04

DIRECT MEASUREMENT OF THE GAIN AND NOISE BANDWIDTHS OF HEB MIXERS ***Y. V. LOBANOV***[1]*, E. TONG*[1]*, A. HEDDEN*[1]*, R. BLUNDELL*[1]*, B. M. VORONOV*[2]*, G. N. GOL'TSMAN*[2]*;* [1]HARVARD-SMITHSONIAN CENTER FOR ASTROPHYSICS, [2]MOSCOW STATE PEDAGOGICAL UNIVERSITY. — THE INTERMEDIATE FREQUENCY (IF) BANDWIDTH OF A HOT ELECTRON BOLOMETER (HEB) MIXER IS AN IMPORTANT PARAMETER OF THE MIXER, WHICH DETERMINES ITS SCOPE OF APPLICATION. THE IF BANDWIDTH IS GENERALLY MEASURED INDIRECTLY USING AN INJECTED SIGNAL BY VARYING THE LO FREQUENCY. WITH THE AVAILABILITY OF WIDEBAND LOW NOISE AMPLIFIERS, IT IS SIMPLE TO MEASURE THE PERFORMANCE OF AN HEB MIXER OVER A WIDE RANGE OF IF AT A FIXED LO FREQUENCY USING THE STANDARD Y-FACTOR METHOD. THIS APPROACH ALLOWS US TO MEASURE BOTH THE GAIN AND NOISE BANDWIDTHS SIMULTANEOUSLY. WE HAVE PERFORMED SUCH A MEASUREMENT AT 810 GHZ, USING A 0.1-4 GHZ CRYOGENIC IF AMPLIFIER. FOR OUR NBN BASED WAVEGUIDE HEB MIXERS, WE HAVE MEASURED RECEIVER NOISE TEMPERATURES OF 500 K AT 1 GHZ IF, RISING TO 1100 K AT 4 GHZ IF. FROM THE RECEIVER POWER OUTPUTS IN RESPONSE TO HOT AND COLD LOADS, WE DEDUCE A GAIN BANDWIDTH OF ~ 3 GHZ. WE HAVE ALSO MEASURED MIXER OUTPUT IMPEDANCE WITH A VECTOR NETWORK ANALYZER. FROM THE THEORY OF OPERATION OF HEB MIXERS, THE DEVICE'S TIME CONSTANT CAN BE EXTRACTED FROM THE IMPEDANCE DATA. THIS TIME CONSTANT IS IN GOOD AGREEMENT WITH THE BANDWIDTH OBSERVED WITH OUR RECEIVER Y-FACTOR MEASUREMENT.

4EPC-05

SENSOR APPLICATION OF A SERIES ARRAY OF MESOSCOPIC SNS JUNCTIONS AS A FERMION OSCILLATOR SYSTEM ***T. MATSUI****, H. OHTA, A. KAWAKAMI;* NATIONAL INST. OF INFO. & COMM. TECH.. — CURRENT TRANSPORT IN AN SERIES ARRAYS OF MESOSCOPIC SNS JUNCTIONS WITH VERY SHORT N-REGION IS DESCRIBED WITH A RESONANCE TUNNELING BETWEEN THE SN AND NS INTERFACES, AND PICTURE OF SEQUENTIAL-TUNNELING THROUGH THE CASCADED QUANTUM DOTS. THE TRANSPORT OF CURRENT IN THE STATE OF APPROXIMATING ZERO VOLTAGE IS EXPRESSED THE ELECTRON-PAIR CURRENT REFLECTS THE MULTIPLE-ANDREEV REFLECTIONS WHICH QUICKLY DECREASES IN ACCORDANCE AS THE BIAS VOLTAGE INCREASE AND A CHARACTERISTIC SHOW NEGATIVE RESISTANCE. WE DEVELOPED NEW PROCESS TO SUPPRESSING THE DISPERSION OF THE SUPERCONDUCTING CURRENT I_C AND MAINTAINING THE VALUE OF I_C AS THE CHARACTERISTIC OF SERIES CONNECTION AT THE HIGHEST POSSIBLE. AS A RESULT, THE VOLTAGE RANGE OF THE NEGATIVE RESISTANCE REGION IS EXPANDED AND DYNAMIC RANGE IS ALSO EXPANDED FOR EACH SERIES ARRAY OF SNS JUNCTIONS. THE MESOSCOPIC SNS JUNCTIONS ARE MADE OF EITHER ALL NB-FILM OR ALL NBN-FILMS SNS WEAK-LINKS. CONDUCTANCE OF THE MESOSCOPIC SNS WEAK-LINKS WAS SENSITIVELY INFLUENCED BY THE CRITICAL RF POWER COUPLING OF MILLIMETER-WAVE. STRONG CONDUCTANCE REDUCTION IN SERIES ARRAYS OF JUNCTIONS IS PROVABLY INDUCED BY THE SUPERCONDUCTING FLUCTUATIONS DUE TO QUASIPARTICLES EXCITATION AND INCREASE IN ELECTRON AND HALL CONCENTRATION AROUND N-REGIONS OF THE SNS STRUCTURES. BEHAVIORS OF THE SERIES ARRAY OF MESOSCOPIC SNS JUNCTIONS MUST BE EXPLAINED BY A FERMION OSCILLATOR SYSTEM.

4EPC-06

DESIGN AND PERFORMANCE OF 660 GHZ SIS MIXERS FOR THE SUBMILLIMETER ARRAY TELESCOPE ***A. HEDDEN***[1]*, E. TONG*[1]*, R. BLUNDELL*[1]*, K. JACOBS*[2]*, C. HONINGH*[2]*, P. PUETZ*[2]*, S. WULFF*[2]*, M. SCHULTZ*[2]*;* [1]HARVARD-SMITHSONIAN CENTER FOR ASTROPHYSICS, [2]PHYSIKALISCHES INSTITUT DER UNIVERSITAT ZU KOLN. — A NEW BATCH OF NB/AL-ALOX/NB SIS DEVICES WITH END-LOADED STUB INTEGRATED TUNING STRUCTURES WAS DESIGNED FOR OPERATION OVER 630-696 GHZ AND FABRICATED FOR THE SUBMILLIMETER ARRAY'S 660 GHZ RECEIVERS. WE PRESENT AN OVERVIEW OF THE DESIGN AND OPTIMIZATION OF THE SUPERCONDUCTING NB INTEGRATED TUNING CIRCUIT AND A SUMMARY OF MIXER PERFORMANCE IN A LAB TEST RECEIVER SYSTEM. IN ORDER TO ACHIEVE GOOD PERFORMANCE AT FREQUENCIES ABOVE THE SUPERCONDUCTING ENERGY GAP FREQUENCY (~660 GHZ FOR NB DEVICES AT 4.2 K), WE HAVE OPTIMIZED THE TUNING CIRCUIT FOR OPERATION TOWARDS THE HIGH FREQUENCY END OF THE BAND. OUR MODEL SHOWS THAT THE INSERTION LOSS OF THE TUNING CIRCUIT IS ONLY ~7% OVER 680-700 GHZ WHERE THE DEVICE POWER COUPLING PEAKS. DEVICES WERE FABRICATED USING E-BEAM LITHOGRAPHY TECHNIQUES AND LIQUID HELIUM DIPTEST MEASUREMENTS SHOW TYPICAL CHARACTERISTICS OF RSUBGAP / RN ~ 15, VGAP ~ 2.8 MV, JC ~10 KA/CM2, RN ~ 25 Ω. MIXER PERFORMANCE WAS MEASURED IN THE LABORATORY USING A LIQUID HE CRYOSTAT. THE MEASUREMENT SETUP USES A ROOM TEMPERATURE LOCAL OSCILLATOR INJECTION SCHEME WITH A POLARIZING WIRE GRID THAT ADDS ~10 K NOISE TO THE SYSTEM. UNCORRECTED RECEIVER NOISE TEMPERATURES (TREC) BELOW 110 K (Y-FACTORS > 2.17) WERE MEASURED BETWEEN 650-690 GHZ WITH MINIMUM TREC OF 100 K AT 672 GHZ. THIS SHOWS THAT THE SUPERCONDUCTING GAP HAS LITTLE IMPACT ON THE RECEIVER SENSITIVITY.

4EPC-07

DEVELOPMENT OF SUPERCONDUCTOR-INSULATOR-SUPERCONDUCTOR (SIS) TERAHERTZ RECEIVER WITH A MECHANICAL AND THERMAL VIBRATION-REDUCED CRYOCOOLER ***T. YAMADA****, K. KIKUCHI, S. KOHJIRO;* AIST. — THE OBJECTIVE OF OUR STUDY IS DEVELOPMENT OF A COMPACT AND WIDEBAND SPECTROMETER OF GASES IN SUB-TERAHERTZ REGION, WHICH CONSISTS OF A SIS MIXER IN 200-500 GHZ BAND AND A GIFFORD-MCMAHON CRYOCOOLER (GMC) WITH A COOLING POWER OF 100 MW AT 4 K. AS A MILESTONE, WE ARE INTRODUCING A 400-MW GMC WITH SPECIAL TECHNIQUE WHICH REDUCES MECHANICAL AND THERMAL VIBRATIONS AS FOLLOWS. THE SAMPLE STAGE SUPPORTED BY FIBER-REINFORCED-PLASTIC RODS HAS WEAK MECHANICAL COUPLE TO A COLDHEAD USING FLEXIBLE FLAT

OXYGEN-FREE COPPER CABLES WITH HIGH THERMAL CONDUCTIVITY. CONSEQUENTLY, IT REDUCED THE VIBRATION FROM 32 UM TO 6 UM. A HELIUM POT BENEATH THE SAMPLE STAGE EFFECTIVELY REDUCED THE THERMAL VIBRATION AT 1 HZ FROM 0.06 $K/HZ^{0.5}$ TO 0.01 $K/HZ^{0.5}$. AN ACTIVE TEMPERATURE CONTROL SUCCESSFULLY REDUCES A LARGE VIBRATION OF 0.2 $K/HZ^{0.5}$ AT 0.01 HZ WHICH CORRELATES TO THE DRIFT OF THE OUTPUT POWER OF THE MIXER. THE THERMAL LOAD OF 4-K STAGE IS SUCCESSFULLY REDUCED TO 80 MW MAINLY BY THE CASCADE OF TWO ZITEX 108 FILMS AS AN INFRARED FILTER. THESE RESULTS ARE PROSPECTIVE ENOUGH TO INTRODUCE A SMALLER 100-MW GMC.

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4EPC-08

TESTING AND ANALYSIS OF BICRYSTAL JOSEPHSON JUNCTION MIXER'S CONVERSION EFFICIENCY AT THZ ***T. HUA**, D. C. LI, L. ZHOU, W. W. XU, J. CHEN, P. H. WU;* RESEARCH INSTITUTE OF SUPERCONDUCTOR ELECTRONICS, NANJING UNIVERSITY, NANJING, CHINA. — THIS PAPER IS A RESEARCH ON THE CONVERSION EFFICIENCY OF HIGH-TEMPERATURE SUPERCONDUCTIVITY BICRYSTAL JOSEPHSON JUNCTION MIXER. USING ION ETCHING, JUNCTION INTEGRATED WITH ANTENNA IS PREPARED. EXPERIMENT ON HARMONIC MIXING UNDER THZ FREQUENCE HAS BEEN CARRIED ON. MECHANISM AND CHARACTERISTICS OF NOISE,RELATIONSHIP BETWEEN CONVERSION EFFICIENCY AND LOCAL OSCILLATION POWER, MICROWAVE SIGNAL POWER, HARMONIC ORDER, BIAS ELECTRIC CURRENT, ETC., HAS BEEN TESTED AND ANALYZED.

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4EPC-09

SIS MIXER DEVELOPMENTS FOR SMA ***C. LI;*** INSTITUTE OF ASTRONOMY AND ASTROPHYSICS, ACADEMIA SINICA. — MIXERS EMPLOYING SUPERCONDUCTING-INSULATING-SUPERCONDUCTING (SIS) TUNNEL JUNCTIONS WERE DESIGNED AT 460 GHZ AND OTHER FREQUENCY BANDS FOR THE SUBMILLIMETER ARRAY (SMA). TO CANCEL JUNCTION CAPACITANCE, VARIOUS TUNING STRUCTURES WERE EMPLOYED. DEVICES WITH HIGH-CURRENT-DENSITY JUNCTIONS ARE FABRICATED FOR WIDER BANDWIDTHS. PRELIMINARY TESTING OF THE 460 GHZ DEVICES SHOWS A RECEIVER NOISE TEMPERATURE AROUND 90 K. NOISE CONTRIBUTIONS FROM OPTICS LOSS AND IF WERE ESTIMATED TO BE AROUND 50K AND 15K, RESPECTIVELY. COMPARISON BETWEEN TEST RESULTS AND SIMULATIONS WILL BE PRESENTED. EMBEDDING IMPEDANCE FOR OPTIMUM RECEIVER NOISE TEMPERATURE IS ALSO DISCUSSED. FOR POSSIBLE UPGRADE, DUAL-POLARIZATION WAVEGUIDE RECEIVERS WITH AN INTEGRATED PLANAR ORTHO-MODE TRANSDUCER (OMT) ARE CONSIDERED. BY OBSERVING DUAL POLARIZATIONS SIMULTANEOUSLY, THE SENSITIVITY OF THE ARRAY IS INCREASED. MAGNETIC FIELD INFORMATION CAN ALSO BE INFERRED. RESULTS FROM 3D EM FIELD SIMULATIONS WILL BE PRESENTED.

4EPC-10

CHARACTERIZATION OF SIS RECEIVERS USING A DIGITAL SPECTROMETER ***C. TONG**, S. PAINE, A. HEDDEN, R. BLUNDELL;* SMITHSONIAN OBSERVATORY. — FOURIER TRANSFORM BASED DIGITAL SPECTROMETERS WHICH OFFER WIDE INSTANTANEOUS BANDWIDTH AND HIGH SPECTRAL RESOLUTION ARE WIDELY USED IN ULTRA-SENSITIVE SIS RECEIVER SYSTEMS. IN THIS PAPER, WE WILL DEMONSTRATE THAT A FAST DIGITAL SPECTROMETER CONNECTED TO THE OUTPUT OF AN SIS RECEIVER CAN BE USED TO PROBE THE STANDING WAVE STRUCTURE IN THE OPTICS BETWEEN THE SIS MIXER AND A TERMINATING INPUT LOAD. IT CAN BE SHOWN THAT THE AMPLITUDE OF THIS VOLTAGE STANDING WAVE IS PROPORTIONAL TO THE SQUARE ROOT OF THE PRODUCT OF THE VOLTAGE REFLECTION COEFFICIENTS OF THE LOAD AND THE MIXER. THIS RELATION CAN BE EXPLOITED TO DERIVE THE INPUT REFLECTION COEFFICIENT OF THE SIS MIXER AS WELL AS ITS SIDEBAND RATIO. BOTH THE THEORY AND EXPERIMENTAL DETAILS WILL BE PRESENTED.

4EPC-11

NOISE AND BANDWIDTH PERFORMANCE OF TWIN VERTICALLY STACKED SIS JUNCTIONS *J. LI[1], **S. SHI**[1], M. WANG[2], T. CHEN[2], C. CHEN[2], W. LU[2], C. CHIU[2];* [1]PURPLE MOUNTAIN OBSERVATORY, [2]INSTITUTE OF ASTRONOMY AND ASTROPHYSICS. — TWIN SIS (SUPERCONDUCTOR-INSULATOR-SUPERCONDUCTOR) JUNCTIONS, WITH A SIMPLE STRUCTURE, YET LARGE BANDWIDTH AND LOW NOISE TEMPERATURE, HAVE BEEN WIDELY USED IN MILLIMETER- AND SUBMILLIMETER-WAVE HETERODYNE MIXERS. WITH THE INCREASE OF FREQUENCY, HOWEVER, THE LENGTH OF THE TUNING INDUCTANCE SEPARATING THE TWO INDIVIDUAL SIS JUNCTIONS BECOMES SHORT WHILE THE JUNCTION'S AREA (I.E., ITS CAPACITANCE) IS FIXED. A SHORT TUNING INDUCTANCE WILL RESULT IN NON-NEGLIGIBLE EFFECT OF THE JUNCTION'S SPREADING INDUCTANCE AND THE DIFFICULTY OF JUNCTION FABRICATION. WITH A SMALL EQUIVALENT GEOMETRIC CAPACITANCE, VERTICALLY STACKED SIS JUNCTIONS (VSJ) ARE BENEFICIAL TO THE INCREASES OF THE JUNCTION'S TUNING INDUCTANCE. WE HAVE DESIGNED TWIN VSJS, I.E., TWO IDENTICAL DOUBLE-BARRIER NB/ALN/NB/ALN/NB JUNCTIONS SEPARATED BY A TUNING INDUCTANCE, AT 220 GHZ, 500 GHZ, AND 660 GHZ WITH THE SAME JUNCTION AREA AND CRITICAL CURRENT DENSITY. THEIR NOISE AND BANDWIDTH PERFORMANCE ARE THOROUGHLY CHARACTERIZED. DETAILED SIMULATION AND EXPERIMENTAL RESULTS WILL BE PRESENTED.

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4EPC-12

STABILITY OF SUPERCONDUCTING HOT ELECTRON BOLOMETER RECEIVERS ***J. CHEN****, Y. JIANG, M. LIANG, X. JIA, L. KANG, B. JIN, W. XU, P. WU;* NANJING UNIVERSITY. — THERE IS GREAT INTEREST IN BUILDING STABLE HETERODYNE RECEIVERS AT THE TERAHERTZ (THZ) WAVEBAND FOR APPLICATIONS IN ASTRONOMY AND SO ON. SUPERCONDUCTING HOT ELECTRON BOLOMETER (HEB) RECEIVERS HAVE BEEN USED FOR SENSITIVE ASTRONOMICAL OBSERVATIONS ABOVE 1 THZ IN HERSCHEL SATELLITE. HOWEVER, ITS STABILITY STILL IS ONE OF THE MAIN ISSUES AT THIS MOMENT. HERE, THE STABILITY OF SUPERCONDUCTING HEB RECEIVERS, FABRICATED BY HIGH-QUALITY ULTRA-THIN NIOBIUM NITRIDE (NBN) FILMS, HAS BEEN CHARACTERIZED BY THE ALLAN VARIANCE MEASUREMENTS WITH DIFFERENT TYPES OF THE LOCAL OSCILLATOR: FAR-INFRARED (FIR) LASER AND MULTIPLIER CHAIN. THE ALLAN TIME ABOUT 1 S HAS BEEN OBTAINED. ALSO, THE STABILIZATION SCHEME USING A RADIATION WITH A FREQUENCY MUCH LOWER THAN THE GAP FREQUENCY OF NBN HAS BEEN CHECKED TO IMPROVE THE STABILITY OF THE HEB RECEIVERS.

WE THANK PROF. G. N. GOL'TSMAN, PROF. Y. MIZUGAKI, DR. S. C. SHI, DR. W. ZHANG AND DR. L. JIANG FOR THEIR HELPFUL DISCUSSIONS.

4EPC-13

MULTIBAND TERAHERTZ DETECTION USING A SUPERCONDUCTING HOT-ELECTRON BOLOMETER DETECTOR AND A TRIBAND MESH FILTER ***L. LIU****[1], D. HERALD[2], J. ZHANG[2], A. LICHTENBERGER[2], R. WEIKLE, II[2], G. XING[1], P. FAY[1];* [1]UNIV. OF NOTRE DAME, [2]UNIV. OF VIRGINIA. — IT IS DESIRABLE TO ACHIEVE MULTIBAND THZ DETECTION IN MANY APPLICATIONS SUCH AS ASTRONOMY, DIAGNOSTICS, BIOSENSING AND THZ SPECTROSCOPY. SUPERCONDUCTING HEB DEVICES HAVE BEEN SHOWN TO EXHIBIT HIGHER SENSITIVITY, AND BROADBAND OPERATION WHEN INTEGRATED WITH QUASI-OPTICAL STRUCTURES SUCH AS SELF-COMPLEMENTARY PLANAR ANTENNAS. IN ORDER TO ACHIEVE A DETECTION SYSTEM CAPABLE OF MULTI-BAND OPERATION, A MULTI-BAND MESHFILTER IS REQUIRED IN ADDITION TO THE DEVELOPMENT OF A BROADBAND SUPERCONDUCTING HEB DETECTOR.IN THIS WORK, A BROADBAND HEB DETECTOR BASED ON A PLANAR SINUOUS ANTENNA THAT COVERS 50 GHZ TO 900 GHZ HAS BEEN DESIGNED AND FABRICATED. FOR MULTIBAND THZ DETECTION, TRIBAND MESHFILTERS USING FRACTAL CROSS-SLOTS AND MULTI-RING SLOT STRUCTURES HAVE BEEN SIMULATED AND FABRICATED. FREQUENCY RESPONSES OF THESE MESHFILTERS HAVE BEEN MEASURED USING A FTIR SYSTEM, AND THE RESULTS HAVE SHOWN THAT THEY COVER THREE THZ BANDS CENTERED AT 250 GHZ, 350 GHZ AND 585 GHZ, WITH 3-DB BANDWIDTHS OF APPROXMATELY 50 GHZ. THE BROADBAND HEB DETECTORS AND THE TRIBAND MESHFILTERS WILL BE MOUNTED IN A CLOSE-CYCLED CRYOCOOLER, AND THE PERFORMANCE OF THE DETECTOR SYSTEM WILL BE STUDIED AND EVALUATED. PARAMETERS INCLUDING THE RESPONSIVITY AND NEP'S AT THE THREE THZ BANDS WILL BE PRESENTED TO DEMONSTRATE THE CAPABILITY OF MULTIBAND THZ DETECTION.

4EPD-01

A RE-ENTRANT MGB_2 CAVITY FOR DYNAMIC CASIMIR EXPERIMENT ***G. GIUNCHI****[1], A. FIGINI ALBISETTI[1], C. BRAGGIO[2], G. CARUGNO[2], G. MESSINEO[3], G. RUOSO[4], G. GALEAZZI[4];* [1]EDISON SPA, [2]INFN SEZIONE PADOVA ,DIPARTIMENTO FISICA "G.GALILEI", [3]INFN SEZIONE TRIESTE ,DIPARTIMENTO FISICA UNIVERSITÀ TRIESTE, [4]LABORATORI NAZIONALI LEGNARO ,INFN ,LEGNARO ,PADOVA. — THE USE OF RF SUPERCONDUCTING RE-ENTRANT CAVITIES HAS BEEN SUGGESTED IN THE FRAMEWORK OF THE RESEARCHES TO DETECT THE PHOTON GENERATION FROM THE VACUUM, DUE TO THE DYNAMICAL CASIMIR EFFECT. A THIN SEMICONDUCTING SLAB, PUT INSIDE THE CAVITY, WILL BE EXCITED BY TRAIN LASER PULSES OF A FREQUENCY TWICE THE RESONANT FREQUENCY OF THE CAVITY, SO THAT IT WILL BE REALIZED A PERIODIC MODULATION OF THE DIELECTRIC CONSTANT OF THE SLAB. IN ORDER TO REALIZE A RF CAVITY THAT CAN SAFELY WORKS AT TEMPERATURES LARGER THAN 4K , WE HAVE DESIGNED AND CONSTRUCTED A MGB_2 RE-ENTRANT CAVITY HAVING THE RESONANT FREQUENCY IN THE RANGE OF 2 - 3 GHZ. THE CAVITY IS MADE BY A CYLINDRICAL CUP OF ABOUT 40 MM OF INTERNAL DIAMETER AND 40 MM OF HEIGHT AND ON ITS BASE IS STANDING A CYLINDRICAL COAXIAL NOSE ON WHICH THE SEMICONDUCTOR SLAB WILL BE DEPOSITED. THE DETAILS OF THE CONSTRUCTION OF THE MGB_2 CAVITY WILL BE PRESENTED AS WELL AS THE MEASUREMENTS OF ITS QUALITY FACTOR, AS A FUNCTION OF THE TEMPERATURE.

EDISON SPA ACKNOWLEDGES THE CNR-IENI LABORATORY IN LECCO , FOR ITS HELP IN THE MATERIALS MANUFACTURING

4EPD-03

THZ DIRECT DETECTOR BASED ON SI WITH SUPERCONDUCTING CONTACTS. ***D. MOROZOV****[1], P. MAUSKOPF[1], P. BARRY[1], T. BRIEN[1], T. WHALL[2], M. PREST[2];* [1]CARDIFF UNIVERSITY, [2]WARWICK UNIVERSITY. — WE DESCRIBE A HIGH SENSITIVITY THZ DETECTOR BASED ON THE HOT ELECTRON EFFECT IN A HIGHLY DOPED THIN SILICON SEMICONDUCTING LAYER WITH TUNNELLING CONTACTS TO SUPERCONDUCTING ISLANDS (S-SM-S). THE INCIDENT POWER IS ABSORBED BY THE RESISTIVE ELECTRONS IN THE DEGENERATELY DOPED SILICON CAUSING AN INCREASE IN THE ELECTRON TEMPERATURE OVER THE TEMPERATURE OF THE SURROUNDING CRYSTAL LATTICE VIBRATIONS (PHONONS). THE MAXIMUM FREQUENCY OF RADIATION WHICH CAN BE ABSORBED IS LIMITED BY THE KINETIC INDUCTANCE OF THE ABSORBING ELECTRONS TO NU_MAX ~ 10 THZ. HOT ELECTRONS IN THE ABSORBER TUNNEL INTO THE SUPERCONDUCTING LEADS THROUGH SCHOTTKY BARRIERS IN THE BOUNDARY BETWEEN SI AND SC MATERIAL (ALUMINIUM). WE PRESENT SIMULATIONS OF THE OPTICAL RESPONSE AND SENSITIVITY OF DIFFERENT DETECTOR CONFIGURATIONS USING SINGLE MODE AND MULTI-MODE ANTENNAS. SENSITIVITY ESTIMATES BASED ON MEASURED PROPERTIES OF TEST STRUCTURES GIVE NOISE EQUIVALENT POWER (NEP) OF 10^-13 W/RTHZ FOR A DEVICE OPERATED AT 4 K, 10^-17 W/RTHZ FOR A DEVICE AT 300 MK AND 10^-19

W/RTHZ FOR A DEVICE OPERATED AT 60 MK. WE ALSO PRESENT INITIAL RESULTS OF OPTICAL TESTS ON PROTOTYPE DEVICES.

4EPD-04

YBCO-FILM BASED TERAHERTZ DETECTORS IN NOT DISSIPATIVE REGIME: CONTROL OF THE THZ RESPONSE BY HEAVY IONS NANOSTRUCTURE IMPLANTATION ***E. MEZZETTI***[1]*, R. GERBALDO*[1]*, G. GHIGO*[1]*, L. GOZZELINO*[1]*, F. LAVIANO*[1]*, B. MINETTI*[1]*, A. ROVELLI*[2]*;* [1]POLITECNICO DI TORINO, [2]ISTITUTO NAZIONALE DI FISICA NUCLEARE - LABORATORI NAZIONALI DEL SUD. — BROADBAND ELECTROMAGNETIC CHARACTERIZATION OF HOT PLASMAS, I.E. IN NUCLEAR FUSION, REQUIRES DETECTORS THAT MUST WITHSTAND HIGH FLUX OF PARTICLE AND ELECTROMAGNETIC RADIATIONS. WE REPORT ABOUT A PROJECT AIMED AT CREATING ROBUST THZ DETECTORS BASED ON YBCO FILMS, WORKING AT LIQUID NITROGEN TEMPERATURE AND IN REGIME OF EXTREME LOW DISSIPATION. THE SCALABLE SENSOR LAYOUT IS COMPOSED BY TWO CONTIGUOUS MEANDERS. ONE OF THEM IS NANOSTRUCTURED BY COLUMNAR DEFECTS (INDUCED BY HIGH ENERGY HEAVY ION IRRADIATION LITHOGRAPHY [E. MEZZETTI ET AL., NIMB 240 (2005) 842]); THE OTHER ONE, AS GROWN YBCO, IS ONLY USED FOR COMPARISONS PURPOSES. BY MEASURING THE VOLTAGE RESPONSE TOTHZ EXCITATION OF YBCO FILM ON DIFFERENT SUBSTRATES (CEO2/YSZ, MGO AND LAALO3), ONLY THE YBCO/CEO2/YSZ FILM [E. MEZZETTI ET AL., IEEE SENSORS IN PRESS] AND SOLELY THE NANOSTRUCTURED PART IS LOCALIZING THE DISSIPATIVE SIGNAL WHEN EXPOSED TO THZ RADIATION. THE SENSOR IS ELECTRICALLY BIASED IN THE TEMPERATURE INTERVAL HOSTING THE “HIDDEN DISSIPATION TAIL” THAT IS LOCATED FAR AWAY FROM THE STANDARD ELECTRIC FIELD DISSIPATION THRESHOLD OF 1 MV/CM. RADIATION-HARDNESS UNDER PROTON AND SWIFT NEUTRON IRRADIATIONS IS FINALLY ADDRESSED.

SUPPORT FROM ISTITUTO NAZIONALE DI FISICA NUCLEARE (INFN) MONADE PROJECT IS GRATEFULLY ACKNOWLEDGED. AUTHORS THANK THE STAFF OF INFN-LNL AND INFN LNS LABORATORIES.

4EPD-05

OPTICAL CHARACTERIZATION OF THE QUANTUM CAPACITANCE DETECTOR ***J. BUENO***[1]*, N. LLOMBART*[2]*, P. K. DAY*[3]*, J. KAWAMURA*[3]*, K. B. COOPER*[3]*, P. M. ECHTERNACH*[3]*;* [1]CENTRO DE ASTROBIOLOGIA, [2]UNIVERSIDAD COMPLUTENSE DE MADRID, [3]JET PROPULSION LABORATORY. — WE PRESENT HERE PRELIMINARY MEASUREMENTS OF OPTICAL PERFORMANCE OF THE QUANTUM CAPACITANCE DETECTOR, A PAIR-BREAKING PHOTODETECTOR FOR FAR-INFRARED AND SUBMILLIMETER RADIATION. IN THIS CONCEPT ANTENNA-COUPLED RADIATION GENERATES QUASIPARTICLES IN A SUPERCONDUCTING ABSORBER, THE DENSITY OF WHICH IS MEASURED USING A SINGLE COOPER-PAIR BOX. WE HAVE FABRICATED AND TESTED A PROTOTYPE DEVICE INCORPORATING A DOUBLE DIPOLE ANTENNA ON AN EXTENDED HEMISPHERICAL SILICON LENS THAT COUPLES RADIATION AT 200μM TO AN ABSORBER. RADIATION WAS GENERATED BY A BLACK-BODY SOURCE PLACED INSIDE THE INNER VACUUM CAN OF A DILUTION REFRIGERATOR. WE HAVE MEASURED AND CHARACTERIZED THE RESPONSE AND THE NOISE OF THE DEVICE AND TO THE OPTICAL SIGNAL OBTAINING A NOISE-EQUIVALENT POWER (NEP), WHICH IS IN THE 10^{-17} W/HZ$^{1/2}$ RANGE AT LOADING POWERS UP TO 10^{-15} W. WE WILL DISCUSS FURTHER IMPROVEMENTS TO ACHIEVE THE PREDICTED NEP 10^{-21}W/HZ$^{1/2}$.

4EPD-07

SINGLE PHOTON RECEIVER BASED ON ABRIKOSOV VORTICES ***G. KARAPETROV****, V. G. YEFREMENKO, G. MIHAJLOVIC, A. M. DATESMAN, S. D. BADER, V. NOVOSAD;* ARGONNE NATIONAL LABORATORY. — WE USE NANOSTRUCTURED SUPERCONDUCTING NB THIN FILMS TO STUDY NON-LOCAL ABRIKOSOV VORTEX DYNAMICS UNDER THE INFLUENCE OF INCOMING PHOTONS. WE EXPLOIT THE EFFECT OF ABRIKOSOV VORTEX CREEP IN A TYPE-II SUPERCONDUCTOR. IN PARTICULAR, WE UTILIZE THE ABRUPT, NON-LINEAR DEPENDENCE OF THE VORTEX CREEP NEAR THE LOWER CRITICAL FIELD HC1 IN THIN FILMS TO DESIGN A SENSITIVE SCHEME FOR SINGLE PHOTON DETECTION. THE MAIN ADVANTAGE, IN ADDITION TO THE HIGH SENSITIVITY, IS THAT NON-LOCAL VORTEX CONTROL ENABLES DIGITAL READOUT OF SINGLE FLUX QUANTA CREATED BY THE INCOMING PHOTONS.WE PRESENT EXPERIMENTAL EVIDENCE OF LONG-RANGE BALLISTIC MOTION OF ABRIKOSOV VORTICES DRIVEN BY AN APPLIED CURRENT IN NANOSCALE SUPERCONDUCTING STRIPS. THE NON-LOCAL VORTEX MOTION IS STRONGLY DEPENDENT ON THE AVAILABILITY OF VORTICES IN THE ACTIVE AREA OF THE DETECTOR THAT ABSORBS THE INCOMING RADIATION. PHOTON-ACTIVATED CREEP, THUS, INCREASES THE NUMBER OF ABRIKOSOV VORTICES THAT ARE AVAILABLE IN THE ACTIVE AREA OF THE DETECTOR AND FACILITATES THEIR GUIDED ESCAPE UNDER THE INFLUENCE OF THE NON-LOCAL CURRENT.THIS WORK AS WELL AS THE USE OF THE CENTER FOR NANOSCALE MATERIALSAT ARGONNE NATIONAL LABORATORY WERE SUPPORTED BY UCHICAGO ARGONNE, LLC, OPERATOR OF ARGONNE NATIONAL LABORATORY (``ARGONNE''). ARGONNE, A U.S. DEPARTMENT OF ENERGY OFFICE OF SCIENCE LABORATORY, IS OPERATED UNDER CONTRACT NO.DE-AC02-06CH11357.

4EPD-08

PHOTORESPONSE CHARACTERIZATION OF YBCO THIN FILMS ***H. ATIKIAN****, B. GHAMSARI, A. H. MAJEDI;* UNIVERSITY OF WATERLOO. — OPTICALLY INDUCED VOLTAGE TRANSIENTS ACROSS CURRENT BIASED YBCO THIN FILM MEANDER LINES AND MICRO-BRIDGES ARE REPORTED. THE DEVICES INCORPORATE A SUPERCONDUCTING COPLANAR WAVEGUIDE (CPW) TRANSMISSION LINE FABRICATED FROM 100NM YBCO THIN FILMS, INTERRUPTED BY MEANDER LINES AND MICRO-BRIDGES TO SERVE THE OPTOELECTRONIC FUNCTION. PHOTODETECTION MEASUREMENTS ARE PERFORMED ON WAFER IN A CRYOGENIC MICROWAVE PROBE STATION. PHOTORESPONSE CHARACTERISTICS ARE INVESTIGATED AS A

FUNCTION OF BIAS CURRENT, INCIDENT OPTICAL POWER, AND TEMPERATURE.

4EPD-09

NUMERICAL ANALYSIS OF SUPERCONDUCTING OPTICAL PLASMONIC WAVEGUIDES ***A. EFTEKHARIAN****, H. MAJEDI;* INSTITUTE FOR QUANTUM COMPUTING, UNIVERSITY OF WATERLOO. — SUPERCONDUCTING OPTOELECTRONIC CIRCUITS CAN BE POTENTIALLY FEASIBLE UPON THE INTEGRATION OF OPTICAL WAVEGUIDES AND ELECTRONIC THIN FILMS AND JUNCTIONS. COUPLING, GUIDING AND DETECTION OF OPTICAL SIGNAL IN SUCH INTEGRATED CIRCUITS SEEM TO BE BEST ACHIEVED BY MEANS OF PLASMONIC WAVEGUIDES.WE REPORT ON OUR NUMERICAL STUDIES OF VARIOUS SUPERCONDUCTING OPTICAL PLASMONIC WAVEGUIDING STRUCTURES SUCH AS 2D SLAB AND RIB WAVEGUIDE COMPOSED OF EITHER THIN LTS OR HTS FILMS ON TOP OF DIELECTRIC MATERIAL POSSIBLY WITH SOME INTER OR OUTER INSULATING LAYERS. OUR NUMERICAL METHODS ARE BASED ON 3D FINITE-DIFFERENCE TIME-DOMAIN TECHNIQUE WHERE ALL LAYERS CAN BE IDENTIFIED BY ITS FREQUENCY-DEPENDENT REFRACTIVE INDICES. THE PROPAGATION AND ATTENUATION CONSTANTS OF SUCH WAVEGUIDES ARE CALCULATED FOR VARIOUS OPTICAL WAVELENGTHS, VARYING TEMPERATURE AND VARIOUS GEOMETRICAL SIZES OF THE STRUCTURE. WE DISCUSS HOW SURFACE PLASMON POLARITON CAN BE EXCITED IN OUR PROPOSED STRUCTURES MAINLY BASED ON TWO COUPLING SCHEMES; BUTT-COUPLING OF OPTICAL FIBER AND SURFACE GRATING STRUCTURE ON THE SUPERCONDUCTING/DIELECTRIC INTERFACE. IN CONCLUSION, WE PRESENT SOME PRELIMINARY DESIGNS BASED ON THE NB/SI AND YBCO/LAALO MULTILAYER STRUCTURES.

4EPD-10

HIGH COUNT-RATE NEAR-IR SINGLE PHOTON DETECTION WITH A NIOBIUM NANOBOLOMETER ***F. W. CARTER****, D. F. SANTAVICCA, A. J. ANNUNZIATA, L. FRUNZIO, D. E. PROBER;* YALE UNIVERSITY. — THE DETECTION OF SINGLE 1550 NM PHOTONS WITH GHZ COUNT RATES, EXCELLENT TIMING RESOLUTION, AND HIGH QUANTUM EFFICIENCY IS IMPORTANT FOR A NUMBER OF APPLICATIONS, INCLUDING QUANTUM KEY DISTRIBUTION, SINGLE-PHOTON CLASSICAL COMMUNICATION, AND CMOS IMAGING FOR DEFECT ANALYSIS. WE REPORT ON THE DEVELOPMENT OF A SUPERCONDUCTING NIOBIUM NANOBOLOMETER FOR SINGLE-PHOTON DETECTION IN THE NEAR-IR. UNLIKE THE SUPERCONDUCTING NANOWIRE SINGLE PHOTON DETECTOR (SNSPD), THE NANOBOLOMETER DEVICE HAS EXTREMELY SMALL INDUCTANCE AND IS OPERATED IN THE RESISTIVE STATE, ALLOWING FOR GHZ COUNT RATES. ALSO DISTINCT FROM THE SNSPD, THE NANOBOLOMETER IS INHERENTLY PHOTON-NUMBER RESOLVING. ONE OF THE KEY CHALLENGES FOR THIS DEVICE IS EFFICIENT COUPLING OF NEAR-IR PHOTONS TO A SUB-MICRON SCALE DETECTOR. WE PRESENT PRELIMINARY RESULTS OF THE DEVICE PERFORMANCE AND DISCUSS TECHNIQUES FOR ACHIEVING EFFICIENT PHOTON COUPLING AT 1550 NM.

4EPD-11

INVESTIGATION AND OPTIMIZATION OF LEKID STRUCTURES AND MULTI-PIXEL ARRAYS AT 4.2 K ***S. H. WUENSCH****, T. KAPPLER, F. GEUPPERT, G. HAMMER, M. SIEGEL;* KARLSRUHE INSTITUTE OF TECHNOLOGY. — WE HAVE INVESTIGATED BASIC PROPERTIES OF LUMPED ELEMENT KINETIC INDUCTANCE DETECTORS (LEKIDS) FOR APPLICATIONS AT LIQUID HELIUM TEMPERATURES. IN CONSIDERATION OF THE OPERATION TEMPERATURE, WE HAVE EXAMINED THE BEHAVIOUR OF THE LOADED QUALITY FACTOR Q_L VERSUS THE COUPLING STRENGTH OF THE RESONANCE CIRCUITS FOR DIFFERENT TYPES OF TRANSMISSION LINES. THEREFORE WE HAVE DESIGNED AND CHARACTERIZED SEVERAL TEST STRUCTURES IN THE FREQUENCY RANGE OF 6 GHZ WHICH ARE SUITABLE FOR LARGE ARRAYS IN MULTI-PIXEL APPLICATIONS. WE ACHIEVED LOADED QUALITY FACTORS UP TO 10,000 AT 4.2 K. THE DEVICES ARE FABRICATED WITH NIOBIUM THIN FILM TECHNOLOGY ON SILICON AND SAPPHIRE SUBSTRATES. LEKID ARRAYS WITH 10 RESONATORS WERE DESIGNED, FABRICATED AND MEASURED WITH OUR DEVELOPED FDM READOUT SYSTEM. THE RESULTS OF THE MEASUREMENTS WILL BE PRESENTED AND DISCUSSED.

4EPD-12

SUBGAP TUNNELING CURRENT AT LOW TEMPERATURE IN NB/AL-ALN/NB SIS JUNCTIONS ***T. NOGUCHI****, T. SUZUKI, T. TAMURA;* NATIONAL ASTRONOMICAL OBSERVATORY OF JAPAN. — QUASIPARTICLE TUNNELING CURRENT OF A SIS JUNCTION WAS NUMERICALLY STUDIED BY TAKING INTO ACCOUNT THE EFFECT OF THE LIFETIME BROADENING OF THE QUASIPARTICLE DENSITY OF STATES AND A LOCALIZED DENSITY OF STATES INSIDE THE ENERGY GAP. ASSUMING THAT THE ENERGY GAP IS A COMPLEX NUMBER WITH A SMALL IMAGINARY PART TO INCORPORATE THE LIFETIME BROADENING, A FINITE NUMBERS OF QUASIPARTCLE STATES APPEAR INSIDE THE ENERGY GAP. CALCULATED QUASIPARTICLE CURRENTS AS FUNCTION OF BIAS VOLTAGE USING THE LIFETIME BROADENED DENSITY OF STATES WERE COMPARED TO THE MEASURED DC I-V CURVES OF A NB/AL-ALN/NB SIS JUNCTION. IT IS FOUND THAT THE CALCULATED QUASIPARTICLE CURRENT AS A FUNCTION OF BIAS VOLTAGE AGREES WELL WITH THOSE OF THE NB/AL-ALN/NB SIS JUNCTION MEASURED AT TEMPERATURES BELOW 4.2 K. IT IS INTERESTING TO NOTE THAT THE CALCULATED SUBGAP CURRENT DECREASES EXPONENTIALLY FROM 4.2 TO ~1.0 K AS TEMPERATURE IS LOWERED AND ALWAYS SHOWS A SATURATION OF THE DECREASE BELOW ~1.0 K, WHICH IS QUALITATIVELY CONSISTENT WITH THE BEHAVIOR OF THE SUBGAP CURRENT OF NB-BASED SIS JUNCTIONS MEASURED AT LOW TEMPERATURE.

THE AUTHORS THANK DR. AKIRA ENDO FOR PREPARATION OF THE NB/AL-ALN/NB SIS JUNCTION, AND DRS. SERGEY SHITOV AND MATTHIAS KROUG FOR USEFUL DISCUSSIONS.

4EPE-01

DISTRIBUTED-ELEMENT PHASE QUBIT ***O. NAAMAN****, J. E. BAUMGARDNER, A. HERR, R. M. LEWIS, J. A. STRONG, J. PARK, A. A. PESETSKI;* NORTHROP GRUMMAN. — WE DESIGNED AND FABRICATED A PHASE QUBIT IN WHICH THE JUNCTION SHUNT REACTANCE IS REALIZED USING DISTRIBUTED ELEMENTS. WITH THIS DISTRIBUTED DESIGN, WE EXPECT MATERIALS LOSSES TO PLAY A LESSER ROLE AS A SOURCE OF DECOHERENCE. WE DERIVE A MODEL HAMILTONIAN FOR THE DEVICE, COMPARE ITS THEORETICAL PERFORMANCE TO THAT OF A LUMPED-ELEMENT PHASE QUBIT, AND PRESENT COHERENCE AND SPECTROSCOPY DATA.

4EPE-02

IDENTIFYING SOURCES OF DECOHERENCE IN A DC SQUID PHASE QUBIT WITH A SUB-MICRON JOSEPHSON JUNCTION AND INTERDIGITATED CAPACITOR ***A. J. PRZYBYSZ****, H. KWON, R. BUDOYO, E. J. CROWE, B. K. COOPER, C. VLAHACOS, S. PAUL, A. DRAGT, C. J. LOBB, J. R. ANDERSON, F. C. WELLSTOOD;* UNIVERSITY OF MARYLAND. — WE HAVE FABRICATED A DC SQUID PHASE QUBIT WITH A SUB-MICRON AL/ALOX/AL QUBIT JUNCTION AND AN INTERDIGITATED SHUNTING CAPACITOR ON A SAPPHIRE SUBSTRATE. THE QUBIT JUNCTION HAS A CRITICAL CURRENT OF 130 NA, AND THE ISOLATION JUNCTION HAS A CRITICAL CURRENT OF 8.3 MA. THE SHUNTING CAPACITANCE IS ABOUT 300 FF. TO REDUCE TWO-LEVEL SYSTEMS AND INCREASE THE RELAXATION TIME T1, WE HAVE REMOVED UNNECESSARY DIELECTRICS, USED A SMALL QUBIT JUNCTION AREA (300 NM X 300 NM), ISOLATED THE QUBIT FROM THE LEADS WITH AN ON-CHIP LC FILTER, AND FABRICATED THE DEVICE ON A BARE SAPPHIRE SUBSTRATE. HOWEVER, AT A TEMPERATURE OF 20 MK, WE FIND T1 AND THE COHERENCE TIME T2 TO BE ON THE ORDER OF HUNDREDS OF NANOSECONDS, WHICH IS ABOUT 50 TIMES LESS THAN ONE WOULD EXPECT FROM LOSS FROM THE LEADS AND DIELECTRIC LOSS IN THE TUNNEL JUNCTION AND SUBSTRATE. WE WILL PRESENT OUR WORK ON IDENTIFYING THE LIMITING SOURCES OF DECOHERENCE THROUGH CAREFUL OBSERVATION OF THE ENERGY RELAXATION, RABI OSCILLATIONS, SPECTROSCOPIC PEAK WIDTH, AND OTHER MEASUREMENTS THAT PROBE RELAXATION, DEPHASING, AND DECOHERENCE IN THE QUBIT.

FUNDED BY THE DOD, CNAM, JQI. ACKNOWLEDGE KEVIN OSBORN AND SERGIY GLADCHENKO AT LPS FOR DEPOSITING SINX.

4EPE-03

TRANSMON QUBIT WITH A LUMPED-ELEMENT RESONANT READOUT ***D. H. SLICHTER****[1], R. VIJAY[1], O. NAAMAN[2], I. SIDDIQI[1];* [1]QUANTUM NANOELECTRONICS LAB, UNIVERSITY OF CALIFORNIA BERKELEY, [2]QUANTUM NANOELECTRONICS LAB, UNIVERSITY OF CALIFORNIA BERKELEY; NORTHROP GRUMMAN, ELECTRONIC SYSTEMS. — WE REPORT PROGRESS ON THE DEVELOPMENT OF A TRANSMON QUBIT COUPLED TO A LUMPED-ELEMENT JOSEPHSON JUNCTION OSCILLATOR. THE ADVANTAGE OF THIS DESIGN IS THAT THE READOUT CIRCUIT CONTAINS NO HIGHER HARMONICS WHICH CAN INDUCE ADDITIONAL QUBIT RELAXATION VIA THE PURCELL EFFECT. HOWEVER, THE LOSSES IN THE THIN FILM DIELECTRIC USED TO REALIZE THE SHUNTING CAPACITOR CAN NEGATIVELY AFFECT BOTH QUBIT PERFORMANCE AND THE INTERNAL QUALITY FACTOR OF THE READOUT OSCILLATOR. WE EXPLORE DIFFERENT DIELECTRICS AND LAYOUT CONFIGURATIONS TO OPTIMIZE QUBIT PERFORMANCE, AND OPERATE THE READOUT IN BOTH THE LINEAR AND NON-LINEAR REGIMES.

DHS ACKNOWLEDGES FUNDING FROM A HERTZ FELLOWSHIP ENDOWED BY BIG GEORGE VENTURES.

4EPE-04

ARCHITECTURE AND OPERATION OF A SUPERCONDUCTOR ADIABATIC OPTIMIZATION PROCESSOR ***M. W. JOHNSON****, A. J. BERKLEY, P. BUNYK, R. HARRIS, J. JOHANSSON, T. LANTING, E. TOLKACHEVA, I. PERMINOV, E. CHAPPLE, B. WILSON, J. HILTON, E. LADIZINSKY, G. ROSE;* D-WAVE SYSTEMS, INC.. — WE HAVE DESIGNED, FABRICATED, AND OPERATED A SYSTEM INTENDED TO SOLVE COMBINATORIAL OPTIMIZATION PROBLEMS USING AN ADIABATIC QUANTUM OPTIMIZATION ALGORITHM. THE SYSTEM COMPRISES RF-SQUID FLUX QUBITS WITH TUNABLE COUPLINGS. WE PRESENT HERE AN OVERVIEW OF THE SYSTEM ARCHITECTURE AND OPERATING PRINCIPLES. WE DISCUSS THE "FLOW-DOWN" OF REQUIREMENTS FROM A SPECIFIED ANALOG PRECISION ON A PROBLEM DESCRIPTION TO REQUIREMENTS ON INDIVIDUAL DEVICES AND FABRICATION TOLERANCES. FOR PROCESS TOLERANCES REASONABLY ACCESSIBLE TO EXISTING SUPERCONDUCTOR FOUNDRIES, WE SHOW THAT OPERATION OF SUCH A PROCESSOR REQUIRES A KNOWLEDGE OF AS-FABRICATED INDIVIDUAL DEVICE PARAMETERS - THEY MUST BE MEASURED. WE DESCRIBE A METHOD FOR EXTRACTING THIS INFORMATION, SCALABLE TO THOUSANDS OF QUBITS.

4EPE-05

DIGITAL QUANTUM GATES ***A. A. PESETSKI****, J. E. BAUMGARDNER, R. M. LEWIS, J. A. STRONG;* NORTHROP GRUMMAN. — WE HAVE DEVELOPED A NEW TECHNIQUE FOR IMPLEMENTING QUANTUM LOGIC GATES. THE TECHNIQUE INVOLVES TUNING THE FREQUENCY OF A QUBIT TO TRANSFER QUANTUM INFORMATION FROM ONE QUBIT TO ANOTHER. THE PRIMARY ADVANTAGE OF THIS TECHNIQUE IS THAT IT ELIMINATES THE NEED FOR PRECISION IN CONTROL PULSES TO OBTAIN HIGH FIDELITY QUANTUM GATES. WE WILL DISCUSS THE TECHNIQUE IN GENERAL AND GIVE EXAMPLES OF THE IMPLEMENTATION OF SPECIFIC GATES SUCH AS SWAP AND CNOT.

4EPE-06

ROBUST AND SCALABLE FLUX QUBITS AND COUPLERS ***T. LANTING****;* D-WAVE SYSTEMS. — WE PRESENT THE EXPERIMENTAL CHARACTERIZATION OF THE CONSTITUENT ELEMENTS OF A SMALL-SCALE PROTOTYPE SUPERCONDUCTING OPTIMIZATION PROCESSOR. THIS PROCESSOR CONTAINED EIGHT RF-SQUID FLUX QUBITS, BASED UPON A DESIGN THAT IS DEMONSTRABLY ROBUST AGAINST

FABRICATION VARIATIONS, AND A NETWORK OF SIXTEEN IN-SITU TUNABLE INDUCTIVE COUPLERS. MEASUREMENTS OF SINGLE QUBIT PERSISTENT CURRENTS AND SINGLE QUBIT TUNNELING AMPLITUDES BETWEEN THE TWO LOWEST ENERGY STATES ARE IN AGREEMENT WITH THE PREDICTIONS OF A QUANTUM MECHANICAL HAMILTONIAN WHOSE PARAMETERS WERE INDEPENDENTLY CALIBRATED FOR ALL EIGHT QUBITS. WE ALSO PERFORMED MACROSCOPIC RESONANT TUNNELING MEASUREMENTS ON PAIRS OF INDUCTIVELY COUPLED QUBITS. THE TUNNELING AMPLITUDES, OBTAINED FROM INITIAL TUNNELING RATES BETWEEN THE TWO LOWEST ENERGY STATES OF EACH COUPLED TWO-QUBIT SYSTEM, ARE IN AGREEMENT WITH THE PREDICTIONS OF A QUANTUM MECHANICAL MODEL OF THESE SYSTEMS. WE CONCLUDE WITH A DISCUSSION OF THE PROSPECTS FOR USING THESE TECHNIQUES TO CHARACTERIZE AND PROBE THE DYNAMICS OF LARGER SYSTEMS OF COUPLED FLUX QUBITS.

4EPE-07

EFFECT OF SPIN-FLIP PULSE SEQUENCES ON DEPHASING IN A FLUX BIASED PHASE QUBIT *B. MAO[1], G. SUN[2],* ***S. HAN[1];*** [1]UNIVERSITY OF KANSAS, [2]NANJING UNIVERSITY. — MAGNETIC FLUX NOISE HAS BEEN IDENTIFIED AS ONE OF THE MAIN SOURCES OF DECOHERENCE IN SUPERCONDUCTING FLUX QUBITS AND FLUX BIASED PHASE QUBITS. WE INVESTIGATE THE EFFECT OF DIFFERENT MICROWAVE PULSE SEQUENCES ON PRESERVING COHERENCE IN A FLUX BIASED PHASE QUBIT. THE RESULT SHOWS THAT FLUX NOISE IS DOMINATED BY LOW FREQUENCY COMPONENTS AND THE HIGH FREQUENCY (F >100 MHZ) FLUX NOISE IS NEGLIGIBLE. FURTHERMORE, WE FOUND THAT EVEN THE SIMPLEST SPIN-FLIP PULSE SEQUENCE IS VERY EFFECTIVE IN SUPPRESSING FLUX NOISE INDUCED DEPHASING AND THUS THE COHERENCE TIME IS ULTIMATELY LIMITED BY THE RATE OF ENERGY RELAXATION.

WE ACKNOWLEDGE NORTHROP GRUMMAN ES IN BALTIMORE MD FOR TECHNICAL AND FOUNDRY SUPPORT AND THANK R. LEWIS, A. PESETSKI, E. FOLK, AND J. TALVACCHIO FOR TECHNICAL ASSISTANCE. THIS WORK WAS SUPPORTED IN PART BY NSF GRANT NO. DMR-0325551.

4EPE-08

QUANTUM COMPUTING WITH QUANTUM KNOTS IN 1024 QUANTUM RANDOM NUMBER GENERATOR ON MAGNETIC FLUX QUBITS *D. O. LEDENYOV[1],* ***V. O. LEDENYOV[2]****, O. P. LEDENYOV[3];* [1]JAMES COOK UNIVERSITY, TOWNSVILLE QUEENSLAND 4811, AUSTRALIA, [2]KHARKOV STATE UNIVERSITY, SVOBODY SQUARE 4, KHARKOV 61077, UKRAINE, [3]NATIONAL SCIENTIFIC CENTRE KHARKOV INSTITUTE OF PHYSICS AND TECHNOLOGY, ACADEMICHESKAYA 1, KHARKOV 61108, UKRAINE. — QUANTUM COMPUTING PROCESSOR KERNEL BASED ON QUANTUM STRUCTURE WITH PROCESSING ELEMENTS IN FORM OF AN ARRAY OF MAGNETIC FLUX QUBITS IN 1024 QRNG_MFQ CHIPSET IS RESEARCHED EXPERIMENTALLY. PROCESSING ELEMENTS PERFORM MEMORYLESS INSTANT MAPPINGS OF MULTIPLE INPUT VALUES TO A SINGLE OUTPUT VALUE USING QUANTUM KNOTS OF VORTICES IN KERNEL. CHARACTERIZATION OF QUANTUM KNOTS IS PERFORMED WITH TWO-DIMENSIONAL DISCRETE WAVELET TRANSFORM (DWT) AND INVERSE DISCRETE WAVELET TRANSFORM (IDWT) FOR HIGH SPEED EFFICIENT CODING OF DIGITAL IMAGES OF QUANTUM KNOTS, OBTAINED BY NEUTRON SCATTERING SPECTROSCOPY IN 1024 QRNG_MFQ CHIPSET. MAIN RESEARCH GOAL WAS TO GET HIGHEST RESOLUTION QUANTUM KNOTS IMAGES WITHOUT APPRECIABLE PICTURE DEGRADATION AT ACCEPTABLE ENERGY COMPACTION RATE DURING IMAGE DECOMPOSITION AND RECONSTRUCTION PROCESSES. ANALYSIS OF QUANTUM KNOTS IMAGES PROVIDED INFORMATION ON PHYSICAL PROPERTIES AND NONLINEAR DYNAMICS OF QUANTUM KNOTS GENERATION. RECENT NOVEL APPLICATIONS OF 1024 QRNG_MFQ CHIPSET IN ULTRA HIGH PERFORMANCE COMPUTING (HPC) SYSTEMS ARE ALSO DISCUSSED.[1] D.O. LEDENYOV, V.O. LEDENYOV AND O.P. LEDENYOV FRONTIERS IN QUANTUM RANDOM NUMBER GENERATOR ON MAGNETIC FLUX QUBITS DESIGN IN APPLICATION TO ULTRA HIGH PERFORMANCE COMPUTING (HPC) SYSTEMS INTERNATIONAL SUPERCONDUCTIVE ELECTRONICS CONFERENCE 2009 FUKUOKA, JAPAN 2009 HTTP://WWW.ISEC09.ORG/PROGRAM.HTM

[2] D.O. LEDENYOV DISSERTATION ON NONLINEAR PHENOMENA IN MICROWAVE SUPERCONDUCTIVITY SUPERVISED BY J. MAZIERSKA AND K. KIKKERT, JAMES COOK UNIVERSITY, QUEENSLAND, AUSTRALIA 2000-2010

4EPF-01

THERMAL RESET AND KINETIC INDUCTANCE IN SUPERCONDUCTING NANOWIRE SINGLE-PHOTON DETECTORS ***A. J. ANNUNZIATA[1]****, D. F. SANTAVICCA[1], J. CHUDOW[1], O. QUARANTA[2], L. FRUNZIO[1], M. ROOKS[1], A. FRYDMAN[3], D. PROBER[1];* [1]YALE UNIVERSITY, [2]UNIVERSITY OF SALERNO, [3]BAR ILAN UNIVERSITY. — SUPERCONDUCTING NANOWIRE SINGLE-PHOTON DETECTORS (SNSPDS) HAVE HIGH COUNT RATES, LOW JITTER, AND LOW DARK COUNT RATES FOR VISIBLE AND NEAR-INFRARED PHOTONS. WE STUDY THERMAL RELAXATION IN NIOBIUM SNSPDS FOLLOWING THE ABSORPTION OF A PHOTON USING A COMBINATION OF EXPERIMENTS AND NUMERICAL MODELING. WE COMPARE THESE RESULTS TO MEASUREMENTS OF NIOBIUM NITRIDE SNSPDS AND MODELS OF NIOBIUM NITRIDE SNSPDS PRESENTED IN THE LITERATURE. OUR MODEL SUGGESTS THAT IN NIOBIUM, SLOW THERMAL RELAXATION OF THE ELECTRON SYSTEM LIMITS THE DETECTOR RESET TIME. WE FIND THAT THE KINETIC INDUCTANCE DETERMINES THE AMOUNT OF HEAT DISSIPATED WHEN A PHOTON IS DETECTED, AND CONSEQUENTLY DETERMINES THE THERMAL RELAXATION TIME, AND THEREFORE THE MINIMUM RESET TIME, FOR A SPECIFIC SNSPD. OUR STUDIES ALSO HIGHLIGHT THE ROLE OF SEVERAL MATERIAL PARAMETERS IN DETERMINING RESET. USING EXPERIMENTAL MEASUREMENTS, WE STUDY THE TEMPERATURE AND BIAS CURRENT DEPENDENCE OF THE KINETIC INDUCTANCE OF NBN NANOWIRES OVER A WIDE RANGE OF CURRENT AND TEMPERATURE. WE FIND THAT THE CURRENT DEPENDENCE OF THE KINETIC INDUCTANCE

DEVIATES FROM WHAT IS EXPECTED FROM THE GINZBURG-LANDAU THEORY.

THIS WORK IS SUPPORTED BY NSF - EPDT, NSF - GRADUATE RESEARCH FELLOWSHIP, AND IBM RESEARCH.

4EPF-02

A NOVEL BIAS SCHEME AND READ OUT ELECTRONICS FOR SUPERCONDUCTING NANOWIRES SINGLE PHOTON DETECTOR ***Z. YAN**, A. MAJEDI, T. JENNEWEIN;* UNIVERSITY OF WATERLOO. — AN OPTOELECTRONIC MIXER BASED ON THE CONVENTIONAL NBN SNSPD HAS BEEN FOUND BY THE AUTHORS TO BE SENSITIVE TO THE AVERAGE INPUT PHOTON FLUX ON THE SINGLE PHOTON LEVEL, DUE TO RF-DRIVEN NONLINEARITY OF THE KINETIC INDUCTANCE OF THE STRUCTURE. HOWEVER, THE INTERMEDIATE FREQUENCY (IF) OBTAINED BY OPTOELECTRONIC MIXING ONLY CORRELATES TO THE AVERAGE PHOTON NUMBER OF THE INPUT PHOTON FLUX IN THE FREQUENCY DOMAIN, ALTHOUGH IT EXHIBITS VERY PROMISING FEATURES, SUCH AS VERY HIGH INPUT PHOTON REPETITION RATE, DARK COUNT FREE, IMPROVED QUANTUM EFFICIENCY, AND POTENTIAL PHOTON NUMBER RESOLVING. SINCE THE SINGLE PHOTON COUNTING IS PERFORMED IN THE TIME DOMAIN, IT IS OF MORE INTEREST TO READ OUT IF SIGNAL IN THE TIME DOMAIN, WHEN THE DETECTOR IS DRIVEN BY A COMBINATION OF DC CURRENT BIAS AND A RF CURRENT. WE SHOW THAT THE ACHIEVABLE NONLINEARITY DISPLAYED IN THE NANOWIRE BY THIS APPROACH IS MUCH STRONGER THAN THE CONVENTIONAL DC BIAS SCHEME CAN MAKE. SUCH STRONG NONLINEARITY BECOMES THE FOUNDATION FOR TRANSFERRING THE DESIRABLE FEATURES EXHIBITED IN THE AFOREMENTIONED OPTOELECTRONIC MIXER INTO THE TIME DOMAIN. WE PRESENT A NOVEL BIAS SCHEME THAT INVOLVES BOTH DC BIAS AND RF LO PUMPING. THE EXPERIMENTAL SETUP INCLUDING THE CORRESPONDING READ OUT ELECTRONICS WILL BE DEPICTED. THE EXPERIMENTAL RESULTS AND COMPARISON WITH PURE DC BIAS SCHEME WILL BE REPORTED AND DISCUSSED.

4EPF-03

SWIFTS WAVEGUIDE MICRO-SPECTROMETER INTEGRATED ON TOP OF A 1D-NBN SSPD ARRAY ***P. CAVALIER**[1], C. CONSTANCIAS[2], A. MORAND[3], L. MAINGAULT[1], P. FEAUTRIER[4], J. VILLEGIER[1];* [1]CEA-INAC, [2]CEA LETI-DPTS, [3]IMEP-LAHC, [4]LAOG. — **SWIFTS WAVEGUIDE MICRO-SPECTROMETER INTEGRATED ON TOP OF A 1D-NBN SSPD ARRAY**SUPERCONDUCTING NANOWIRE SINGLE PHOTON DETECTORS BASED ON 4 NM THICK EPI-NBN LAYERS HAVE BEEN OPTIMIZED IN UNIFORMITY AND EFFICIENCY FOR A WIDE OPTICAL BAND (0.5-5µM), THANKS TO THE USE OF AN E-BEAM WRITER. THE SWIFTS DEVICE (STATIONARY WAVE INTEGRATED TRANSFORM SPECTROMETER) IS INTEGRATED ON TOP OF A 1D PARALLEL ARRAY OF 50NM WIDTH SINGLE STRIPE SSPD NANO-WIRES. COLOURED LIGHT, AROUND 1.55µM WAVELENGTHS, IS INTRODUCED THROUGH PIGTAILED COUPLERS INSIDE LOW-LOSSES PE-CVD DEPOSITED AND PATTERNED SI3N4 MONOMODE RIB WAVEGUIDES, DESIGNED TO PRODUCE A COUNTER-PROPAGATIVE STATIONARY WAVE OVER THE NANOWIRE ARRAY. STATE-OF-THE-ART LITHOGRAPHIC AND PASSIVATING TECHNOLOGIES, ALLOW US TO REACH NANOWIRE ARRAY DIMENSIONS CAPABLE OF DIRECTLY SAMPLING THE STATIONARY WAVE PROFILE. SO WE CAN REBUILD THE INCIDENT LIGHT SPECTRUM BY INVERSE FOURIER TRANSFORM WITH A WAVELENGTH RESOLUTION UP TO $\Delta\Lambda$ = 170NM. MULTIPLEXING SOLUTIONS ARE BEING ALSO INVESTIGATED BASED ON SQUIDS OR KIDS.INVESTIGATED MICRO-SWIFTS RAISES INTEREST AMONG ASTROPHYSICAL COMMUNITY AS APPLICATIONS CAN BE MULTIPLE (DIFFERENTIAL SPECTROMETERS, FRINGE-TRACKERS...) FOR A RELATIVELY LOW COST.*EC SINPHONIA NMP4-CT-2005-16433 & CNES-CEA GRANT*

4EPF-04

SUPERCONDUCTING NANOWIRE SINGLE PHOTON DETECTOR DEVELOPED FOR PRACTICAL QKD APPLICATIONS *L. B. ZHANG, Q. Y. ZHAO, L. KANG, J. CHEN, C. H. CAO, **P. H. WU**;* RESEARCH INSTITUTE OF SUPERCONDUCTOR ELECTRONICS, DEPARTMENT OF ELECTRONIC SCIENCE & ENGINEERING, NANJING UNIVERSITY. — SUPERCONDUCTING NANOWIRE SINGLE-PHOTON DETECTOR (SNSPD) IS A PROMISING CANDIDATE IN THE APPLICATIONS OF LONG-DISTANCE QUANTUM KEY DISTRIBUTION (QKD) DUE TO ITS LOW NOISE MERIT. FOR THE PURPOSE OF PRACTICAL QKD APPLICATIONS, A SNSPD WAS DEVELOPED CONSIDERING SYSTEM PERFORMANCE, USAGE COSTS, WORKING CONVENIENCE AND RELIABILITY. THE DETAILS OF CHIPS FABRICATION, OPTICAL COUPLING, ELECTRIC CIRCUIT AND MEASUREMENT SETTINGS WERE INTRODUCED. WITH THEM, WE DISCUSSED THE SYSTEM PERFORMANCES, INCLUDING DARK COUNT RATE, SYSTEM EFFICIENCY AND NOISE EQUIVALENT POWER. EXPERIMENTS IMPLY ALL THESE PERFORMANCES DEPEND ON THE BIAS CURRENT QUITE REMARKABLY AND IN MANY CASES THE IMPROVEMENT IN ONE OF THEM WILL INEVITABLY DEGRADE THE OTHERS. THUS A COMPROMISE SHOULD BE REACHED SO THAT THE WHOLE SYSTEM IS OPTIMIZED. BASED ON THESE CONSIDERATIONS, AN OPERATING POINT OF I_B=0.91I_C IS CHOSEN FOR OUR DEVICE, GIVING RISE TO A SYSTEM EFFICIENCY OF 0.5% (1550 NM) AND A DARK COUNT RATE OF 2 HZ AT 4.2 K, WHICH CORRESPONDS TO AN NOISE EQUIVALENT POWER OF 4.2×10^{-17} W/HZ$^{1/2}$. THE SUITABILITY OF THIS CHOICE OF THE OPERATING POINT IS SUPPORTED BY THE CALCULATIONS OF THE KEY GENERATION RATES OF A QKD SYSTEM WHEN SUCH A DETECTOR IS USED IN IT.

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4EPF-05

HIGH SPATIAL RESOLUTION DISTRIBUTED FIBER SENSOR THERMOMETER USING RAMAN SCATTERING IN SINGLE-MODE FIBER ***S. NAM**[1], B. BAEK[1], S. DYER[1], M. TANNER[2], R. HADFIELD[2], S. MIKI[3], Z. WANG[3];* [1]NIST, [2]HERIOT-WATT UNIVERSITY, [3]NICT. — DISTRIBUTED FIBER SENSORS ARE AN

ATTRACTIVE ALTERNATIVE TO POINT SENSORS, WHERE A SINGLE FIBER LINE COULD REPLACE THOUSANDS OF INDIVIDUAL SENSORS, SIMPLIFYING THE INSTALLATION AND READOUT. THE THREAD-LIKE QUALITIES OF THE FIBER SENSOR MAKE IT AN ATTRACTIVE ALTERNATIVE FOR LONG STRUCTURES, WIDE AREAS, 3D CONSTRUCTIONS, OR HARSH ENVIRONMENTS. A DISTRIBUTED TEMPERATURE SENSOR HAS BEEN DEMONSTRATED USING AN OPTICAL FIBER AND RAMAN SCATTERING WITH A TEMPERATURE RESOLUTION OF 10 K AND A SPATIAL RESOLUTION OF 3 M [2]. IN THE RAMAN SENSOR, THE TEMPERATURE IS DETERMINED FROM A RATIO OF THE STRENGTH OF THE STOKES AND ANTI-STOKES SCATTERED SIGNALS, WHILE THE POSITION ALONG THE FIBER IS OBTAINED FROM TIME DELAY BETWEEN THE INPUT PULSE AND THE DETECTION OF BACKSCATTERED PHOTONS. IN THIS PAPER, WE DEMONSTRATE A DISTRIBUTED FIBER SENSOR IN WHICH THE TEMPERATURE OF THE FIBER IS DETERMINED FROM THE RATIO OF STOKES AND ANTI-STOKES RAMAN SCATTERED SIGNALS. WE ACHIEVE HIGH SPATIAL RESOLUTION BY DETECTING THE RAMAN SCATTERED SIGNALS WITH OUR LOW-JITTER SUPERCONDUCTING NANOWIRE SINGLE-PHOTON DETECTORS (SNSPDS). THE TIMING JITTER OF THE SNSPDS IS EXTREMELY LOW (~60 PS) [3], YIELDING EXTREMELY HIGH TIMING RESOLUTION IN THE DETECTION OF THE RAMAN BACKSCATTERED PHOTONS WHICH SIGNIFICANTLY IMPROVES THE SPATIAL RESOLUTION OF THE THERMOMETER.

4EPF-06

MULTICHANNEL SNSPD SYSTEM WITH 21% SYSTEM DETECTION EFFICIENCY AT 1550NM WAVELENGTH ***S. MIKI****, T. YAMASHITA, M. FUJIWARA, M. SASAKI, Z. WANG;* NATIONAL INSTITUTE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY. — IN THE FIELD OF OPTICAL QUANTUM INFORMATION APPLICATIONS, MULTICHANNEL SUPERCONDUCTING NANOWIRE SINGLE PHOTON DETECTOR (SNSPD) SYSTEM BASED ON CLOSED-CYCLE CRYOCOOLER HAVE RECENTLY BEEN RECOGNIZED AS PROMISING FROM A PRACTICAL PERSPECTIVE, NOT ONLY BECAUSE OF THEIR GOOD PERFORMANCE BUT ALSO THEIR SIMPLE, STABLE AND CONTINUOUS OPERATION. AT PRESENT, THE TYPE OF SNSPD DEVICES MOSTLY USED IN THE MULTICHANNEL SYSTEM IS SINGLE-LAYER NANOWIRE DEVICES. ALTHOUGH THEY HAVE BEEN SUCCESSFULLY EMPLOYED IN MANY APPLICATIONS, FURTHER IMPROVEMENT IN THE SYSTEM PERFORMANCE, ESPECIALLY IN THE SYSTEM DETECTION EFFICIENCY (DE), IS HIGHLY DESIRABLE. IN THIS WORK, WE PRESENT THE SYSTEM PERFORMANCES OF MULTICHANNEL SINGLE PHOTON DETECTOR SYSTEM USING SNSPDS WITH OPTICAL CAVITY STRUCTURE, WHICH ARE FIBER-COUPLED BY USING SMALL BLOCKS. WE HAVE SUCCEEDED TO IMPLEMENT 6 SNSPD DEVICES WITH OPTICAL CAVITY STRUCTURE INTO A GM CRYO-COOLER SYSTEM SIMULTANEOUSLY. ALL CHANNELS SHOWED HIGHER SYSTEM DE (AT A 100 HZ DARK COUNT RATE) THAN 10 % AT 1550 NM WAVELENGTH, AND BEST CHANNEL SHOWED 21 % AND 30 % AT 1550 NM AND 1310 NM WAVELENGTH, RESPECTIVELY.

4EPG-01

COMPACT FIBER-COUPLED PACKAGING TECHNIQUE FOR SNSPDS WITH OPTICAL CAVITY STRUCTURE ***S. MIKI***[1]*, T. YAMASHITA*[1]*, M. FUJIWARA*[1]*, M. SASAKI*[1]*, M. TAKEDA*[2]*, Z. WANG*[1]*;* [1]NATIONAL INSTITUTE OF INFORMATION AND COMMUNICATION TECHNOLOGY, [2]SHIZUOKA UNIVERSITY. — ALTHOUGH PLACING OPTICAL CAVITY STRUCTURE ON THE SNSPD DEVICE IS AN EFFECTIVE TO ENHANCE PHOTO-ABSORPTION COEFFICIENT, SIMULTANEOUS EFFICIENT OPTICAL COUPLING TO THE NANOWIRE AREA WAS CRUCIAL FOR IMPROVEMENT OF SYSTEM DE. SINCE A COMPACT FIBER-COUPLED PACKAGING TECHNIQUE, WHICH HAVE BEEN WELL DEVELOPED FOR SINGLE LAYER SNSPD DEVICES, IS SUITABLE FOR MULTI-CHANNEL SYSTEM, BECAUSE OF ITS SIMPLICITY, COMPACT SIZE, AND HIGH RELIABILITY, WE PRESENT THE DEVELOPMENT OF THIS TECHNIQUE FOR SNSPDS WITH OPTICAL CAVITY IN THIS WORK. THE NANOWIRES WERE FABRICATED BY 4-NM-THICK NBN THIN FILMS ON MGO SUBSTRATES, AND THE OPTICAL CAVITY STRUCTURE CONSISTING OF A 100-NM-THICK AU MIRROR AND 250-NM-THICK SIO CAVITY WERE COVERED ON NANOWIRE AREA TO ACT AS AN OPTICAL CAVITY AT A WAVELENGTH 1300-1600 NM. THE DEVICES WERE MOUNTED INTO SMALL CHIP-MOUNTING BLOCKS, AND THE SINGLE-MODE OPTICAL FIBERS WERE FIXED TO FIBER-HOLDING BLOCKS. THESE BLOCKS WERE JOINED, AND WE HAVE EMPLOYED TWO APPROACHES FOR EFFICIENT OPTICAL COUPLING. FIRST APPROACH IS SHORTENING OF OPTICAL PATH LENGTH BY REDUCING THE SUBSTRATE THICKNESS. SECOND IS SHRINKING LIGHT BEAM WAIST AT THE NANOWIRE AREA BY USING FIBER-SPLICED SMALL LENSES. IN BOTH APPROACHES, WE HAVE SUCCEEDED TO IMPLEMENT SNSPDS WITH OPTICAL CAVITY INTO COMPACT PACKAGES AND SHOWED HIGH SYSTEM DETECTION EFFICIENCY UP TO 20 % AT 1550 NM WAVELENGTH.

4EPG-02

DEVELOPMENT OF A VERSATILE EXPERIMENTAL SETUP FOR SUPERCONDUCTING NANOWIRE SINGLE PHOTON DETECTORS ***M. KESHAVARZ AKHLAGHI****, A. HAMED MAJEDI;* UNIVERSITY OF WATERLOO. — WE REPORT THE DEVELOPMENT OF A NEW SETUP TO STUDY SUPERCONDUCTING NANOWIRE SINGLE PHOTON DETECTORS (SNSPDS). THE DEVICE IS MOUNTED ON THE VARIABLE TEMPERATURE STAGE OF A HOMEMADE DIPSTICK OPTICAL CRYOSTAT WITH A CAPACITY OF 20MW AT 1.8K. THE TEMPERATURE IS ADJUSTED BY A HEATER, A TEMPERATURE CONTROLLER AND ALSO PUMPING LIQUID HELIUM THROUGH A CAPILLARY TUBE AT A RATE LESS THAN 0.1L/HOUR. AN ALMOST VIBRATION FREE OPERATION IS ACHIEVED BY FIRMLY MOUNTING THE CRYOSTAT ON THE EDGE OF AN OPTICAL TABLE WHILE IT IS NOT TOUCHING THE BODY OF THE CRYOGEN DEWAR. THE FEMTOSECOND 1064NM LASER PULSES ARE WAVELENGTH CONVERTED USING A CONTINUOUSLY TUNEABLE PHASE MATCHED NONLINEAR PROCESS. THE PULSES AFTER INTENSITY AND POLARIZATION CONTROL STAGES ARE COUPLED TO THE SNSPD THROUGH AN OPTICAL WINDOW BY EXPLOITING A ROOM TEMPERATURE MOTORIZED BEAM STEERING MECHANISM. THE ELECTRIC RESPONSE OF THE DEVICE IS AMPLIFIED AND MONITORED ON EITHER A FAST OSCILLOSCOPE OR A PROGRAMMABLE COUNTER. THE SETUP PROVIDES LOW COST, FLEXIBLE AND

RELIABLE OPERATION OF THE SNSPDS UNDER A WIDE RANGE OF EXCITATION CONDITIONS. WE ALSO PRESENT SOME OF THE PRELIMINARILY RESULTS TO FURTHER SHOW THE SYSTEM PERFORMANCE.

4EPG-03

PERFORMANCES OF FIBER-COUPLED SUPERCONDUCTING NANOWIRE SINGLE-PHOTON DETECTORS MEASURED AT ULTRALOW TEMPERATURE ***T. YAMASHITA****, S. MIKI, W. QIU, M. FUJIWARA, M. SASAKI, Z. WANG;* NATIONAL INSTITUTE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY. — RECENTLY SUPERCONDUCTING NANOWIRE SINGLE-PHOTON DETECTORS (SNSPD) ARE EXPECTED TO PLAY A KEY ROLE FOR MANY APPLICATIONS. IN THE APPLICATIONS, FURTHER IMPROVEMENTS OF THE SNSPD PERFORMANCES ARE HIGHLY DESIRABLE. FROM A PRACTICAL POINT OF VIEW, A FIBER-COUPLED TECHNIQUE IS FEASIBLE BECAUSE OF THE EFFICIENT OPTICAL COUPLING BETWEEN INCIDENT PHOTONS AND ACTIVE AREA, RESULTING IN THE HIGH SYSTEM DETECTION EFFICIENCY (DE). LARGE-SIZE DEVICES GENERALLY USED IN THE FIBER COUPLING, HOWEVER, HAVE NOT SHOWN INTRINSIC DEVICE DE AS ACHIEVED IN SMALL-SIZE DEVICES SO FAR, AND LIMITED THE SYSTEM DE. WE MEASURED THE TEMPERATURE DEPENDENCIES OF THE FIBER-COUPLED SNSPD PERFORMANCES IN DETAIL FROM 4 K DOWN TO THE ULTRALOW TEMPERATURE OF 16 MK FOR 1550 NM WAVELENGTH. THE SYSTEM DE INCREASED WITH DECREASING THE TEMPERATURE AND REACHED TO THE CONSIDERABLY HIGH VALUE OF 16% WITH 100 HZ DARK COUNT RATE BELOW 1.2 K, EVEN WITHOUT AN OPTICAL CAVITY STRUCTURE. THE HIGH SYSTEM DE INDICATES THAT THE DEVICE DE OF OUR SNSPD ALMOST REACHED TO THE INTRINSIC ONES.

4EPG-04

SUPERCONDUCTOR/FERROMAGNET PROXIMIZED NANOSTRUCTURES FOR OPTICAL PHOTON DETECTION APPLICATIONS ***G. P. PEPE****[1], L. PARLATO[1], N. MARROCCO[1], V. PAGLIARULO[1], G. PELUSO[1], C. DE LISIO[1], A. BARONE[1], R. CRISTIANO[2], M. EJARNAES[2], A. CASABURI[2], H. MYOREN[3], T. TAINO[3], R. SOBOLEWSKI[4], C. BONAVOLONTÀ[1];* [1]CNR-SPIN AND UNIVERSITY OF NAPLES FEDERICO II, [2]CNR ISTITUTO DI CIBERNETICA, NAPLES, [3]SAITAMA UNIVERSITY, SAITAMA, JAPAN, [4]UNIVERSITY OF ROCHESTER NY, USA. — THE PROXIMITY EFFECT IN SUPERCONDUCTING HETEROSTRUCTURES HAS BEEN EXTENSIVELY INVESTIGATED IN NANO-LAYERED SYSTEMS. INDEPENDENTLY, AMONG SUPERCONDUCTING MATERIALS USED FOR HIGH PERFORMANCE NANOWIRE SUPERCONDUCTIVE SINGLE-PHOTON DETECTORS (SSPDS), NBN WAS DEMONSTRATED TO HAVE THE UNIQUE CHARACTERISTICS IN TERMS OF FAST RESPONSE, HIGH QUANTUM EFFICIENCY IN INFRARED, AND EVEN PHOTON-NUMBER AND -ENERGY RESOLVING CAPABILITIES. WE PRESENT HERE, THE NANO-STRUCTURED NBN MEANDERS WITH OVERLAYERS OF WEAK-FERROMAGNETIC NICU FILMS AND INVESTIGATE THE ROLE OF THE PROXIMITY EFFECT ON THE DEVICE PERFORMANCE. WE REPORT ON OUR CRYOGENIC (DOWN TO 4 K), ULTRAFAST PUMP-PROBE EXPERIMENTS (100-FS-WIDE, 850-NM-WAVELENGTH PULSES WITH 82-MHZ REPETITION RATE), INTENDED TO STUDY THE INFLUENCE OF THE PROXIMITY EFFECT ON THE DYNAMICS OF NONEQUILIBRIUM QUASIPARTICLES DURING THE FIRST FEW PICOSECONDS AFTER THE LASER PULSE ABSORPTION. WE ALSO DEMONSTRATE OUR SSPDS BASED ON NBN/NICU BILAYER MEANDERS (48 UM LENGTHS AND <500 NM WIDTHS) IN TERMS OF THEIR PHOTON RESPONSE EFFICIENCY, AS WELL AS TRANSPORT PROPERTIES. OUR RESULTS ARE COMPARED WITH THAT OBTAINED BY USING THE STANDARD NBN SSPD MEANDERS. REALIZED DEVICES SHOWED AN INCREASE OF THE SUPERCONDUCTING CRITICAL CURRENTS IN THE PRESENCE OF A THIN FERROMAGNETIC OVERLAYER, WHICH RESULTS IN AN INCREMENT OF THE PHOTORESPONSE VOLTAGE (UP TO A FACTOR 6).

4EPG-05

TWO NEW GROWTH METHODS FOR SUPERCONDUCTING NIOBIUM NITRIDE THIN FILMS FOR PHOTODETECTION ***M. W. RABIN****, T. L. WILLIAMSON, G. ZOU, M. A. HOFFBAUER, Q. JIA, D. ROSENBERG, N. R. WEISSE-BERNSTEIN, O. A. VALENZUALA, T. G. HOLESINGER;* LOS ALAMOS NATIONAL LABORATORY. — WE REPORT ON TWO METHODS FOR GROWING SUPERCONDUCTING NBN THIN FILMS FOR FABRICATION INTO FAST PHOTON DETECTORS. FIRST, ENERGETIC NEUTRAL ATOM BEAM LITHOGRAPHY/EPITAXY (ENABLE) USES A COLLIMATED NEUTRAL ATOMIC NITROGEN FLUX TO INDUCE SURFACE CHEMICAL REACTIONS FORMING NITRIDES. THE N ATOM KINETIC ENERGY OF 2-5 EV OVERCOMES THE REACTION ENERGY BARRIER AND REDUCES THE NEED FOR SUBSTRATE HEATING. ENABLE HAS BEEN USED TO GROW HIGHLY CRYSTALLINE FILMS, ~10 NM THICK, WITH GRAIN SIZE OF ~5NM, SHARP INTERFACES TO SAPPHIRE SUBSTRATES, AND TC=10 K (THOUGH ROUNDED, ΔTC=0.5 K). SECOND, POLYMER ASSISTED DEPOSITION (PAD) IS A CHEMICAL SOLUTION DEPOSITION TECHNIQUE IN WHICH A SOLUBLE POLYMER CONTROLS THE VISCOSITY AND BINDS METAL IONS TO PREVENT PREMATURE PRECIPITATION AND FORMATION OF METAL OLIGOMERS. THE RESULT IS A HOMOGENEOUS DISTRIBUTION OF THE METAL PRECURSORS AND THE FORMATION OF UNIFORM METAL NITRIDE FILMS. PAD HAS GROWN THIN (18 NM) EPITAXIAL NBN FILMS ON SRTIO3 (12.6% LATTICE MISMATCH), WITH TC OF 14 K, A SHARP TRANSITION, A RESIDUAL RESISTIVITY RATIO RRR OF 98.4. WE WILL DISCUSS FILM CHARACTERIZATION AND PRELIMINARY RESULTS ON NANOPATTERNED DEVICES.

WE GRATEFULLY ACKNOWLEDGE SUPPORT FROM THE LOS ALAMOS LABORATORY DIRECTED RESEARCH PROGRAM.

4EPG-06

NIOBIUM NITRIDE FILM GROWTH FOR NEXT GENERATION SUPERCONDUCTING SINGLE PHOTON DETECTORS ***L. SAN EMETERIO ALVAREZ****[1], W. JIANG[1], K. SENAPATI[1], Z. H. BARBER[1], M. G. TANNER[2], R. J. WARBURTON[2], R. H. HADFIELD[2];* [1]UNIVERSITY OF CAMBRIDGE, [2]HERIOT-WATT UNIVERSITY. — NIOBIUM NITRIDE (NBN) IS A HIGHLY PROMISING MATERIAL FOR SUPERCONDUCTING SINGLE PHOTON DETECTOR

APPLICATIONS [1,2], OFFERING HIGH ABSORPTION FROM VISIBLE TO MID INFRARED WAVELENGTHS, WITH VERY FAST THERMAL TIME CONSTANTS [3]. WE REPORT ON ULTRATHIN (~5 NM) NBN FILM GROWTH ON SAPPHIRE, QUARTZ AND GAAS SUBSTRATES, WITH TRANSITION TEMPERATURES TC ~10 K, COMPATIBLE WITH DEVICE OPERATION AT 4 K. THE EFFECTS OF REDUCTION OF GROWTH TEMPERATURE (TO ROOM TEMPERATURE) ARE REPORTED, AS WELL AS PROCESSING ISSUES RELATED TO THE FABRICATION OF THESE FILMS INTO MEANDER TYPE SUPERCONDUCTING NANOWIRE SINGLE PHOTON DETECTOR DEVICES, USING E-BEAM LITHOGRAPHY AND REACTIVE ION ETCHING (LINE WIDTH 100NM, 50% FILLED FACTOR). WE REPORT ON ELECTRICAL AND OPTICAL CHARACTERIZATION OF THESE DEVICES AND ON SIMULATIONS OF HIGH EFFICIENCY NEXT GENERATION DEVICE DESIGNS. OUR ULTIMATE GOAL IS TO PRODUCE HIGH EFFICIENCY SUPERCONDUCTING NANOWIRE SINGLE PHOTON DETECTORS, INTEGRATED ON-CHIP WITH OPTICAL CAVITIES AND WAVEGUIDES.[1] G.N. GOL'TSMAN ET AL., APPLIED PHYSICS LETTERS 79 6 2001[2] R.H. HADFIELD, NATURE PHOTONICS 3 696 2009[3] IL'IN ET AL., APPLIED PHYSICS LETTERS 76 2752 2000

EPSRC FUNDING

4EPH-01

STUDY OF INTERDIFFUSION OF IR AND (AU, AL) INTO SI/SIN SUBSTRATES ***M. RIBEIRO GOMES***[1]*, D. BAGLIANI*[2]*, F. GATTI*[2]*, E. ALVES*[3]*, N. PESSOA BARRADAS*[3]*, F. BRUNETTO*[2]*, M. DELL'ANNA*[2]*, M. GALEAZZI*[4]*;* [1]UNIVERSITY OF LISBON, CENTRE FOR NUCLEAR PHYSICS, [2]I.N.F.N. AND UNIVERSITY OF GENOA, [3]INSTITUTO TECNOLÓGICO E NUCLEAR, [4]UNIVERSITY OF MIAMI. — IN THIS WORK, WE WILL PRESENT THE WORK ON THE DIFFUSION OF AU, AL AND IR INTO SOLID SUBSTRATES IN THE FRAMEWORK OF THE MARE PROJECT, IN PARTICULAR, FOCUSING ON THE OPTIMIZATION OF TRANSITION EDGE SENSORS (TES). THE TES DETECTION PERFORMANCE SEVERELY DEPENDS ON THE PHYSICAL AND CHEMICAL PROPERTIES. CHARACTERISTICS SUCH AS FLUX TRAPPING AND VORTEX FLUCTUATIONS CONSTITUTE KEY ASPECTS FOR A DETECTOR OPTIMIZATION, IN TERMS OF SENSITIVITY, REPRODUCIBILITY AND NOISE. THE PHYSICAL PROPERTIES OF THIN MULTILAYER STRUCTURES AND INTERFACE ROUGHNESS/MIXING ARE CRUCIAL.INTERDIFFUSION OCCURS NATURALLY IN A MULTILAYERED THIN FILM STRUCTURE, SOMETIMES WITH ADVERSE EFFECTS. THE PROCESS OF INTERDIFFUSION AND COMPOUND FORMATION IN THE (AU, AL)-IR THIN FILMS, OF DIFFERENT THICKNESSES, DEPOSITED ON SI SUBSTRATES AND SIN MEMBRANES IS INVESTIGATED USING HIGH RESOLUTION ION BEAM ANALYSIS: RUTHERFORD BACKSCATTERING SPECTROMETRY (RBS) AND PARTICLE INDUCED X-RAY EMISSION (PIXE). THESE SYSTEMS ARE ALSO SUBJECTED TO ANNEALING TREATMENTS, FOR A TEMPERATURE RANGE UP TO 700°C AND FOR DIFFERENT ANNEALING TIMES. THE CONCENTRATION DEPTH PROFILES OF THE ENTIRE MULTILAYER STRUCTURE WILL BE SHOWN. THE RESULTS WILL BE DISCUSSED IN TERMS OF FUNDAMENTAL PROPERTIES OF THE SUPERCONDUCTING-TO-NORMAL PHASE TRANSITION DETECTOR PERFORMANCE.

4EPH-02

THE ROLE OF SUBSTRATE PROPERTIES IN ELECTRON-PHONON COUPLING IN NORMAL METALS BELOW 1 K ***J. M. UNDERWOOD****, P. J. LOWELL, G. C. O'NEIL, J. N. ULLOM;* NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY. — AS A METAL IS COOLED TO SUB-KELVIN TEMPERATURES, THE THERMAL COUPLING BETWEEN ELECTRONS AND PHONONS BECOMES VANISHINGLY SMALL. THIS WEAKENED ELECTRON-PHONON COUPLING IS EXPLOITED IN DEVICES SUCH AS THIN-FILM SENSORS AND REFRIGERATORS WHERE THE ELECTRON TEMPERATURE CAN BE ELEVATED OR REDUCED COMPARED TO THE PHONON TEMPERATURE. FOR TEMPERATURES AROUND 100 MK, THE DOMINANT PHONON MODES HAVE WAVELENGTHS THAT OFTEN EXCEED THE THICKNESS OF THE THIN FILMS. IT IS ANTICIPATED THAT IN THIS REGIME THE PHONON DISTRIBUTION WITHIN A FILM BECOMES DEPENDENT ON THE ACOUSTIC PROPERTIES OF THE SUBSTRATE. WE ARE INVESTIGATING THE EFFECT OF SUBSTRATE SOUND VELOCITY AND GEOMETRY (MEMBRANE VS. BULK) ON THE ELECTRON-PHONON COUPLING IN NORMAL METAL FILMS OF AL:MN AND CU. WE COMPARE OUR MEASUREMENTS OF ELECTRON-PHONON COUPLING STRENGTHS WITH THEORETICAL MODELS OF ELECTRON-PHONON COUPLING FOR DIRTY AND CLEAN METALS.

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4EPH-03

AN INVESTIGATION OF THE LONGITUDINAL PROXIMITY EFFECT IN SUPERCONDUCTING AND NORMAL METAL TES ***A. BROWN***[1]*, J. A. CHERVENAK*[2]*, G. KLETETSCHKA*[3]*, N. S. JETHAVA*[4]*, V. MIKULA*[3]*;* [1]NASA-GSFC/MEI TECHNOLOGIES INC, [2]NASA-GSFC, [3]NASA-GSFC/CATHOLIC UNIVERSITY, [4]NASA-GSFC/ORAU. — AS THE TES VOLUME AND (EFFECTIVE) TC BECOME VERY SMALL - FOR VOLUME < 10 MU M X 10 MU M X 0.5 MU M AND TC < 90 MK - WE APPROACH A REGIME IN WHICH THE NOISE EQUIVALENT POWER IS DOMINATED BY FLUCTUATIONS IN POWER DISSIPATING FROM THE TES ELECTRONS TO ITS PHONONS. OUR ULTIMATE GOAL IS TO BUILD A TES BOLOMETER THAT OPERATES IN THIS REGIME TO BE USED FOR FAR-INFRARED AND SUB-MM ASTRONOMY. IN THIS STUDY, WE CHARACTERIZE THE R VS T BEHAVIOR OF SMALL TES IN ORDER TO ENGINEER A TES BOLOMETER THAT HAS A VERY LOW TC. SADLEIR ET AL [1] FOUND THAT AS THE DISTANCE L BETWEEN TWO SUPERCONDUCTING LEADS, WITH THE LEAD TC >> THE TES TC, CONNECTED AT OPPOSITE ENDS OF TES APPROACHES ZERO, SUPERCONDUCTIVITY IS INDUCED PARALLEL TO THE CURRENT FLOW, OR LONGITUDINALLY, AND RESULTS IN A MUCH HIGHER EFFECTIVE TES TC. HERE WE PRESENT EFFECTIVE TC MEASUREMENTS OF MO/AU TES BOUNDED BY NB LEADS AS A FUNCTION OF L WHICH RANGES BETWEEN 4 AND 36 MU M. WE OBSERVE THAT THE EFFECTIVE TC IS SUPPRESSED FOR CURRENT DENSITY OF ORDER 10^-6 A/MU M^2. WE ALSO EXPLORE THE POSSIBILITY OF USING A NORMAL METAL TES.[1]J. E. SADLEIR, S. J. SMITH, S. R. BANDLER, J. A. CHERVENAK, AND J. R. CLEM, "LONGITUDINAL

PROXIMITY EFFECTS IN SUPERCONDUCTING TRANSITION-EDGE SENSORS," ARXIV:0910.2451V1 (2009).

4EPH-04

INVESTIGATION OF THE LATERAL PROXIMITY EFFECT IN A TRANSITION-EDGE HOT-ELECTRON MICRO-BOLOMETER ***E. M. BARRENTINE***[1], *D. E. BRANDL*[1], *A. D. BROWN*[2], *K. L. DENIS*[2], *W. T. HSIEH*[2], *P. C. NAGLER*[2], *T. R. STEVENSON*[2], *D. J. TALLEY*[2], *P. T. TIMBIE*[1], *K. U-YEN*[2]; [1]UNIVERSITY OF WISCONSIN-MADISON, [2]NASA GODDARD SPACE FLIGHT CENTER. — FUTURE GROUND AND SPACE-BASED ASTRONOMY MISSIONS IN THE MILLIMETER AND SUB-MILLIMETER RANGE WILL RELY UPON KILOPIXEL DETECTORS ARRAYS. WE ARE DEVELOPING A SUPERCONDUCTING TRANSITION-EDGE HOT-ELECTRON BOLOMETER (THM) FOR USE IN THESE NEXT GENERATION MISSIONS. THERMAL ISOLATION OF THE THM IS CONTROLLED BY THE HOT-ELECTRON EFFECT BETWEEN THE ELECTRONS AND PHONONS WITHIN THE SMALL-VOLUME OF THE SUPERCONDUCTING DETECTOR. TO REACH A NOISE LEVEL BELOW PHOTON-NOISE LIMITS IN LOW-BACKGROUND OBSERVATIONS THE OPTIMAL DETECTOR SIZE OCCURS AT THE MICRON LENGTH SCALE. ON THESE SMALL SCALES SUPERCONDUCTING PROXIMITY EFFECTS BECOME IMPORTANT, PARTICULARLY, A LATERAL PROXIMITY EFFECT BETWEEN THE SUPERCONDUCTING DEVICE LEADS AND THE DETECTOR. WE PRESENT MEASUREMENTS OF THE TRANSITION BEHAVIOR OF BOTH GOLD AND MOLYBDENUM/GOLD TESS IN CONTACT WITH NIOBIUM SUPERCONDUCTING LEADS AT VARIOUS LENGTH SCALES. WE INVESTIGATE THE POSSIBILITY OF USING THE LATERAL PROXIMITY EFFECT BETWEEN THE DETECTOR AND SUPERCONDUCTING LEADS AS THE SUPERCONDUCTING MECHANISM FOR THIS TYPE OF TRANSITION-EDGE SENSOR.

4EPH-05

MAGNESIUM AS A LIGHT-WEIGHT ALTERNATIVE TO COPPER FOR MANUFACTURING REFRIGERATORS ***K. PRASAI***[1], *D. BOGORIN*[1], *M. GALEAZZI*[1], *D. MCCAMMON*[2], *Y. UPRETY*[1]; [1]UNIVERSITY OF MIAMI, [2]UNIVESITY OF WISCONSIN. — SEVERAL APPLICATIONS USING SUPERCONDUCTING DETECTORS REQUIRE VERY LIGHT WEIGHT COMPONENTS (E.G., IN SPACE APPLICATIONS). WE HAVE INVESTIGATED THETHERMAL PROPERTIES (CONDUCTIVITY, DIFFUSIVITY, AND HEAT CAPACITY) OF MAGNESIUM IN THE WORKING RANGE OF SUPERCONDUCTING DETECTORS (60-150 MK). WE FOUND THAT THE CHARACTERISTICS OF HIGH PURITY (99.9%) MAGNESIUM ARE COMPARABLE TO THAT OF OFHC COPPER, BUT WITH A FACTOR OF 5 SMALLER WEIGHT. IN THIS PAPER WE WILL PRESENT OUR RESULTS AND ILLUSTRATE SOME APPLICATIONS WHERE CU HAS ALREADY BEEN REPLACED WITH MG IN THE COLD END OF REFRIGERATORS.

4EPH-06

DEVELOPMENT OF ALPHA SPECTROMETERS USING MAGNETIC MICROCALORIMETERS *I. KIM, Y. JANG, M. KIM, J. LEE, K. LEE, M. LEE, S. LEE, W. YOON,* ***Y. KIM****;* KOREA RESEARCH INSTITUTE OF STANDARDS AND SCIENCE (KRISS). — DEVELOPMENT OF ALPHA SPECTROMETERS USING MAGNETIC MICROCALORIMETERSWE REPORT THE RECENT PROGRESS MADE IN DEVELOPING ALPHA SPECTROMETERS USING MAGNETIC CALORIMETERS AND SUPERCONDUCTING ELECTRONICS. A MINIATURE SQUID SUSCEPTOMETER IN A GRADIOMETRIC CONFIGURATION WAS EMPLOYED TO MEASURE TEMPERATURE SIGNALS OF A 50 UM DIAMETER AU:ER PARAMAGNETIC SENSOR. THE SENSOR WAS ATTACHED TO A SMALL PIECE OF GOLD IN 0.4 X 0.2 X 0.03 MM^3. THE GOLD FOIL TOGETHER WITH THE AU:ER SENSOR STRUCTURED A TEMPERATURE SENSOR ASSEMBLY ON THE SQUID CHIP. ANOTHER GOLD FOIL WITH 2 X 2 X 0.03 MM^3 WAS PLACED IN NEXT TO THE SENSOR SQUID ASSEMBLY. THE EXTRA FOIL SERVED AS A MAIN ABSORBER FOR INCIDENT ALPHA PARTICLES. THE THERMAL CONNECTION BETWEEN THE ABSORBER FOIL AND THE SENSOR FOIL WAS MADE WITH A FEW GOLD BONDING WIRES. THE WIEDEMANN-FRANZ TYPE THERMAL CONDUCTANCE WAS MUCH DOMINANT TO THEIR INDIVIDUAL THERMAL LINKS TO THERMAL BATH. THE HEAT CAPACITY OF THE ABSORBER FOIL WAS MORE THAN AN ORDER OF MAGNITUDE LARGER THAN THAT OF OTHERS IN THE SENSOR ASSEMBLY NEAR 100 MK. THE HEAT FLOW BETWEEN DIFFERENT PARTS OF THE DETECTOR WAS INVESTIGATED WITH A THERMAL MODEL. WITH A FIRST TRIAL OF THIS TYPE DETECTOR HIGH ENERGY RESOLUTION BETTER THAN 10 KEV WAS ACHIEVED FOR 5.5 MEV ALPHA PARTICLES.

4EPH-07

PERFORMANCE ESTIMATION FOR THIN-FILM MAGNETIC MICROCALORIMETERS WITH IN-PLANE MAGNETIZATION ***S. T. P. BOYD***[1], *F. T. JAECKEL*[1], *R. A. CANTOR*[2]; [1]UNIVERSITY OF NEW MEXICO, [2]STAR CRYOELECTRONICS. — WE HAVE RECENTLY DESCRIBED A PROMISING MAGNETIC GEOMETRY FOR THIN-FILM MAGNETIC MICROCALORIMETERS USING IN-PLANE MAGNETIZATION. THIS ACHIEVED BY SANDWICHING A RING-SHAPED PARAMAGNETIC FILM BETWEEN A SPIRAL PANCAKE COIL AND A SUPERCONDUCTING CAP LAYER THAT SUPPRESSES THE OUT-OF-PLANE COMPONENT OF THE MAGNETIC FIELD. THE INCREASED UNIFORMITY OF THE IN-PLANE MAGNETIZATION, COMBINED WITH THE SUPPRESSION OF PARASITIC INDUCTANCE BY THE CAP LAYER, SHOULD OFFER BOTH HIGHER PERFORMANCE AND CLOSER CONTACT TO THE PHYSICS OF BULK SAMPLES. HERE WE DESCRIBE RESULTS OF A COMPUTATIONAL STUDY COMPARING THE ESTIMATED PERFORMANCE OF THREE DIFFERENT GEOMETRIES: (1) THE NOW-STANDARD MEANDER GEOMETRY, (2) A MEANDER GEOMETRY "SANDWICH", AND (3) THE SPIRAL PANCAKE "SANDWICH." EARLY RESULTS, WITHOUT FULL OPTIMIZATION, INDICATE THAT PERFORMANCE WILL IMPROVE AS WE SWITCH FROM GEOMETRY 1 TO 2 TO 3, WITH THE LARGEST PERCENTAGE IMPROVEMENT OCCURRING IN THE TRANSITION FROM 1 TO 2. IN THIS REPORT WE PRESENT RESULTS OF THE FULL STUDY NOW UNDERWAY.

4EPH-08

FLUX-COUPLED DIRECT FEEDBACK IN A SQUID AMPLIFIER ***B. A. HINES***[1], *K. M. SUNDQVIST*[2], *D. N. SEITZ*[2], *M. E. HUBER*[1]; [1]UNIVERSITY OF COLORADO DENVER, [2]UNIVERSITY OF

CALIFORNIA BERKELEY. — THE CRYOGENIC DARK MATTER SEARCH EMPLOYS DC SUPERCONDUCTING QUANTUM INTERFERENCE DEVICE (SQUID) SERIES ARRAY AMPLIFIERS (SSAAS) IN THE PHONON READOUT SYSTEM. THESE AMPLIFIERS ARE IN A TRANSRESISTANCE TOPOLOGY UTILIZING FEEDBACK FROM ROOM-TEMPERATURE ELECTRONICS. THE INPUT COIL OF EACH SSAA IS IN SERIES WITH A PHONON SENSOR COMPOSED OF MANY PARALLEL TRANSITION EDGE SENSORS (TESS). THE SSAA CONSISTS OF 100 INDIVIDUAL SQUIDS, EACH SURROUNDED BY PLANAR INPUT AND FEEDBACK COILS WITH AN ELECTRICALLY ISOLATED FLUX-FOCUSING WASHER THAT INCREASES THE INDUCTIVE COUPLING BETWEEN THE SQUID AND EACH COIL. A ROOM-TEMPERATURE GAIN STAGE COMPLETES THE FEEDBACK LOOP BETWEEN THE SSAA OUTPUT VOLTAGE AND THE FEEDBACK COIL CURRENT. WE REPORT ON THE SIGNIFICANT MUTUAL INDUCTANCE THAT EXISTS DIRECTLY BETWEEN THE FEEDBACK AND INPUT COILS, ON ITS IMPACT ON THE FEEDBACK NETWORK OF THE AMPLIFIER, AND ON THE TRANSFER FUNCTION OF THE AMPLIFIER. THE RESULTING EFFECTS INCLUDE A PARTIAL NULLING OF THE INPUT COIL'S SELF-INDUCTANCE, AS WELL AS RESONANT PEAKING IN THE CLOSED-LOOP RESPONSE OF THE AMPLIFIER, THE STRENGTH OF WHICH DEPENDS ON THE IMPEDANCE OF THE INPUT COIL CIRCUIT.

4EX-01

(INVITED) **PERFORMANCE OF THE ALMA BAND 10 SIS RECEIVER PROTOTYPE MODEL** ***Y. UZAWA***[1], *Y. FUJII*[1], *K. KANEKO*[1], *M. KROUG*[1], *T. KOJIMA*[1], *K. KUROIWA*[1], *A. MIYACHI*[1], *K. MAKISE*[2], *Z. WANG*[2], *W. SHAN*[3]; [1]NATIONAL ASTRONOMICAL OBSERVATORY OF JAPAN, [2]NATIONAL INSTITUTE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY, [3]PURPLE MOUNTAIN OBSERVATORY. — WE HAVE DEVELOPED A DUAL POLARIZATION PROTOTYPE MODEL OF THE ATACAMA LARGE MILLIMETER/SUBMILLIMETER ARRAY (ALMA) BAND 10 (0.78-0.95 THZ) RECEIVERS. THE FRONT-END OPTICS COMPRISES A PAIR OF ELLIPSOIDAL MIRRORS, A FREE-STANDING WIRE GRID, AND TWO CORRUGATED FEED HORNS. A WAVEGUIDE MIXER BLOCK IS ATTACHED TO EACH FEED HORN IN WHICH AN NBTIN-BASED SUPERCONDUCTOR-INSULATOR-SUPERCONDUCTOR (SIS) MIXER CHIP, WHICH USES A QUARTZ SUBSTRATE, IS MOUNTED TO A WR-1.2 FULL-HEIGHT WAVEGUIDE. A LOCAL OSCILLATOR (LO) SIGNAL RECEIVING HORN AND A WAVEGUIDE 10-DB LO COUPLER ARE INTEGRATED IN THE BLOCK TO PROVIDE THE LO SIGNAL TO THE MIXER CHIP. A FIXED-TUNED MULTIPLIER WITH A DIAGONAL HORN LOCATED AT THE 110-K STAGE IS USED FOR THE LO, AND THE LO SIGNAL IS QUASI-OPTICALLY COUPLED TO THE MIXER RECEIVING HORN. A VERY WIDE INTERMEDIATE FREQUENCY (IF) SYSTEM WITH A BANDWIDTH OF 4-12 GHZ IS EMPLOYED. THE RECEIVER DEMONSTRATED DOUBLE SIDEBAND (DSB) NOISE TEMPERATURES OF ABOUT 200 K WITHOUT ANY CORRECTION FOR LOSS IN FRONT OF THE RECEIVER AT THE CENTER FREQUENCY OF 870 GHZ AT AN OPERATING PHYSICAL TEMPERATURE OF 4 K.

WE THANK M. TAKEDA OF SHIZUOKA UNIVERSITY FOR VALUABLE DISCUSSIONS ON THE SIS MIXERS, AND M. CANDOTTI OF TTI FOR INSIGHTFUL COMMENTS ON THE OPTICS.

4EX-02

BALLOON-BORNE SUPERCONDUCTING INTEGRATED RECEIVER FOR ATMOSPHERIC RESEARCH ***O. KISELEV***[1], *M. BIRK*[2], *A. ERMAKOV*[1], *L. FILIPPENKO*[1], *H. GOLSTEIN*[3], *R. HOOGEVEEN*[3], *N. KINEV*[1], *B. VAN KUIK*[3], *A. DE LANGE*[3], *G. DE LANGE*[3], *P. YAGOUBOV*[4], *V. KOSHELETS*[1]; [1]KOTEL'NIKOV INSTITUTE OF RADIO ENGINEERING AND ELECTRONICS RAS, [2]DLR GERMAN AEROSPACE CENTRE, REMOTE SENSING TECHNOLOGY INSTITUTE, D-82234 WESSLING, GERMANY, [3]SRON NETHERLANDS INSTITUTE FOR SPACE RESEARCH, P.O. BOX 800, 9700 AV GRONINGEN, THE NETHERLANDS, [4]EUROPEAN ORGANIZATION FOR ASTRONOMICAL RESEARCH IN THE SOUTHERN HEMISPHERE (ESO) KARL-SCHWARZSCHILD-STRASSE 2; D-85748 GARCHING BEI MÜNCHEN, GERMANY. — A SUPERCONDUCTING INTEGRATED RECEIVER (SIR) WAS PROPOSED MORE THAN 10 YEARS AGO AND HAS SINCE THEN BEEN DEVELOPED UP TO THE POINT OF PRACTICAL APPLICATIONS. WE HAVE DEMONSTRATED FOR THE FIRST TIME THE CAPABILITIES OF THE SIR TECHNOLOGY FOR HETERODYNE SPECTROSCOPY BOTH IN THE LABORATORY AND AT REMOTE OPERATION UNDER HARSH ENVIRONMENTAL CONDITIONS FOR ATMOSPHERIC RESEARCH. WITHIN A SIR THE MAIN COMPONENTS NEEDED FOR A SUPERCONDUCTING HETERODYNE RECEIVER SUCH AS AN SIS-MIXER WITH QUASI-OPTICAL ANTENNA, A FLUX-FLOW OSCILLATOR (FFO) AS THE LOCAL OSCILLATOR, AND A HARMONIC MIXER TO PHASE-LOCK THE FFO ARE INTEGRATED ON A SINGLE CHIP. LIGHT WEIGHT AND LOW POWER CONSUMPTION COMBINED WITH BROADBAND OPERATION AND NEARLY QUANTUM LIMITED SENSITIVITY MAKE THE SIR A PERFECT CANDIDATE FOR FUTURE AIRBORNE AND SPACE-BORNE MISSIONS. THE NOISE TEMPERATURE OF THE SIR WAS MEASURED TO BE AS LOW AS 120 K, WITH AN INTERMEDIATE FREQUENCY BAND OF 4 - 8 GHZ IN DOUBLE SIDEBAND OPERATION; THE SPECTRAL RESOLUTION IS WELL BELOW 1 MHZ. THE SIR WAS IMPLEMENTED IN THE THREE-CHANNEL BALLOON-BORNE INSTRUMENT TELIS (TERAHERTZ AND SUBMILLIMETER LIMB SOUNDER) THAT DETECTS SPECTRAL EMISSION LINES OF STRATOSPHERIC TRACE GASES (LIKE CLO AND BRO). THESE GASES EVEN IN SMALL QUANTITIES CAN HAVE A SIGNIFICANT IMPACT ON THE ATMOSPHERE BECAUSE THEY SPEED UP CERTAIN CHEMICAL PROCESSES, SUCH AS OZONE DEPLETION.

THE WORK WAS SUPPORTED BY THE RFBR PROJECTS 09-02-00246, 09-02-12172-OFI-M, AND GRANT FOR LEADING SCIENTIFIC SCHOOL 5423.2010.2

4EX-03

LOW NOISE 1 THZ SIS MIXER FOR STRATOSPHERIC OBSERVATORY ***A. KARPOV***[1], *D. MILLER*[1], *J. A. STERN*[2], *B. BUMBLE*[2], *H. G. LEDUC*[2], *J. ZMUIDZINAS*[1]; [1]CALIFORNIA INSTITUTE OF TECHNOLOGY, [2]JPL, CALIFORNIA INSTITUTE OF TECHNOLOGY. — WE REPORT THE DEVELOPMENT OF A LOW NOISE AND BROADBAND SIS MIXER AIMED FOR 1 THZ CHANNEL OF THE CALTECH AIRBORNE SUBMILLIMETER

INTERSTELLAR MEDIUM INVESTIGATIONS RECEIVER (CASIMIR), DESIGNED FOR THE STRATOSPHERIC OBSERVATORY FOR FAR INFRARED ASTRONOMY, (SOFIA). THE MIXER USES NB/AL-ALN/NBTIN SIS JUNCTIONS WITH CRITICAL CURRENT DENSITY OF 30-50 KA/CM2. THE JUNCTIONS ARE SHAPED IN ORDER TO OPTIMIZE THE SUPPRESSION OF THE JOSEPHSON DC CURRENTS. WE ARE USING A DOUBLE SLOT PLANAR ANTENNA TO COUPLE THE MIXER CHIP WITH THE TELESCOPE BEAM. THE RF MATCHING MICROCIRCUIT IS MADE USING NB AND GOLD FILMS. THE MIXER IF CIRCUIT IS DESIGNED TO COVER 4 - 8 GHZ BAND. A RECEIVER WITH THE NEW MIXER HAS A LOW NOISE OPERATION IN A 0.9 - 1.05 THZ BAND. THE MINIMUM DSB RECEIVER NOISE MEASURED AT 1 THZ IS 260 K (Y=1.64), APPARENTLY THE LOWEST REPORTED UP TO DATE. THE RECEIVER NOISE CORRECTED FOR THE LOSS IN THE LO INJECTION BEAM SPLITTER AND IN THE CRYOSTAT WINDOW IS 200 K. THE COMBINATION OF A BROAD OPERATION BAND WITH A LOW RECEIVER NOISE IS MAKING THE NEW MIXER A USEFUL ELEMENT FOR APPLICATION AT SOFIA. WE WILL DISCUSS THE PROSPECTIVE OF A FURTHER IMPROVEMENT OF THE SENSITIVITY AND EXTENSION OF THE UPPER FREQUENCY OF OPERATION OF SIS MIXER.

THIS WORK IS SUPPORTED BY SOFIA / USRA INSTRUMENT DEVELOPMENT PROGRAM

4EX-04

ULTRAWIDE NOISE BANDWIDTH OF NBN HOT-ELECTRON BOLOMETER MIXERS WITH IN SITU GOLD CONTACTS *I. TRETYAKOV, M. FINKEL, S. RYABCHUN, A. MASLENNIKOVA, N. KAUROVA, A. LOBASTOVA, B. VORONOV,* ***G. GOL'TSMAN****;* MOSCOW STATE PEDAGOGICAL UNIVERSITY. — WE REPORT A NOISE BANDWIDTH OF 7 GHZ IN THE NEW GENERATION OF PHONON-COOLED NBN HEB MIXERS THAT ARE BEING DEVELOPED FOR THE SPACE OBSERVATORY MILLIMETRON. THE MIXERS WERE PATTERNED FROM NBN-AU FILMS DEPOSITED IN SITU ON TOP OF HIGH-RESISTIVITY SI SUBSTRATES. THE HEB RECEIVER DRIVEN BY A 2.5-THZ LOCAL OSCILLATOR OFFERED A NOISE TEMPERATURE OF 600 K IN A 50-MHZ FINAL DETECTION BANDWIDTH. AS THE FILTER CENTER FREQUENCY WAS SWEPT THIS VALUE REMAINED UNCHANGED UP TO THE CUTOFF FREQUENCY OF THE CRYOGENIC AMPLIFIER AT 7 GHZ. WE BELIEVE THAT SUCH A LOW VALUE OF THE NOISE TEMPERATURE IS DUE TO REDUCED OHMIC LOSS AT THE INTERFACE BETWEEN THE SUPERCONDUCTING FILM AND THE GOLD CONTACTS. ALSO, THE INDEPENDENCE OF THE RECEIVER NOISE ON THE INTERMEDIATE FREQUENCY SUPPORTS THE IDEA OF ADDITIONAL DIFFUSION COOLING IN OUR MIXERS.

4EX-05

HETERODYNE MIXING AND DIRECT DETECTION PERFORMANCE OF A SUPERCONDUCTING NBN HOT-ELECTRON BOLOMETER *W. ZHANG, K. ZHOU, S. LI, W. MIAO, Z. LIN, Y. REN,* ***S. SHI****;* PURPLE MOUNTAIN OBSERVATORY. — THE HETERODYNE MIXING AND DIRECT DETECTION PERFORMANCE OF A SUPERCONDUCTING NBN HOT-ELECTRON BOLOMETER (HEB) INTEGRATED WITH A SPIRAL ANTENNA HAVE BEEN THOROUGHLY CHARACTERIZED. THE MEASURED RECEIVER NOISE TEMPERATURE AND IF GAIN BANDWIDTH, APPROXIMATELY EQUAL TO 550 K AT 0.85 THZ AND 3 GHZ AT ITS OPTIMUM BIAS POINT, WERE FOUND IN GOOD AGREEMENT WITH THOSE SIMULATED WITH THE HOT-SPOT MODEL TAKING ACCOUNT OF THE HEB'S CURRENT-DEPENDENT RESISTIVE TRANSITION. IN ADDITION, THE RECEIVER NOISE TEMPERATURE AND IF GAIN BANDWIDTH WERE BOTH FOUND INSENSITIVE TO THE BATH TEMPERATURE, WHILE THE BIAS POINT WAS FIXED. FURTHERMORE, THE HEB'S FREQUENCY RESPONSE WAS MEASURED BY A FOURIER TRANSFORM SPECTROMETER AT DIFFERENT BIAS POINTS AND BATH TEMPERATURES. THE ESTIMATED NOISE EQUIVALENT POWER (NEP) WAS CLOSE TO 10-13 W/HZ0.5 AROUND THE HEB'S TRANSITION TEMPERATURE. DETAILED EXPERIMENTAL AND THEORETICAL RESULTS WILL BE PRESENTED.

THE HEB DEVICE USED IN THIS EXPERIMENT WAS FABRICATED BY RADIO PHYSICS LAB, MOSCOW STATE PEDAGOGICAL UNIVERSITY, RUSSIA. THIS WORK WAS SUPPORTED IN PART BY NSFC UNDER GRANT NOS. 10803021, 10933005, AND 10621303.

4EX-06

LARGE-SIGNAL FREQUENCY RESPONSE OF AN HEB MIXER: FROM DC TO TERAHERTZ ***Y. LOBANOV****[1], E. TONG[1], A. HEDDEN[1], R. BLUNDELL[1], B. VORONOV[2], G. GOL'TSMAN[2];* [1]HARVARD-SMITHSONIAN CENTER FOR ASTROPHYSICS, [2]MOSCOW STATE PEDAGOGICAL UNIVERSITY. — WE PRESENT A STUDY OF THE LARGE SIGNAL FREQUENCY RESPONSE OF A PHONON-COOLED HEB MIXER OVER A WIDE FREQUENCY RANGE. IN OUR EXPERIMENT, WE HAVE SUBJECTED THE HEB MIXER TO INCIDENT ELECTROMAGNETIC RADIATION FROM 0.5 GHZ TO 1 THZ. THE MIXER ELEMENT (WITH TC ~ 10 K) IS AN NBN FILM DEPOSITED ON CRYSTALLINE QUARTZ WITH A 200 NM MGO BUFFER LAYER. THE MIXER CHIP IS MOUNTED IN A 200 GHZ WAVEGUIDE CAVITY, COUPLED TO FREE SPACE WITH A DIAGONAL HORN. AT MICROWAVE FREQUENCIES, ELECTROMAGNETIC RADIATION IS APPLIED THROUGH THE COAXIAL BIAS PORT OF THE MIXER BLOCK. AT HIGHER FREQUENCIES THE INPUT SIGNAL PASSES VIA THE DIAGONAL HORN FEED. AT EACH FREQUENCY, THE INCIDENT POWER IS VARIED AND A FAMILY OF I-V CURVES IS RECORDED. THESE CURVES ARE ALSO COMPARED TO THOSE OBTAINED WHEN THE BATH TEMPERATURE IS CHANGED. FROM THE CURVES WE IDENTIFY 3 DISTINCT REGIMES OF OPERATION OF THE MIXER SEPARATED BY THE PHONON RELAXATION FREQUENCY AND THE SUPERCONDUCTING ENERGY GAP FREQUENCY OBSERVED AT ~3 GHZ AND ~660 GHZ RESPECTIVELY. IN THIS PAPER, WE WILL PRESENT THE OBSERVED DATA AND DISCUSS THE RESULTS OF OUR EXPERIMENT.

4EX-07

NBN HOT-ELECTRON BOLOMETER FOR DETECTION OF SHORT THZ PULSES *K. S. ILIN[1], A. D. SEMENOV[2], V. JUDIN[3], H. W. HUEBERS[4],* ***M. SIEGEL****[1], A. S. MUELLER[5];* [1]INSTITUTE OF MICRO- AND NANOELECTRONIC SYSTEMS, KARLSRUHE INSTITUTE OF

TECHNOLOGY, D-76187 KARLSRUHE, GERMANY, [2]GERMAN AEROSPACE CENTER, BERLIN, 12489 GERMANY, [3]LABORATORY FOR APPLICATIONS OF SYNCHROTRON RADIATION, UNIVERSITY OF KARLSRUHE, 76128 GERMANY, [4]GERMAN AEROSPACE CENTER, BERLIN, 12489 GERMANY, INSTITUT FÜR OPTIK UND ATOMARE PHYSIK, TECHNISCHE UNIVERSITÄT BERLIN, D-10623 BERLIN, GERMANY, [5]LABORATORY FOR APPLICATIONS OF SYNCHROTRON RADIATION, UNIVERSITY OF KARLSRUHE, 76128 GERMANY, INSTITUTE FOR SYNCHROTRON RADIATION, KARLSRUHE INSTITUTE OF TECHNOLOGY, 76021 GERMANY. — SHORT TERAHERTZ (THZ) PULSES PLAY AN IMPORTANT ROLE IN MANY THZ SYSTEMS. EXAMPLES ARE TIME DOMAIN SPECTROMETERS, FREE ELECTRON LASERS, AND ELECTRON STORAGE RINGS. ALSO FOR THE CHARACTERIZATION OF LASER DYNAMICS FAST THZ DETECTORS ARE REQUIRED. TYPICAL TIME SCALES ARE IN THE ORDER OF 100 PS. A DETECTOR SYSTEM BASED ON A SUPERCONDUCTING NBN ULTRA-FAST BOLOMETER WITH AN INTRINSIC RESPONSE TIME OF ABOUT 100 PS HAS BEEN DEVELOPED. WE HAVE DEVELOPED A RELIABLE MULTI-LAYER TECHNOLOGY FOR FABRICATION OF NBN HOT-ELECTRON BOLOMETERS FOR DIRECT DETECTION AND MIXERS FOR THZ RADIATION. THIS TECHNOLOGY CONTAINS AN ACTIVE 5 NM THICK NBN LAYER, NBN BUFFER LAYERS, AND AU LAYER FOR ANTENNA STRUCTURES. THE NBN HOT-ELECTRON BOLOMETER IS EMBEDDED INTO A PLANAR LOG-SPIRAL ANTENNA WHICH IS INTEGRATED WITH AN ELLIPTICAL SILICON LENS.FOR EVALUATION AND DEMONSTRATION OF ITS CAPABILITIES THE DETECTOR SYSTEM WAS IMPLEMENTED AT THE ELECTRON STORAGE RING ANKA WHICH PROVIDES THZ PULSES WITH A FWHM OF LESS THAN 10 PS. THE RESPONSE TO THESE PULSES HAS A FULL WIDTH AT HALF MAXIMUM (FWHM) OF 165 PS THAT IS PARTLY LIMITED BY THE READOUT ELECTRONICS. BASED ON THE FWHM OF THE SINGLE-BUNCH SIGNAL AND THE 3.5 GHZ BANDWIDTH OF THE MICROWAVE AMPLIFIERS WE ESTIMATE A BOLOMETER RESPONSE TIME OF LESS THAN 130 PS.

4EY-01

(INVITED) **50 GHZ OPERATION OF SFQ FLOATING-POINT MULTIPLIER USING 10 KA/CM^2 NB PROCESS** ***Y. SHIMAMURA***[1]*, K. TOSHIKI*[1]*, F. MIYAOKA*[1]*, Y. YAMANASHI*[1]*, N. YOSHIKAWA*[1]*, A. FUJIMAKI*[2]*, N. TAKAGI*[2]*, K. TAKAGI*[2]*;* [1]YOKOHAMA NATIONAL UNIVERSITY, [2]NAGOYA UNIVERSITY. — WE HAVE BEEN DEVELOPING A LARGE-SCALE RECONFIGURABLE DATA-PATH (LSRDP) USING SINGLE-FLUX-QUANTUM (SFQ) CIRCUIT TO REALIZE HIGH-END COMPUTER SYSTEMS. THE LSRDP IS COMPOSED OF A LARGE NUMBER OF FLOATING-POINT UNITS (FPUS) AND RECONFIGURABLE ROUTING NETWORK SWITCHES. BECAUSE THE DATA ARE DIRECTLY TRANSFERRED BETWEEN FPUS WITHOUT MEMORY ACCESSES IN THE LSRDP, THE SO-CALLED MEMORY-WALL PROBLEM CAN BE IMPROVED. A FLOATING-POINT MULTIPLIER (FPM) IS ONE OF THE MAIN CIRCUIT COMPONENTS OF THE LSRDP. IN THE PREVIOUS STUDY, THE HALF-PRECISION FPM WAS DESIGNED USING THE ISTEC 2.5 KA/CM^2 NB STANDARD PROCESS AND ITS COMPLETE OPERATION WAS DEMONSTRATED AT 25 GHZ. RECENTLY, TO MAKE FURTHER LARGE SFQ CIRCUITS WITH ENHANCED PERFORMANCE, THE ISTEC 10 KA/CM^2 NB ADVANCED PROCESS (ADP2.1) HAS BEEN DEVELOPED. IN THIS STUDY, AN 11-BIT BIT-SERIAL FPM ARE DESIGNED AND IMPLEMENTED USING THE ADP2.1 PROCESS. THE CORRECT OPERATIONS OF THE MAIN CIRCUIT BLOCKS OF THE FPM INCLUDING A MULTIPLIER FOR SIGNIFICANDS AND NORMALIZER WERE CONFIRMED AT 51 GHZ BY ON-CHIP HIGH-SPEED TEST. THE FULL OPERATION OF THE FPM IS UNDER INVESTIGATION AND THE RESULTS WILL BE SHOWN AT THE CONFERENCE.

NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY PARTIALLY CONTRIBUTED TO THE CIRCUIT FABRICATION.

4EY-02

CLOCK LINE CONSIDERATIONS FOR AN SFQ LARGE SCALE RECONFIGURABLE DATA PATHS PROCESSOR ***I. KATAEVA***[1]*, H. AKAIKE*[1]*, A. FUJIMAKI*[1]*, S. NAGASAWA*[2]*, N. TAKAGI*[1]*;* [1]NAGOYA UNIVERSITY, [2]ISTEC-SRL. — WE ARE DEVELOPING AN SFQ RECONFIGURABLE DATA PATHS PROCESSOR (SFQ-RDP) IMPLEMENTED AS A TWO DIMENSIONAL ARRAY OF FLOATING POINT UNITS CONNECTED USING OPERAND ROUTING NETWORKS. CLOCKING OF THE LARGE SCALE SFQ CIRCUITS IS A MAJOR ISSUE DUE TO ACCUMULATED JITTER AND CLOCK SKEW THAT GROW WITH THE INCREASE OF THE CLOCK LINE LENGTH. WE HAVE ESTIMATED THE JITTER ACCUMULATED IN DATA AND CLOCK PATHS OF THE SFQ-RDP, ITS IMPACT ON THE OPERATING FREQUENCY AND IDENTIFIED THE CRITICAL PARTS OF THE PROCESSOR. IN ORDER TO PREVENT THE PERFORMANCE DEGRADATION, WE HAVE PROPOSED TO DIVIDE THE PROCESSOR IN SEVERAL PARTS THAT ARE CLOCKED INDIVIDUALLY BY AN EXTERNAL JITTER-FREE SYSTEM CLOCK. FIFO BUFFERS INSERTED BETWEEN THE PROCESSORS STAGES AND CLOCK CONTROLLERS ARE USED TO SYNCHRONIZE EACH STAGE WITH THE NEXT ONE AND AS A RESULT THE ACCUMULATION OF THE JITTER IS LIMITED TO ONE STAGE OF THE PROCESSOR ONLY. THE CLOCK DISTRIBUTION AND SYNCHRONIZATION PROTOTYPE HAS BEEN DESIGNED FOR ISTEC-SRL ADP 10 KA/CM2 PROCESS AND WE ARE GOING TO PRESENT EXPERIMENTAL RESULTS.

4EY-03

IMPROVED ROBUSTNESS FOR RSFQ CIRCUITS BY IMPLEMENTING MULTIPLE PHASE SHIFTING ELEMENTS ***O. MIELKE***[1]*, T. ORTLEPP*[2]*, R. STOLZ*[1]*, J. KUNERT*[1]*, H. G. MEYER*[1]*, H. TOEPFER*[2]*;* [1]INSTITUTE OF PHOTONIC TECHNOLOGY, [2]ILMENAU UNIVERSITY OF TECHNOLOGY. — RAPID SINGLE FLUX QUANTUM ELECTRONICS IS CHARACTERIZED BY A VERY LOW SWITCHING ENERGY. THIS ADVANTAGE LEADS TO A NOISE SUSCEPTIBILITY WHICH BECOMES A CHALLENGE FOR LARGE-SCALE CIRCUITS AS WELL AS FOR CIRCUITS USING JOSEPHSON JUNCTIONS WITH REDUCED CRITICAL CURRENT DENSITY.THE IMPROVED OPERATION RANGE AND ADVANCED NOISE IMMUNITY OF BASIC CELLS RESULTING FROM AN IMPLEMENTED PHASE SHIFTING ELEMENT WAS ALREADY DEMONSTRATED. ONE OF THOSE ELEMENTS IS THE PI-PHASESHIFTER. IT CONSISTS OF A SINGLE FLUX QUANTUM TRAPPED IN A SUPERCONDUCTING LOOP. THE PI-

PHASESHIFTER CAN BE EASILY PRODUCED IN STANDARD NIOBIUM TECHNOLOGY WITHOUT ANY PROCESS MODIFICATIONS. THIS IS AN ADVANTAGE CONCERNING THE RELIABLE FABRICATION OF COMPLEX CIRCUITS.SMALL IMPROVEMENTS OF THE OPERATION RANGE OF BASIC RSFQ CELLS ARE LEADING TO REMARKABLE ENHANCEMENTS OF COMPLEX CIRCUITS. WE ANALYZED RSFQ-CIRCUITS COMPOSED OF SEVERAL BASIC CELLS WITH 4 AND 8 PI-PHASESHIFTERS. THE EXPERIMENTALLY EVALUATED OPERATION RANGE IS INCREASED BY 10% COMPARED TO THE STANDARD RSFQ-CIRCUIT. WE PREDICT A LARGE POTENTIAL OF PI-PHASESHIFTERS TO IMPROVE THE NOISE IMMUNITY IN SMALL SCALE ULTRA-LOW ENERGY RSFQ CIRCUITS.

THE PROJECT WAS SUPPORTED BY FLUXONICS E.V.

4EY-04

MULTI-BIT MIXERS FOR DIGITAL-RF RECEIVERS ***T. V. FILIPPOV****, S. SARWANA, A. SAHU, A. F. KIRICHENKO, D. GUPTA;* HYPRES. — HYPRES, INC HAS SUCCESSFULLY COMPLETED THE DEVELOPMENT OF THE FIRST SUPERCONDUCTOR DIGITAL CHANNELIZING RECEIVER. THIS FIRST-GENERATION CHANNELIZER CIRCUIT, COMPRISING A SINGLE-BIT DIGITAL IN-PHASE AND QUADRATURE (I&Q) MIXER AND TWO SECOND-ORDER DECIMATION FILTERS, WAS BUILT WITH RAPID SINGLE FLUX QUANTUM (RSFQ) LOGIC AND DEMONSTRATED AT CLOCK RATES OF 20 GHZ. WITH ABOUT 12000 JOSEPHSON JUNCTIONS, THIS CIRCUIT IS THE MOST COMPLEX HIGH-SPEED FUNCTIONAL RSFQ CIRCUIT EVER DEMONSTRATED. THE FURTHER DEVELOPMENT OF DIGITAL-RF RECEIVERS REQUIRES A MULTI-BIT ($N \times K$) MULTIPLIER FOR DIGITAL MIXING OF N-BIT DATA STREAMS PROVIDED BY ADVANCED LP OR BP MODULATOR AND K-BIT DIGITAL LOCAL OSCILLATOR (LO). WE REPORT OUR RESULTS ON DESIGN OF BOTH $N \times 1$ -BIT AND $1 \times K$ -BIT MIXERS WHERE EITHER DATA OR LO STREAMS CAN HAVE MULTI-BIT REPRESENTATION. THE REPORTED APPROACH IS THE GENERALIZATION OF 1×1 -BIT MIXER USED IN THE FIRST-GENERATION CHANNELIZER. THE DETAILED BLOCK-DIAGRAMS ARE GIVEN FOR BOTH TYPES AND THE CORRECT OPERATION OF TEST CHIPS WITH 3-BIT MIXERS ARE REPORTED. WE ALSO REPORT THE VALIDATION OF 2×1 -BIT MIXER DESIGN IN 20-30 GHZ RANGE WITH BOTH LP AND BP ADCS. DESIGN ISSUES OF SCALING TO A DIGITAL-RF RECEIVER, CONTAINING MULTI-BIT MIXERS ARE DISCUSSED.

THIS WORK WAS SUPPORTED BY OFFICE OF NAVAL RESEARCH.

4EY-05

HIGH-SPEED TEST OF A RADIX-2 BUTTERFLY PROCESSING ELEMENT FOR THE FAST FOURIER TRANSFORM USING SFQ CIRCUITS ***F. MIYAOKA****, T. KAINUMA, Y. SHIMAMURA, Y. YAMANASHI, N. YOSHIKAWA;* YOKOHAMA NATIONAL UNIVERSITY. — A SINGLE-FLUX-QUANTUM (SFQ) BUTTERFLY PROCESSING ELEMENT (BPE) WAS DEVELOPED FOR FFT PROCESSORS BASED ON BIT-SERIAL ARCHITECTURE. THE BPE CONSISTS OF THREE ADDERS, FOUR SUBTRACTORS AND FOUR MULTIPLIERS. IN OUR PREVIOUS STUDY, WE REPORTED THE CIRCUIT ARCHITECTURE OF A 4-BIT BIT-SERIAL SFQ BPE AND CONFIRMED THE CORRECT OPERATION OF HALF OF IT AT 16 GHZ. IN THIS STUDY, WE MODIFIED ITS CIRCUIT ARCHITECTURE TO IMPROVE THE TIMING BETWEEN EACH CIRCUIT BLOCK AND THE ROBUSTNESS OF THE CIRCUITS. FIRST OF ALL, THE FFT ALGORITHM WAS CHANGED FROM DECIMATION-IN-TIME TO DECIMATION-IN-FREQUENCY TYPE, WHICH EXCHANGES THE ORDER OF MULTIPLIERS AND SUBTRACTORS/ADDERS, RESULTING IN THE EASINESS OF THE TIMING DESIGN. SEVERAL BUFFERS WERE ALSO ADDED BETWEEN EACH CIRCUIT BLOCK FOR THE ADJUSTMENT OF TIMING BETWEEN CLOCK AND DATA SIGNALS. WE HAVE IMPLEMENTED THE 4-BIT BPE USING THE ISTEC 2.5 KA/CM^2 NB STANDARD PROCESS (STP2). THE TOTAL JUNCTION NUMBER IS 5763 AND ITS POWER CONSUMPTION IS 1.7 MW. RIGHT NOW COMPLETE OPERATION OF 4-BIT BPE IS CONFIRMED AT 13 GHZ. THE LATEST TEST RESULTS WILL BE SHOWN AT THE CONFERENCE.

NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY PARTIALLY CONTRIBUTED TO THE CIRCUIT FABRICATION.

4EY-06

DESIGN AND IMPLEMENTATION OF COMPONENT CIRCUITS OF AN SFQ HALF-PRECISION FLOATING-POINT ADDER USING 10 KA/CM2 NB PROCESS ***T. KAINUMA****[1], Y. YAMANASHI[1], N. YOSHIKAWA[1], A. FUJIMAKI[2], N. TAKAGI[2], K. TAKAGI[2];* [1]YOKOHAMA NATIONAL UNIVERSITY, [2]NAGOYA UNIVERSITY. — WE ARE DEVELOPING A LARGE-SCALE RECONFIGURABLE DATA-PATH (LSRDP) BASED ON SINGLE-FLUX-QUANTUM (SFQ) CIRCUITS. A FLOATING-POINT ADDER (FPA) IS ONE OF THE MAIN CIRCUIT COMPONENTS OF THE LSRDP. RECENTLY, THE ISTEC 10 KA/CM2 NB ADVANCED PROCESS (ADP2.1) WITH EIGHT SUPERCONDUCTIVE LAYERS HAS BEEN DEVELOPED. BY ADOPTING THIS PROCESS, THE CLOCK FREQUENCY AND THE DESIGN FLEXIBILITY OF LOGIC CIRCUITS ARE SIGNIFICANTLY ENHANCED. IN THIS STUDY, COMPONENT CIRCUITS OF THE HALF-PRECISION SFQ FPA, INCLUDING A SHIFTER, AN ADDER/SUBTRACTOR AND NORMALIZERS WERE DESIGNED AND IMPLEMENTED USING THE ADP2.1. THEIR TARGET OPERATION FREQUENCY IS 50 GHZ. THE SHIFTER PERFORMS SHIFTING AND ROUNDING OF THE SIGNIFICANDS. THE ADDER/SUBTRACTOR CARRIES OUT ADDITION AND SUBTRACTION OF THE SIGNIFICANDS BIT-SERIALLY. THE NORMALIZERS SHIFT THE SIGNIFICAND TO FIT IT TO THE NORMALIZED SCIENTIFIC NOTATION. THE DC BIAS MARGINS OF THE SHIFTER, THESE COMPONENT CIRCUITS ARE OPTIMIZED AND EVALUATED TO BE BETTER THAN -9%~25% BY LOGIC SIMULATIONS. HIGH-SPEED TEST RESULTS WILL BE PRESENTED AT THE CONFERENCE.

NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY PARTIALLY CONTRIBUTED TO THE CIRCUIT FABRICATION.

4EY-07

DESIGN APPROACH OF DYNAMICALLY RECONFIGURABLE SINGLE FLUX QUANTUM LOGIC GATES ***Y. YAMANASHI****, I.*

OKAWA, N. YOSHIKAWA; YOKOHAMA NATIONAL UNIVERSITY. — NOVEL RECONFIGURABLE SUPERCONDUCTIVE SINGLE FLUX QUANTUM (SFQ) LOGIC GATES, THE FUNCTIONS OF WHICH CAN BE DYNAMICALLY RECONFIGURED BY INPUTTING CONTROL SIGNALS, HAVE BEEN INVESTIGATED. CHARACTERISTICS OF SINGLE FLUX QUANTUM CIRCUITS CAN BE EASILY MODULATED BY APPLYING CURRENTS OR MAGNETIC FIELDS BECAUSE OF HIGH SENSITIVITY OF SUPERCONDUCTIVE CIRCUITS. WE HAVE INVESTIGATED SEVERAL DESIGN APPROACHES SUITABLE FOR REALIZATION OF THE DYNAMICALLY RECONFIGURABLE SFQ LOGIC GATES. AND WE EMPLOYED DIRECT CURRENT INJECTION TO THE LOGIC GATE USING A NON-DESTRUCTIVE READ-OUT FLIP-FLOP. BY CHANGING THE INTERNAL STATE OF THE NON-DESTRUCTIVE READ-OUT FLIP-FLOP, THE LOGIC FUNCTION CAN BE DYNAMICALLY RECONFIGURED. WE HAVE DESIGNED AND TESTED A DYNAMICALLY RECONFIGURABLE LOGIC CIRCUIT, WHOSE LOGIC FUNCTION OF THE LATCHING AND NON-LATCHING FUNCTIONS CAN BE RECONFIGURED. THE MEASURED DC BIAS MARGIN WAS 72.5% - 107.2%. THE INVESTIGATED CIRCUIT STRUCTURE CAN BE APPLIED TO MORE SOPHISTICATED DYNAMICALLY RECONFIGURABLE SINGLE FLUX QUANTUM LOGIC GATES AND DYNAMICALLY RECONFIGURABLE SFQ PROCESSORS.

THIS PROJECT IS SUPPORTED BY MEXT'S PROGRAM "PROMOTION OF ENVIRONMENTAL IMPROVEMENT FOR INDEPENDENCE OF YOUNG RESEARCHERS"

4LA-01**DEGRADATION OF YBCO COIL PERFORMANCE DUE TO EPOXY IMPREGNATION** ***T. TAKEMATSU***[1]*, R. HU*[1]*, T. TAKAO*[1]*, Y. YANAGISAWA*[2]*, H. NAKAGOME*[2]*, D. UGLIETTI*[3]*, T. KIYOSHI*[3]*, M. TAKAHASHI*[4]*, H. MAEDA*[4]*;* [1]FACULTY OF SCIENCE AND TECHNOLOGY, SOPHIA UNIVERSITY, [2]GRADUATE SCHOOL OF ENGINEERING, CHIBA UNIVERSITY, [3]SUPERCONDUCTING MATERIALS CENTER, NATIONAL INSTITUTE FOR MATERIALS SCIENCE, [4]SYSTEMS AND STRUCTURAL BIOLOGY CENTER, RIKEN. — AFTER COMMERCIALIZATION OF YBCO TAPES, A LARGE NUMBER OF TYPES OF YBCO COILS HAVE BEEN DEVELOPED. HOWEVER, THEIR BASIC PERFORMANCES HAVE NOT BEEN SYSTEMATICALLY INVESTIGATED SO FAR. THEY ARE DEMONSTRATED HERE FOR A YBCO DOUBLE PANCAKE. A YBCO DOUBLE PANCAKE WAS DRY WOUND WITH A COMMERCIAL YBCO TAPE AROUND A FIBER REINFORCED PLASTIC COIL FORM, WHICH ALLOWED A SHORT SAMPLE CRITICAL CURRENT OF 52A AT 77K. IT WAS THEN IMPREGNATED WITH EPOXY RESIN AND CHARGED AT 77K; THE NORMAL TRANSITION CURRENT WAS DRAMATICALLY DEGRADED TO 14A. OBSERVATION OF THE TOP SURFACE OF THE DOUBLE-PANCAKE BY A METALLURGICAL MICROSCOPE REVEALED SEVERAL LONG CRACKS ALONG THE EDGE OF THE YBCO TAPE, DUE TO FRACTURE AT THE BOUNDARY BETWEEN BUFFER LAYERS AND THE YBCO. BASED ON A STRUCTURAL CALCULATION, THE RADIAL STRESS DUE TO COOL DOWN HAS A TENSILE PEAK OF +7MPA; THIS IS CLOSE TO THE DELAMINATION STRENGTH OF YBCO TAPES UNDER TRANSVERSE TENSILE STRESS, +10~20 MPA. THUS IT IS DEMONSTRATED THAT IF A YBCO COIL IS EPOXY IMPREGNATED, EXCESSIVE RADIAL STRESS DELAMINATES THE YBCO TAPE, DEGRADING THE YBCO COIL PERFORMANCE; THE SAME SCENARIO MAY BE APPLIED TO THE ELECTRO-MAGNETIC FORCE. FOR A DRY WOUND COIL, THE TURNS ARE SEPARATED IF THE CUMULATIVE TENSILE RADIAL STRESS TENDS TO APPEAR, AND THEREFORE NO DEGRADATION IS OBSERVED. FURTHER INVESTIGATION IS BEING MADE ON THE EFFECT OF WINDING TENSION AND THE USE OF A LOW-THERMAL CONTRACTION WINDING FORM.

THIS WORK IS SUPPORTED BY S-INNOVATION, JST IN JAPAN.

4LA-02

ELECTRICAL AC LOSS MEASURMENTS ON A 2G YBCO COIL ***C. REY****, R. DUCKWORTH, W. SCHWENTERLY;* OAK RIDGE NATIONAL LABORATORY. — THE OAK RIDGE NATIONAL LABORATORY (ORNL) IS COLLABORATING WITH WAUKESHA ELECTRIC SYSTEMS (WES) TO CONTINUE DEVELOPMENT OF HTS POWER TRANSFORMERS. SECOND-GENERATION YBCO COATED CONDUCTORS WILL BE REQUIRED FOR AN ECONOMICALLY-COMPETITIVE DESIGN. IN ORDER TO ADEQUATELY SIZE THE REFRIGERATION SYSTEM FOR THESE TRANSFORMERS, THE AC LOSS OF THESE HTS COILS MUST BE CHARACTERIZED. ELECTRICAL AC LOSS MEASUREMENTS WERE CONDUCTED ON A PROTOTYPE HIGH VOLTAGE (HV) COIL WITH CO-WOUND STAINLESS STEEL AT 60 HZ IN A LIQUID NITROGEN BATH USING A LOCK-IN AMPLIFIER TECHNIQUE. THE PROTOTYPE HV COIL CONSISTED OF 26 CONTINUOUS (WITHOUT SPLICE) SINGLE PANCAKE COILS CONCENTRICALLY CENTERED ON A STAINLESS STEEL FORMER. FOR AC LOSS MEASUREMENT PURPOSES, VOLTAGE TAP PAIRS WERE SOLDERED ACROSS EACH SET OF TWO SINGLE PANCAKE COILS SO THAT A TOTAL OF 13 SEPARATE VOLTAGE MEASUREMENTS COULD BE MADE ACROSS THE ENTIRE LENGTH OF THE COIL. AC LOSS MEASUREMENTS WERE TAKEN AS A FUNCTION OF AC EXCITATION CURRENT. RESULTS SHOW THAT THE LOSS IS PRIMARILY CONCENTRATED AT THE ENDS OF THE COIL WHERE THE OPERATING FRACTION OF CRITICAL CURRENT IS THE HIGHEST AND SHOW A DISTINCT DIFFERENCE IN CURRENT SCALING OF THE LOSSES BETWEEN LOW CURRENT AND HIGH CURRENT REGIMES.

RESEARCH SPONSORED BY THE U.S. DEPARTMENT OF ENERGY - OFFICE OF ELECTRICITY DELIVERY AND ENERGY RELIABILITY, ADVANCED CABLES AND CONDUCTORS PROGRAM UNDER CONTRACT DE-AC05-00OR22725 WITH OAK RIDGE NATIONAL LABORATORY, MANAGED AND OPERATED BY UT-BATTEL

4LA-03**COUPLING AC LOSS OF YBCO PANCAKE COILS** ***V. A. GRINENKO***[1]*, K. NENKOV*[1]*, C. STIEHLER*[1]*, M. VOJENCIAK*[2]*, G. FUCHS*[1]*, B. HOLZAPFEL*[1]*;* [1]LEIBNIZ INSTITUTE FOR SOLID STATE AND MATERIALS RESEARCH DRESDEN, [2]INSTITUTE OF ELECTRICAL ENGINEERING, CENTRE OF EXCELLENCE CENG, BRATISLAVA. — IN SOME AC APPLICATIONS IT IS NECESSARY TO HAVE SUPERCONDUCTING COILS WITH HIGH CRITICAL CURRENTS AND A LOW NUMBER OF TURNS. THIS COULD BE REALIZED BY WINDING A COIL FROM A CABLE CONSISTING OF SEVERAL SUPERCONDUCTING TAPES CONNECTED IN PARALLEL. THIS COIL CONFIGURATION LOOKS VERY UNFAVORABLE WITH RESPECT TO AC LOSSES FOR SEVERAL REASONS. THE FIRST ONE IS THE NON-UNIFORM CURRENT

DISTRIBUTION IN UNTWISTED TAPES CONNECTED IN PARALLEL WHICH CAN LEAD TO HIGHER AC LOSSES. THE SECOND ONE IS THAT COUPLING LOSSES DUE TO COUPLING CURRENTS ARE EXPECTED TO ARISE IN AC MAGNETIC FIELD WHEN PARALLEL SUPERCONDUCTORS ARE SEPARATED BY A FINITE RESISTANCE. WE INVESTIGATED BOTH AC TRANSPORT CURRENT AND MAGNETIZATION LOSSES IN EXTERNAL AC MAGNETIC FIELD FOR YBCO PANCAKE COILS WITH DIFFERENT NUMBER OF TURNS (N = 4 - 40) WOUND FROM N PARALLEL TAPES (N = 1-4). IT IS SHOWN EXPERIMENTALLY AND THEORETICALLY THAT BY OPTIMIZING THE RESISTANCE BETWEEN THE PARALLEL TAPES THE AC LOSSES CAN BE SIGNIFICANTLY REDUCED. IN SOME CASES, THE AC LOSSES IN COILS WITH N PARALLEL TAPES AND N TURNS ARE COMPARABLE WITH THOSE IN COILS WITH N*N TURNS WOUND FROM ONE TAPE.

THE PART OF THE HTS COILS USED IN THESE EXPERIMENTS WAS PROVIDED BY OSWALD ELEKTROMOTOREN. THE AUTHORS ARE GRATEFUL FOR SUPPLYING THE COILS. THIS WORK WAS SUPPORTED BY THE MARIE CURIE RESEARCH TRAINING NETWORK (RTN) NESPA, MRTN-CT-2006-035619.

4LA-04

QUENCH INITIATION IN YBCO LAYER-WOUND COILS USING AC CURRENT OR AC MAGNETIC FIELD ***M. DALBAN-CANASSY***[1], *U. P. TROCIEWITZ*[1], *Y. VIOUCHKOV*[2], *S. V. P. S. PAMIDI*[3]; [1]ASC-NHMFL, [2]NHMFL, [3]CAPS-FSU. — A LAYER WOUND YBCO COIL HAS BEEN BUILT AND SETUP TO INVESTIGATE ON THE FEASIBILITY OF INDUCING A CONTROLLED QUENCH BY GENERATING AC LOSSES IN THE CONDUCTOR. TWO METHODS ARE USED: SUPERIMPOSING AN AC CURRENT ONTO THE DC TRANSPORT CURRENT CIRCULATING IN THE COIL, AND EXPOSING THE COIL TO AN AC FIELD GENERATED BY AN EXTERNAL HELICAL MAGNET. IN THE HELICAL MAGNET SETUP, THE SETUP CAN BE POSITIONED SO THAT THE FIELD GENERATED IS EITHER PARALLEL OR PERPENDICULAR TO THE AXIAL DIRECTION OF THE COIL. IN THE PARALLEL CONFIGURATION, THE TRANSITION IS TRIGGERED IN THE WHOLE COIL AT ONCE, AS OPPOSED TO A LOCAL TRANSITION EVERY HALF TURN IN THE PERPENDICULAR DIRECTION. MINIMUM QUENCH ENERGIES FOR THE TWO CONFIGURATIONS AS WELL AS THE CORRESPONDING FREQUENCIES OF EXCITATION ARE REPORTED AND DISCUSSED.

4LA-05

EVALUATION OF THE NORMAL-ZONE PROPAGATION CHARACTERISTICS OF REBCO COATED CONDUCTOR WITH LAMINATED CU TAPE ***M. DAIBO****, S. FUJITA, M. HARAGUCHI, Y. IIJIMA, T. SAITOH;* FUJIKURA LTD.. — THE HIGH PERFORMANCE REBCO COATED CONDUCTORS SUCH AS OVER A FEW HUNDREDS AMPERE PER CM AT 77K HAVE BEEN DEVELOPED FOR THE SUPERCONDUCTING APPLICATIONS IN THE LAST FEW YEARS. THE QUENCH CHARACTERISTICS, SUCH AS THE NORMAL-ZONE PROPAGATION AND THE HOT-SPOT TEMPERATURE RAISING, OF REBCO COATED CONDUCTORS ARE THE IMPORTANT ISSUES FOR SAFETY OPERATING OF THE SUPERCONDUCTING APPLICATIONS. THE SEVERAL EXPERIMENTAL RESULTS OF THE QUENCH CHARACTERISTICS OF REBCO COATED CONDUCTORS HAVE BEEN REPORTED. BUT THERE IS INSUFFICIENT THE EXPERIMENTAL RESULTS OF QUENCH CHARACTERISTICS OF REBCO COATED CONDUCTOR WITH LAMINATED CU TAPE OF OVER 0.1MM THICKNESS WHICH EXPECT TO BE APPLIED TO THE SUPERCONDUCTING APPLICATIONS FOR OPERATING HIGH AMPERE IN THE FUTURE. IN THIS WORK WE PRESENTED THE EXPERIMENTAL RESULTS OF THE NORMAL-ZONE PROPAGATION CHARACTERISTICS AND THE THERMAL BEHAVIOR OF REBCO COATED CONDUCTOR WITH LAMINATED CU TAPE ,WHICH TAPE IS COOLED BY MEANS OF CRYOCOOLER AND KEPT UNDER VACUUM AT BELOW 77K . WE ALSO INVESTIGATED THE INFLUENCE OF THE STABILIZER CU TAPE THICKNESS OF REBCO COATED CONDUCTOR.

4LA-06

QUENCH CHARACTERISTICS OF 2212 SOLENOID INSERT COILS IN BACKGROUND FIELDS UP TO 20 TESLA ***Y. YANG***[1]*, E. A. YOUNG*[1]*, I. FALORIO*[1]*, W. O. S. BAILEY*[1]*, J. SIMKIN*[2]*, S. P. G. CHAPPELL*[3]*;* [1]UNIVERSITY OF SOUTHAMPTON, [2]VECTOR FIELDS, COBHAM TECHNICAL SERVICES, [3]OXFORD INSTRUMENTS. — WHILE BI-2212 HIGH FIELD INSERT COILS HAVE BEEN DEMONSTRATED TO BE A PROMISING TECHNOLOGY, THEIR CRYOGENIC STABILITY AND QUENCH PROPAGATION ARE YET TO BE FULLY UNDERSTOOD. THE PRESENT WORK SHOWS DATA FROM SYSTEMATIC QUENCH MEASUREMENTS AT 4.2K ON TWO 6-LAYER 300MM HIGH BI-2212 SOLENOID COILS AT DIFFERENT CURRENTS I BETWEEN 50% AND 95% OF IC IN BACKGROUND FIELDS UP TO 20T. THE QUENCH WAS INDUCED BY LOCALISED HEAT PULSES (20-100MS) AND RECORDED WITH TEMPORAL-SPATIAL RESOLVED VOLTAGE TAPS AND THERMOMETERS. BY PRECISE CONTROL OF THE POWER DELIVERED IN THE HEAT PULSE, THE MINIMUM QUENCH ENERGY MQE AND THE TIME CONSTANT FOR THE QUASI-STATIONARY MINIMUM PROPAGATION ZONE MPZ WAS OBTAINED FOR EACH TEST CONDITION. MQE WAS FOUND TO FOLLOW A SCALING LAW OF IC^2/I^4. THE MPZ WAS SHOWN TO BE CONFINED WITHIN THE SAME LAYER WHERE THE QUENCH STARTED. THE PROPAGATION WAS ALSO PREDOMINANTLY ALONG THE WINDING LAYER WITH A RELATIVELY SLOW VELOCITY LESS THAN 50CM/S. THE CORRESPONDING RADIAL PROPAGATION VELOCITY OF ABOUT 5MM/S. THE INTERPLAY BETWEEN THE HTS COILS AND WITH THE LTS MAGNETS WERE ALSO STUDIED TO AID THE DESIGN OF 20T+ HIGH FIELD MAGNETS WITH INTEGRATED LTS AND HTS COILS. THE RESULTS WERE ANALYSED IN THE CONTEXT OF A WIDE CURRENT TEMPERATURE RANGE FOR CURRENT SHARING IN THE BI-2212 WIRE AND THE T^3 DEPENDENCE OF C_p AT LOW TEMPERATURES. THE QUENCH DATA IS ALSO CONSISTENTLY WITH MODELLING RESULTS USING QUENCH MODULE OF OPERA.

THIS COLLABORATIVE PROJECT AMONG OXFORD INSTRUMENTS, COBHAM TECHNICAL SERVICES AND UNIVERSITY OF SOUTHAMPTON AND SUPPORTED IN PART BY THE TECHNOLOGY STRATEGIC BOARD.

4LA-07

EXPERIMENTAL STUDY OF MAGNETIC EFFECTS ON THE STABILITY MARGIN OF WIND-AND-REACT $BI_2SR_2CACU_2O_X$ COILS ***L. YE***[1]*, F. HUNTE*[1]*, J. SCHWARTZ*[1]*, D. ARBELAEZ*[2]*, S. PRESTEMON*[2]*;* [1]DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING, NORTH CAROLINA STATE UNIVERSITY, RALEIGH, NC 27695, USA, [2]LAWRENCE BERKELEY NATIONAL LABORATORY, BERKELEY, CA 94720, USA. — AS PART OF THE VHFSMC EFFORT AIMED AT THE DEVELOPMENT OF HIGH FIELD SUPERCONDUCTING MAGNET TECHNOLOGIES FOR HIGH ENERGY PHYSICS, THE QUENCH BEHAVIOR OF $BI_2SR_2CACU_2O_X$ (BI2212) COILS IS INVESTIGATED IN A MAGNETIC FIELD UP TO 8 T. IN PARTICULAR, THIS STUDY FOCUSES ON THE FIELD-DEPENDENCE OF THE MINIMUM QUENCH ENERGY AND NORMAL ZONE PROPAGATION VELOCITIES. SINGLE-LAYER COILS ARE CONSTRUCTED FROM BI2212 STRAND AND FITTED WITH AN ARRAY OF THERMOCOUPLES AND VOLTAGE TAPS LOCATED RELATIVE TO A HEATER ATTACHED TO THE COIL. PRELIMINARY RESULTS SHOW THAT A THERMALLY INDUCED QUENCH IS MORE LIKELY TO OCCUR WHEN A VOLTAGE PULSE IS DELIVERED TO THE HEATER IN THE PRESENCE OF A MAGNETIC FIELD. THE TRANSPORT CURRENT IN THE COIL, AND THUS JOULE HEATING, HOWEVER, ACT AS THE PRIMARY DRIVERS FOR IN-FIELD QUENCH PROPAGATION. THESE RESULTS LAY THE GROUNDWORK FOR A COMPREHENSIVE STUDY OF QUENCH GENERATION, PROPAGATION AND DETECTION FOR PROTECTION OF HIGH FIELD MAGNET SYSTEMS.

THIS WORK SUPPORTED BY THE US DEPARTMENT OF ENERGY AS PART OF THE VERY HIGH FIELD SUPERCONDUCTING MAGNET COLLABORATION.

4LA-08

OBSERVATION OF IMPOSTER FLUX PUMPING ***R. WEINSTEIN***[1]*, D. PARKS*[2]*, R. SAWH*[2]*, K. DAVEY, IEEE FELLOW*[3]*;* [1]BEAM PARTICLE DYNAMICS LAB, PHYSICS DEPT. AND TEXAS CENTER FOR SUPERCONDUCTIVITY, UNIVERSITY OF HOUSTON, 632 SCIENCE RESEARCH BLDG. 1, HOUSTON TX 77204-5005, USA, WEINSTEIN@UH.EDU, [2]BEAM PARTICLE DYNAMICS LAB, PHYSICS DEPT. AND TEXAS CENTER FOR SUPERCONDUCTIVITY, UNIVERSITY OF HOUSTON, 632 SCIENCE RESEARCH BLDG. 1, HOUSTON TX 77204-5005, USA, [3]INDEPENDENT CONSULTANT, 1844 OLD MISSION RD., EDGEWATER, FL, USA, KDAVEY@IEEE.ORG. — A FLUX PUMPING EXPERIMENT REPORTING PARTIAL ACTIVATION OF BULK YBCO [1,2] WAS REPRODUCED IN A MODIFIED GEOMETRY. RESULTS APPEAR VERY SIMILAR TO THE EARLIER WORK. SIGNIFICANT B FIELD APPEARED AT INTERNAL HTS REGIONS (E.G., AT R = 0) WHERE B HAD BEEN ZERO. HOWEVER, WHEN THE PUMPING SIGNAL WAS REMOVED, AND PERMANENT MAGNETS WERE USED TO MAINTAIN THE DC FIELD WHILE ELIMINATING ANY NOISE WHICH MIGHT ACT AS A PUMPING SIGNAL, THE SAME RESULTS WERE OBSERVED. THE FIELD INCREASE AT R = RMAX/2 EXHIBITED THE TIME DEPENDENCE OF ORDINARY CREEP. THE MEASURED FIELD DISTRIBUTION, B(R), IS CONSISTENT WITH INWARD CREEP. (AN APPLIED FIELD, AFTER ZFC, RESULTS IN TRAPPED FIELD AT LARGE R. FLUXOIDS THEN CREEP INWARD TOWARD R = RMAX/2 AND R = 0.) THE INTERNAL FIELDS NEVER EXCEED THE APPLIED FIELD. THESE RESULTS SHOULD BE INTERPRETED AS A NOVEL EXAMPLE OF CREEP, RATHER THAN FLUX PUMPING. THESE RESULTS MAY APPLY TO REFS. [1,2].[1] T.A. COOMBS, Z. HONG, Z.X. ZHU, AND G. KRABBES, "A NOVEL HEAT ENGINE FOR MAGNETIZING SUPERCONDUCTORS," SUPERCOND. SCI. TECHNOL., 21 (2008) 034001.[2] YU YAN, QUAN LI, AND T.A. COOMBS, "THERMALLY ACTIVATED MAGNETIZATION FLUX PUMP IN SINGLE GRAIN YBCO BULK," SUPERCOND. SCI. TECHNOL., 22 (2009) 105011.

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4LB-01

(INVITED) **HTS FAULT CURRENT LIMITERS -FIRST COMMERCIAL DEVICES FOR DISTRIBUTION LEVEL GRIDS IN EUROPE** ***J. BOCK***[1]*, S. KRAMER*[1]*, M. BLUDAU*[1]*, S. ELSCHNER*[2]*;* [1]NEXANS SUPERCONDUCTORS, [2]UNIVERSITY OF APPLIED SCIENCE. — NEXANS SUPERCONDUCTORS GMBH (NSC) HAS SUCCESSFULLY DESIGNED, BUILT AND TESTED THE FIRST TWO HTS FAULT CURRENT LIMITER (FCL) SYSTEMS ON A COMMERCIAL BASIS FOR TWO DIFFERENT APPLICATION CASES IN EUROPE. BOTH SYSTEMS ARE LIVE IN THE CUSTOMER GRIDS SINCE LAST QUARTER OF 2009, ONE OF THEM IS PROTECTING THE HOUSE LOAD OF A BROWN COAL POWER STATION - THE FIRST HTS DEVICE OPERATING IN A POWER STATION WORLD WIDE. THE SUPERCONDUCTING COMPONENTS OF BOTH LIMITERS ARE DESIGNED AND PRODUCED BY NEXANS AND ARE BASED ON BULK MCP BSCCO-2212. NSC IS ABLE TO COVER THE FULL CHAIN OF THE NEW SYSTEMS STARTING FROM RAW MATERIAL POWDER, VIA HTS TUBES, FCL COMPONENTS AND MODULES TO THE COMPLETE SYSTEM AND HAS ALSO INTEGRATED THE AUXILIARY EQUIPMENT FOR COOLING.BEFORE FIELD INSTALLATION BOTH SYSTEMS WERE INTENSIVELY TESTED UNDER DIFFERENT HIGH-VOLTAGE AND HIGH-POWER CONDITIONS AT THE INDEPENDENT AND CERTIFIED TEST LAB IPH IN BERLIN. THE PRESENTATION WILL DESCRIBE THE FULL PROCESS FROM DESIGN TO COMMISSIONING AND FIRST EXPERIENCES FROM FIELD OPERATION. MOREOVER, NSC IS INVOLVED IN FURTHER PROJECTS OF WHICH FIRST RESULTS OF THE PLANNING AND DESIGN PHASE WILL BE REPORTED.

4LB-02

PERFORMANCE OF 2G HTS TAPES IN SUB-COOLED LN_2 FOR SUPERCONDUCTING FAULT CURRENT LIMITER APPLICATIONS ***J. LLAMBES***[1]*, D. HAZELTON*[1]*, V. SELVAMANICKAM*[2]*;* [1]SUPERPOWER-INC, [2]UNIVERSITY OF HOUSTON. — WITHIN THE PAST FEW YEARS A NEWER, MORE ROBUST TYPE OF SUPERCONDUCTOR KNOWN AS SECOND-GENERATION HIGH TEMPERATURE SUPERCONDUCTOR (2G HTS) WIRE, HAS BECOME AVAILABLE IN SUFFICIENT QUANTITY AND LENGTHS FOR DEVELOPERS TO BUILD PROTOTYPE DEVICES AND TEST THEIR CAPABILITIES. THIS NEW MATERIAL OFFERS THE POTENTIAL FOR REVOLUTIONARY CHANGES IN SUPERCONDUCTING TRANSFORMERS AND SUPERCONDUCTING FAULT CURRENT LIMITERS TO ENABLE

BETTER THERMAL STABILITY AND FAST QUENCHING CAPABILITIES THAT CAN MEET THE STRINGENT DEMANDS OF LARGE TRANSIENT FAULTS FOR DISTRIBUTION AND TRANSMISSION POWER LINES. THIS NEW MATERIAL HAS RE-INVIGORATED THE WORLDWIDE RACE TO DEVELOP A SUCCESSFUL SFCL DEVICE THAT WILL MEET THE STRINGENT DEMANDS OF THE ELECTRIC UTILITY APPLICATION.THIS MANUSCRIPT WILL DISCUSS THE LATEST TESTS AND CAPABILITIES OF SUB-COOLED SFCL MODULES DESIGNED FOR DISTRIBUTION AND TRANSMISSION LINES. WE WILL ALSO DISCUSS THE ADVANTAGES AND SUPERIOR PERFORMANCE OF THE NEW 2G HTS MATERIALS UNDER SUB-COOLED LIQUID NITROGEN OPERATION WHEN USED IN SUPERCONDUCTING FAULT CURRENT LIMITERS.

THIS WORK IS SUPPORTED IN PART BY THE US DEPARTMENT OF ENERGY (DOE) AND THE ELECTRIC POWER RESEARCH INSTITUTE (EPRI).

4LB-03

ENSYSTROB -RESISTIVE FAULT CURRENT LIMITER BASED ON COATED CONDUCTORS FOR MEDIUM VOLTAGE APPLICATIONS *A. KUDYMOW[1], **S. ELSCHNER**[2], S. FINK[1], W. GOLDACKER[1], F. GRILLI[1], C. SCHACHERER[1], M. NOE[1], A. HOBL[3], J. BOCK[3];* [1]KARLSRUHE INSTITUTE OF TECHNOLOGY, INSTITUTE FOR TECHNICAL PHYSICS, [2]UNIVERSITY OF APPLIED SCIENCE, MANNHEIM, [3]NEXANS SUPERCONDUCTORS GMBH. — A NEW GERMAN GOVERNMENT FUNDED PROJECT FOR A RESISTIVE FAULT CURRENT LIMITER HAS STARTED IN SEPTEMBER 2009 (ENSYSTROB) WITH PARTNERS FROM INDUSTRY, RESEARCH CENTRES AND UTILITIES. IT AIMS AT THE CONSTRUCTION OF A MEDIUM VOLTAGE CURRENT LIMITER (12 KV, 800 A) FOR THE PROTECTION OF THE AUXILIARY SUPPLY IN A POWER PLANT. SPECIAL FEATURES OF THIS APPLICATION ARE LARGE IN-RUSH CURRENTS (4100 A FOR 50MS, 1800 A FOR 15 S). WE REPORT ON DESIGN AND CHARACTERISTICS OF A FCL COMPONENT ON BASIS OF COATED CONDUCTORS (CC). A CAREFUL ELECTRICAL CHARACTERISATION OF SEVERAL COMMERCIALLY AVAILABLE CONDUCTORS AND A DETAILED DISCUSSION OF THE NEEDED NORMAL CONDUCTING PROTECTION IS PRESENTED. THE SUPERCONDUCTING COMPONENTS ARE BIFILAR PANCAKE COILS CONSISTING OF PAIRS OF CC IN FACE TO BACK CONFIGURATION. SUCCESSFUL LIMITATION EXPERIMENTS ON FIRST COMPONENTS WITH PROSPECTIVE CURRENTS IN THE WHOLE RANGE ARE SHOWN. ALSO THE STABILITY WITH RESPECT TO HIGH VOLTAGE COULD BE DEMONSTRATED. THE AC-LOSSES UNDER NORMAL OPERATION WERE EVALUATED BY SIMULATION AND EXPERIMENT AND ARE SMALLER THAN THE HEAT INPUT OF THE CURRENT LEADS. A COMPARISON OF THE CC BASED MODULE WITH A COMPONENT FROM BSCCO 2212 BULK MATERIAL (NEXANS SUPERCONDUCTORS) WILL BE PRESENTED.

THE PROJECT IS FUNDED BY THE GERMAN MINISTRY FOR ECONOMICS AND TECHNOLOGY (BMWI) UNDER GRANT NO 03KP102B

4LB-04

HEAT PROPAGATION VELOCITIES IN COATED CONDUCTORS FOR FAULT CURRENT LIMITER APPLICATIONS. *L. **ANTOGNAZZA**[1], M. DECROUX[1], M. THERASSE[1], M. ABPLANALP[2];* [1]UNIVERSITY OF GENEVA, DPMC, [2]ABB CORPORATE RESEARCH CENTRE IN SWITZERLAND. — THE DEVELOPMENT OF SUPERCONDUCTING FAULT CURRENT LIMITERS (SFCL) ARE MAINLY BASED ON COATED CONDUCTORS (CC) IN SPITE OF THE LOW ELECTRIC FIELDS THE CC CAN SUSTAIN DUE TO THEIR POOR THERMAL BEHAVIOUR AND THE VERY LOW PROPAGATION VELOCITIES OF THE NORMAL ZONE. NOWADAYS THE SFCL DEMONSTRATORS ARE MADE OF COIL BUT ANOTHER WAY OF BUILDING THEM IS TO USE PLATES WITH A MEANDERED LINE. THIS SHOULD IMPROVE THE SPREADING OF THE HEAT AND ALSO REDUCE THE RECOVERY TIME. ANOTHER ADVANTAGE OF THE MEANDERED LINE ON A PLATE IS THE LATERAL PROPAGATION OF THE HEAT. INDEED IN A MEANDER THE HEAT GENERATED BY A LOCAL DISSIPATIVE ZONE DIFFUSES ALSO LATERALLY AND SWITCHES THE ADJACENT LINES, INCREASING THE APPARENT PROPAGATION VELOCITY OF THE NORMAL ZONE. THERE IS ALSO A POSSIBILITY TO INCREASE THE LATERAL PROPAGATION VELOCITY OF THE HEAT BY ADDING ONTO THE HASTELLOY SUBSTRATE A THERMAL SHORT CIRCUIT (AN AG FILM FOR INSTANCE) BETWEEN THE LINES WITHOUT AN ELECTRICAL SHORT CIRCUIT. THESE TEST STRUCTURES WERE DEVELOPED ON CC ALLOWING TO SIMULTANEOUSLY MEASURE THE PROPAGATION OF A HEAT FRONT IN THE SUBSTRATE AND IN THE HASTELLOY/AG BILAYER. THEY ARE MADE OF A HEATER LINE AND SEVERAL PARALLEL SUPERCONDUCTING STRIPS WHERE THE PROPAGATION OF THE T_C TEMPERATURE FRONT IS RECORDED. WE WILL DISCUSS THE BENEFIT OF THIS APPROACH AS COMPARED TO THE STANDARD COIL GEOMETRY.

4LB-05

S/N TRANSITION PROCESS OF YBCO THIN FILM CONSIDERED FROM 2 DIMENSIONAL VOLTAGE DISTRIBUTION MEASUREMENT *M. **MORI**[1], H. NISHIOKA[1], J. BABA[1], T. NITTA[2], T. KUMAGAI[3], M. SHIBUYA[4];* [1]THE UNIVERSITY OF TOKYO, [2]MEISEI UNIVERSITY, [3]NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL (AIST), [4]KANTO GAKUIN UNIVERSITY. — THE PROCESS OF RESISTANCE GENERATION IN A YBCO THIN FILM USED IN RESISTIVE TYPE FAULT CURRENT LIMITERS (SFCLS) HAS NOT BEEN CLARIFIED COMPLETELY. IT IS GENERALLY CONSIDERED THAT THE NORMAL CONDUCTING STATE AREA EXPANDS FROM THE CENTER OF A POINT WHERE S/N TRANSITION OCCURS FIRST. DURING THIS PROCESS, A THIN FILM MAY BE BURNED OUT BY OVERHEAT. UNDERSTANDING THE PROCESS OF RESISTANCE GENERATION WOULD LEAD TO PREVENT THIN FILMS FROM THIS BURNOUT.IN THIS PAPER, THE VOLTAGE DISTRIBUTION OF A YBCO THIN FILM IS MEASURED BY PROBES ARRANGED 2 DIMENSIONALLY ON A THIN FILM TO UNDERSTAND HOW TO EXPAND THE NORMAL TRANSITION AREA ON YBCO THIN FILMS. THE PROBES ARE PLACED IN A MATRIX OF 3 TIMES 10 ON A 30-BY-210 MILLIMETER YBCO THIN FILM, THEN A SINUSOIDAL WAVE CURRENT WHOSE AMPLITUDE IS SEVERAL HUNDREDS AMPERE FLOWS INTO THE THIN FILM CONNECTED

WITH A PARALLEL RESISTANCE.IT IS OBSERVED FROM THESE MEASUREMENTS THAT A NARROW NORMAL CONDUCTING STATE BAND VERTICAL TO THE CURRENT APPEARS FIRST, AND THE BAND EXPANDS ALONG THE CURRENT. THE CRITICAL CURRENT OF THIS BAND IS THE LOWEST ALONG THE THIN FILM. THIS BAND IS CONSIDERED TO HAVE A GREAT INFLUENECE ON RESISTANCE GENERATION OF THE YBCO THIN FILM.

4LB-06

TRANSIENT HEAT TRANSFER OCCURRING IN COATED CONDUCTORS UNDER SHORT CURRENT PULSES ***D. COLANGELO***[1]*, F. ROY*[1]*, F. GRILLI*[2]*, F. SIROIS*[3]*, B. DUTOIT*[1]*;* [1]ECOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE, SWITZERLAND, [2]INSTITUTE FOR TECHNICAL PHYSICS (ITP), FORSCHUNGSZENTRUM KARLSRUHE GMBH, KARLSRUHE, GERMANY, [3]ECOLE POLYTECHNIQUE DE MONTR´EAL, PO BOX 6079 STATION CENTRE-VILLE, MONTR´EAL, QC, H3C 3A7, CANADA. — SECOND-GENERATION HIGH TEMPERATURE SUPERCONDUCTOR (HTS) TAPES ARE GOOD CANDIDATES FOR FAULT CURRENT LIMITER (FCL) APPLICATIONS DUE TO THE HIGH RESISTIVITY OF THEIR SUBSTRATE. THEIR VERY HIGH CURRENT DENSITIES, HOWEVER, EXPOSE THEM TO THE RISK OF THERMAL RUNAWAY, SO THAT MOST OF THE PROPOSED COATED CONDUCTORS (CC) FOR FCLS USE A THIN SILVER LAYER AS STABILIZER.THE HEAT TRANSFER TO THE COOLING MEDIA AS WELL AS THE DURATION AND AMPLITUDE OF HEAT INPUTS ARE IMPORTANT ASPECTS OF THE PROBLEM. MORE SPECIFICALLY, THE QUESTION OF HOW LONG AND IN WHICH COOLING CONDITIONS THE STABILIZER CAN WITHSTAND A HIGH ENERGY INPUT WITHOUT DAMAGING THE TAPE IS OF INTEREST.IN ORDER TO ANSWER THIS QUESTION, WE USED SILVER WIRE OF SMALL CROSS-SECTION TO MEASURE THE TIME NEEDED FOR SPECIFIC ENERGY INPUTS TO REACH THE FILM BOILING REGION IN LIQUID NITROGEN. THE MEASUREMENTS WERE DONE AT ATMOSPHERIC PRESSURE FOR DIFFERENT BATH TEMPERATURE (FROM 77 K DOWN TO 70 K) AND FOR DIFFERENT AMPLITUDE AND DURATION CURRENT PULSES.THE RESULTS GIVE US EXPERIMENTAL DATA THAT CAN BE DIRECTLY IMPLEMENTED IN NUMERICAL CODES IN ORDER TO MODEL SFCLS IN DIFFERENT OPERATING MODES.THE RESEARCH LEADING TO THESE RESULTS HAS RECEIVED FUNDING FROM THE EUROPEAN UNION SEVENTH FRAMEWORK PROGRAMME (FP7/2007 - 2013) UNDER GRANT AGREEMENT NO. 241285

4LB-07

TEST MODEL PRODUCTION OF SUPERCONDUCTING FAULT CURRENT LIMITER FOR POWER SYSTEM WITH ELECTROMAGNETIC REPULSION SWITCH ADAPTED TO HIGH SPEED RE-CLOSING ***Y. SATO***[1]*, H. ANJI*[1]*, H. OKUMO*[2]*, N. TAKAO*[2]*, S. YANABU*[1]*;* [1]TOKYO DENKI UNIVERSITY, [2]TOKYO ELECTRIC POWER COMPANY. — FAULT CURRENT LIMITERS ARE DEVICES THAT CONTROL THE FAULT CURRENT GENERATED IN THE POWER SYSTEM. THE SUPERCONDUCTOR BECOMES THE SUPERCONDUCTING STATE BY MEETING THE REQUIREMENT OF A CRITICAL CURRENT, A CRITICAL TEMPERATURE, AND A CRITICAL FLUX, AND CURRENT CAN BE PASSED IN THE SUPERCONDUCTORS WITH NO RESISTANCE. HOWEVER, THE SUPERCONDUCTOR METASTASIZES TO THE NORMAL CONDUCTING STATE, AND GENERATES RESISTANCE BY THE CURRENT THAT EXCEEDS THE CRITICAL CURRENT SUCH AS THE FAULT CURRENTS. WE ARE RESEARCHING THE FAULT CURRENT LIMITER THAT ADDS THE ELECTROMAGNETIC REPULSION SWITCH TO S/N TRANSITION TYPE SUPERCONDUCTING FAULT CURRENT LIMITER USING THIS PHENOMENON. THIS ELECTROMAGNETIC REPULSION SWITCH IS A STRUCTURE TO BE COMPOSED BY THE VACUUM INTERRUPTER AND THE REACTOR, AND TO SHORTEN THE TIME THAT AN EXCESSIVE CURRENT FLOWS TO THE SUPERCONDUCTOR. AS A RESULT, IT IS POSSIBLE TO MAKE THE FAULT CURRENT LIMITER AT A LOW PRICE AND SMALL SIZE, THROUGH THE REDUCTION OF THE QUANTITY OF EXPENSIVE CONSUMED SUPERCONDUCTORS. THE FAULT CURRENT LIMITER HAS MANY OTHER ADVANTAGES, WHICH ARE DESCRIBED TO THE FOLLOW. LARGE CAPACITY TEST MODEL WAS PRODUCED, AND REPORT IT.

4LC-01

(INVITED) **PROGRESS AND STATUS OF A 2G HTS POWER CABLE IN LONG ISLAND POWER AUTHORITY (LIPA) GRID** ***J. MAGUIRE***[1]*, J. YUAN*[1]*, W. ROMANOSKY*[1]*, F. SCHMIDT*[2]*, R. SOIKA*[2]*, S. BRATT*[3]*, C. KING*[1]*, J. MCNAMARA*[1]*, T. WELSH*[4]*;* [1]AMERICAN SUPERCONDUCTOR CO., [2]NEXANS DEUTSCHLAND GMBH, [3]AIR LIQUIDE, [4]LONG ISLAND POWER AUTHORITY. — UNDERGROUND HIGH TEMPERATURE SUPERCONDUCTOR (HTS) POWER CABLES HAVE ATTRACTED EXTENSIVE INTEREST IN RECENT YEARS DUE TO THEIR POTENTIAL FOR HIGH POWER DENSITY. WITH FUNDING SUPPORT FROM THE UNITED STATES DEPARTMENT OF ENERGY, THE WORLD'S FIRST TRANSMISSION VOLTAGE LEVEL HTS POWER CABLE HAS BEEN DESIGNED, FABRICATED AND PERMANENTLY INSTALLED IN LONG ISLAND POWER AUTHORITY (LIPA) GRID. THE HTS CABLE WAS SUCCESSFULLY COMMISSIONED ON APRIL 22, 2008. IN 2007, A NEW DOE SUPERCONDUCTOR POWER EQUIPMENT (SPE) PROGRAM TO ADDRESS THE OUTSTANDING ISSUES FOR INTEGRATING HTS CABLES INTO THE UTILITY GRID WAS AWARDED TO THE CURRENT PROJECT TEAM (LIPA II). THE GOAL OF THE LIPA II IS TO DEVELOP AND INSTALL A REPLACEMENT PHASE CONDUCTOR MANUFACTURED USING AMSC'S SECOND GENERATION WIRE. IN ADDITION, THE TEAM WILL ALSO ADDRESS THE OUTSTANDING COMPONENTS DEVELOPMENT NECESSARY FOR BETTER FULL SCALE INTEGRATION INTO A TRANSMISSION GRID INCLUDING INTEGRAL MANAGEMENT OF THERMAL SHRINKAGE OF THE CABLE CONDUCTOR, OPTIMIZATION OF THE CRYOSTAT DESIGN TO MITIGATE THE IMPLICATIONS OF POTENTIAL CABLE DAMAGE, AND THE DEVELOPMENT AND DEMONSTRATION OF A FIELD SPLICE IN THE OPERATING UTILITY GRID, AND DEVELOPMENT OF A HTS CABLE SPECIFIC MODULAR, HIGHER EFFICIENCY, REFRIGERATION SYSTEM. THIS PAPER WILL REPORT ON THE STATUS OF THE DEVELOPMENT OF THESE COMPONENTS.

4LC-02

(INVITED) **STATUS OF SUPERCONDUCTING CABLE DEMONSTRATION PROJECT IN JAPAN** ***S. HONJO***[1]*, T. MIMURA*[1]*, Y. KITOH*[1]*, Y. NOGUCHI*[1]*, T. MASUDA*[2]*, H. YUMURA*[2]*, M. IKEUCHI*[3]*, H. YAGUCHI*[3]*;* [1]TOKYO ELECTRIC POWER COMPANY, [2]SUMITOMO ELECTRIC INDUSTRIES, [3]MAYEKAWA MFG. — HTS CABLE DEMONSTRATION PROJECT, SO CALLED YOKOHAMA PROJECT, SUPPORTED BY MINISTRY OF ECONOMY, TRADE AND INDUSTRY (METI) AND NEW ENERGY AND INDUSTRIAL TECHNOLOGY DEVELOPMENT ORGANIZATION (NEDO) HAS STARTED IN JAPAN. THE TARGET OF THIS PROJECT IS TO OPERATE A 66 KV, 200 MVA HTS CABLE IN THE NETWORK OF TOKYO ELECTRIC POWER COMPANY IN ORDER TO DEMONSTRATE ITS RELIABILITY AND STABLE OPERATION. THE DEMONSTRATION SITE IS DECIDED TO ASHAHI SUBSTATION IN YOKOHAMA. BASED ON THE ANALYSIS OF THE NETWORK CONDITIONS OF THE SITE, THE DESIGN OF THE HTS CABLE SYSTEM HAS BEEN DECIDED. A 30-METER HTS CABLE SYSTEM HAS BEEN DEVELOPED AND TESTED IN SEI'S FACILITY TO CONFIRM THE DESIGN AND PERFORMANCE. THIS PAPER DESCRIBES THE SCHEME AND SCHEDULE OF THIS PROJECT, THE CABLE DESIGN CONCEPT AND MAJOR TEST RESULTS OF THE 30-METER HTS CABLE SYSTEM.

4LC-03

(INVITED) **DEVELOPMENTAL RESULTS OF 154KV, 1GVA, 30M HTS CABLE** ***J. CHO***[1]*, K. SIM*[1]*, S. KIM*[1]*, S. LEE*[2]*, H. JANG*[2]*, C. CHOI*[2]*, B. YANG*[3]*, S. KIM*[4]*, H. YEOM*[5]*, S. LEE*[6]*, M. PARK*[7]*;* [1]KERI, [2]LS CABLE, [3]KEPRI, [4]CVE, [5]KIMM, [6]UIDUK UNIV., [7]CHANGWON NATIONAL UNIV.. — THE 154 KV, 1GVA, HTS CABLE SYSTEM HAVE BEEN DEVELOPED BY KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE (KERI), LS CABLE LTD., KOREA ELECTRIC POWER RESEARCH INSTITUTE (KEPRI) AND CVE THAT IS ONE OF DAPAS (DEVELOPMENT OF ADVANCED POWER SYSTEM APPLIED BY SUPERCONDUCTIVITY TECHNOLOGIES) PROGRAMFOR THE TYPE TEST OF HTS CABLE, THE DEVELOPED HTS CABLE SYSTEM INSTALLED AND TESTED IN SHIELD ROOM IN KEPCO (KOREA ELECTRIC POWER COMPANY) TESTING CENTER.THIS PAPER DESCRIBES THE RESULTS OF DEVELOPMENTAL THE 30M, 1 PHASE, 154KV, 1GVA HTS CABLE. BY THE TYPE TEST RESULT, THE DEVELOPED 154KV HTS CABLE SYSTEM WAS PROVEN AS SATISFYING THE PERFORMANCES NEEDED TO NETWORK ACCESSION SEVERELY COMPARING TO CONVENTIONAL CABLE SYSTEM.

THIS WORK WAS SUPPORTED BY A GRANT FROM THE CENTER FOR APPLIED SUPERCONDUCTIVITY TECHNOLOGY OF THE 21ST CENTURY FRONTIER R&D PROGRAM, FUNDED BY THE MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY, REPUBLIC OF KOREA.

4LC-04

(INVITED) **RUSSIAN PROGRAM ON HTS POWER CABLES** ***V. VYSOTSKY****, V. SYTNIKOV;* RUSSIAN SCIENTIFIC R&D CABLE INSTITUTE. — THE RUSSIAN R&D PROGRAM FOR SUPERCONDUCTING POWER DEVICES IS UNDERWAY, SUPPORTED BOTH BY GOVERNMENT AND ELECTRIC POWER COMPANIES. IN THIS PROGRAM R&D OF HTS POWER CABLES IS CONSIDERED AS MOST ADVANCED AND CLOSE TO COMMERCIALIZATION. IN THE FRAMEWORK OF THE PROGRAM, SEVERAL, HEAVILY INSTRUMENTED, 5 M CABLES HAVE BEEN TESTED. BOTH 1G AND 2G HTS WIRES WERE USED FOR 5 M CABLES. AS THE SECOND STEP: 30 M - 3 PHASE EXPERIMENTAL POWER CABLE WITH RATED PARAMETERS 1500/2000A AND 20 KV HAS BEEN DEVELOPED PRODUCED AND SUCCESSFULLY TESTED. DURING EXPERIMENTAL CABLE TESTS CRITICAL CURRENT DEPENDENCIES ON TEMPERATURE OF ALL PHASES WERE MEASURED. CABLE UNDERWENT HIGH VOLTAGE TESTS AND FULL LOAD TESTS THAT WERE PASSED SUCCESSFULLY. THE FOLLOWING STEP THE ACCEPTANCE TEST OF 3X200 M POWER CABLE WITH SAME RATING: 1.5/2KA - 20 KV HAS BEEN COMPLETED IN DECEMBER OF 2010. THIS CABLE HAS SUPERCONDUCTING SHIELD AND IS MADE OF DI-BSSCO WIRES FROM SEI. THE CABLE IS FIRST INSTALLED AT THE EXPERIMENTAL TEST FACILITY TO UNDERGO EXTENSIVE TESTS, THAN IT WILL BE REINSTALLED TO MOSCOW UTILITY GRID. IN THE FRAMEWORK OF THE PROGRAM THE SPECIAL TEST FACILITY HAS BEEN DEVELOPED PERMITTING TO TEST DIFFERENT HTS ELECTRICAL POWER DEVICES AT VOLTAGES UP TO 110 KV AND CURRENTS UP TO 3000 ARMS UNDER FULL LOAD. IN THE PAPER THE DETAILS ABOUT HTS POWER CABLES DEVELOPMENT AND TESTS ARE PRESENTED.

THIS WORK IS SUPPORTED BY FEDERAL GRID COMPANY UNITED ENERGY SYSTEM AND BY MINISTRY OF SCIENCE AND EDUCATION OF RUSSIAN FEDERATION

4LC-05

CRYOGENIC AND ELECTRICAL DESIGN STUDIES OF HELIUM GAS COOLED SUPERCONDUCTING DC CABLE ***S. V. PAMIDI***[1]*, H. RODRIGO*[1]*, C. H. KIM*[1]*, J. KIM*[1]*, D. CROOK*[1]*, S. RANNER*[1]*, B. TROCIEWITZ*[1]*, S. DALE*[1]*, D. KNOLL*[2]*, D. LINDSAY*[2]*, D. WILLEN*[2]*, C. THIDEMANN*[2]*, H. LENTGE*[2]*, J. KEPHART*[3]*, B. FITZPATRICK*[3]*;* [1]FLORIDA STATE UNIVERSITY, [2]ULTERA, [3]NAVAL SURFACE WARFARE CENTER CARDEROCK DIVISION. — FLORIDA STATE UNIVERSITY CENTER FOR ADVANCED POWER SYSTEMS (FSU-CAPS), IN COLLABORATION WITH ULTERA (A SOUTHWIRE - NKT CABLES JOINT VENTURE) AND NAVAL SURFACE WARFARE CENTER CARDEROCK DIVISION, IS WORKING ON AN OFFICE OF NAVAL RESEARCH FUNDED PROJECT TO FABRICATE AND TEST A SUPERCONDUCTING DC CABLE WITH NOMINAL RATING OF 1 KV AND 3 KA AT 77 K. THE CABLE WILL BE COOLED USING CIRCULATING CRYOGENIC HELIUM GAS AND WILL BE TESTED IN THE TEMPERATURE RANGE OF 40 - 77 K. THE CABLE WILL BE INSTALLED AND INTEGRATED WITH THE FSU-CAPS' CRYOGENIC TEST BED AND POWER HARDWARE IN THE LOOP (PHIL) TEST ENVIRONMENT. THE CABLE WILL BE SUBJECTED TO A COMPREHENSIVE DYNAMIC TEST PROTOCOL TO UNDERSTAND THE INTERRELATION BETWEEN THE ELECTRICAL AND THERMAL BEHAVIOR. THE PURPOSE OF THE PROJECT IS TO DEMONSTRATE THE POTENTIAL OF SUPERCONDUCTING DC CABLES AND TO UNDERSTAND THE IMPLICATIONS OF CRYOGENIC HELIUM GAS ENVIRONMENT ON STRUCTURAL AND DIELECTRIC PROPERTIES IN DESIGN CONSIDERATIONS OF THE CABLE. THE PAPER WILL PRESENT CONCEPTUAL DESIGN AND PROGRESS ON UNDERSTANDING THE UNDERLYING CRYOGENIC AND ELECTRICAL ENGINEERING CHALLENGES.

THE PROJECT IS FUNDED BY THE OFFICE OF NAVAL RESEARCH

4LPA-01

DYNAMIC PROPERTIES OF MAGNETIC LEVITATION SYSTEM USING HIGH-TEMPERATURE SUPERCONDUCTORS ***I. SAKAI****, T. HIGUCHI;* DEPARTMENT OF PRECISION ENGINEERING, SCHOOL OF ENGINEERING, THE UNIVERSITY OF TOKYO. — PINNING EFFECT OF A BULK HIGH-TEMPERATURE SUPERCONDUCTOR(HTS) HAS VARIOUS POSSIBLE APPLICATIONS. ABOVE ALL, IT ENABLES A NON-CONTACT STABLE LEVITATION SYSTEM WITHOUT ACTIVE CONTROL. IT IS WELL KNOWN THAT STABLE MAGNETIC LEVITATION OF PERMANENT MAGNETS BY HTSS. HOWEVER, WE HAVE ACHIEVED SIMILAR SUSPENSION, WHERE SOFT MAGNETIC MATERIALS ARE SUSPENDED BY PINNING EFFECT OF HTSS. USING THIS UNIQUE TECHNIQUE, IT WILL BE POSSIBLE TO REALIZE A SIMPLE STRUCTURE AND LOW COST LEVITATION SYSTEM THAT DOES NOT REQUIRE COSTLY PERMANENT MAGNETS. IN THE MECHANICAL DESIGN OF THE LEVITATION SYSTEM, IT IS IMPORTANT TO EVALUATE ITS DYNAMIC BEHAVIOR AS WELL AS STATIC ONE. IN THIS WORK, WE APPLY THE SYSTEM TO A HARMONIC OSCILLATOR MODEL AND MEASURE THE SPRING CONSTANT AND DAMPING CONSTANT. IN ADDITION TO VIBRATION ANALYSIS, A NOVEL MEASUREMENT METHOD WHICH USE REPETITIVE CONTROL IS PROPOSED. THE OBTAINED RESULTS SHOW THAT THE DYNAMIC PROPERTIES OF THE SYSTEM ARE RELATED TO APPROACH PROCESS AND THE VELOCITY OF THE SOFT MAGNETIC MATERIAL. ALSO, THEY LEAD TO A COMPREHENSION OF THE LEVITATION MECHANISM

4LPA-02

THE DYNAMIC CHARACTERISTICS OF THE HTS BULK SUPERCONDUCTING ACTUATOR DRIVEN WITH AC ELECTROMAGNETS ***D. INOUE****, S. KIM, J. JOO, Y. UWANI;* OKAYAMA UNIVERSITY. — ELECTRIC DEVICE APPLICATIONS OF A HIGH TEMPERATURE SUPERCONDUCTING (HTS) BULK MAGNET, HAVING STABLE LEVITATION AND SUSPENSION PROPERTIES DUE TO THEIR STRONG FLUX PINNING FORCE, HAS BEEN PROPOSED AND DEVELOPED. WE HAVE BEEN INVESTIGATING A THREE-DIMENSIONAL (3-D) SUPERCONDUCTING ACTUATOR USING HTS BULKS TO DEVELOP A NON-CONTRACTIVE TRANSPORTATION DEVICE THAT MOVES FREELY IN SPACE. IT IS EXPECTED THAT OUR PROPOSED 3-D SUPERCONDUCTING ACTUATOR WILL BE USEFUL AS A TRANSPORTER USED IN A CLEAN ROOM WHERE SILICON WAFERS, THEY DO NOT LIKE MECHANICAL CONTACT AND DUST, ARE MANUFACTURED. THE PROPOSED SUPERCONDUCTING ACTUATOR CONSISTS OF THE TRAPPED HTS BULK AS A MOVER AND TWO-DIMENSIONALLY ARRANGED ELECTROMAGNETS AS A STATOR. UP TO NOW, THE ELECTROMAGNETS CONSISTED WITH IRON CORE AND COPPER COIL WERE USED AS A STATOR, AND EACH ELECTROMAGNET WAS INDIVIDUALLY CONTROLLED USING DC SUPPLIES. THE MOVEMENT OF HTS BULK (MOVER) WAS NOT SMOOTH BECAUSE OF THE DC CONTROL. IN THIS PAPER, THE NEW ELECTROMAGNETS DRIVEN WITH AC CONTROLLED CURRENT WAS PROPOSED TO IMPROVE THE CHARACTERISTICS OF THE MOVEMENT OF THE MOVER. THE CHARACTERISTICS OF HORIZONTAL MOVEMENT AND LEVITATION PROPERTIES BY NEWLY PROPOSED ELECTROMAGNETS WILL BE PRESENTED.

4LPA-03

OPERATING CHARACTERISTIC ANALYSIS OF ELECTROMAGNETIC SUSPENSION SYSTEM CONSIDERING THE VARIATION OF THE MAGNETIC FIELD DISTRIBUTION DUE TO THE VIBRATION ***J. JANG****[1], K. CHANG[1], Y. KIM[1], Y. CHUNG[2], C. LEE[3], T. KO[1];* [1]YONSEI UNIVERSITY, [2]THE UNIVERSITY OF SUWON, [3]KOREA RAILROAD RESEARCH INSTITUTE. — MAGLEV SYSTEM IS CONSISTS OF EMS(ELECTROMAGNETIC SUSPENSION)SYSTEM AND EDS(ELECTRODYNAMIC SUSPENSION)SYSTEM. IN CASE OF EMS SYSTEM, THE LEVITATION IS ACCOMPLISHED BASED ON THE MAGNETIC ATTRACTION FORCE BETWEEN A RAIL AND ELECTROMAGNETS. IN CASE OF EDS SYSTEM, THE LEVITATION IS ACHIEVED BASED ON THE REPULSIVE FORCE BETWEEN A RAIL AND ELECTROMAGNETS. IF THE GUIDE RAIL OF MAGLEV ADOPTING EMS SYSTEM IS NOT FLAT, THE GAP BETWEEN GUIDE RAIL AND U-SHAPED IRON CORE IS CHANGED. THIS VIBRATION LEADS TO THE CHANGE OF MAGNETIC FIELD DISTRIBUTION AND THE INDUCTANCE OF IRON CORE. FROM THIS POINT VIEW, LEVITATION FORCE IS CHANGED AND THE EMS SYSTEM CAN BE UNSTABLE DUE TO THESE VARIATIONS. IN THIS PAPER, DESIGN OF EMS SYSTEM IS PERFORMED BY MEANS OF THE SIMULATION THAT CONSIDERING THE VARIATIONS OF OPERATIONAL CHARACTERISTICS. IN ADDITION, WE CALCULATE THE TURNS AND THE OPERATING CURRENT OF THE HTS TAPES TO MAINTAIN THE LEVITATION FORCE WITH RESPECT TO THE SHAPE AND THE LENGTH OF HTS COIL. MATHEMATICAL MODEL OF THE EMS SYSTEM WAS PROVED BY THE SIMULATION.

THIS STUDY WAS SUPPORTED BY THE KOREA SCIENCE AND ENGINEERING FOUNDATION (KOSEF) GRANT FUNDED BY THE KOREA GOVERNMENT (MEST 2009 - 0085369)

4LPA-04

EFFECT OF AN ADDITIONAL MASS ON NONLINEAR RESONANCE OF A BEAM LEVITATED OVER HIGH-TC SUPERCONDUCTING BULKS ***T. TAKABAYASHI****, T. KOKUZAWA, T. SUGIURA;* KEIO UNIVERSITY. — HIGH-TC SUPERCONDUCTING MAGNETIC LEVITATION SYSTEMS ARE ABLE TO MAINTAIN STABLE LEVITATION WITHOUT CONTROL. HOWEVER, THE NONLINEARITY OF THE ELECTROMAGNETIC FORCE MUST BE TAKEN INTO CONSIDERATION. THIS NONLINEARITY HAS A GREAT EFFECT ON LOW DAMPED SYSTEMS, AND CAN CAUSE COMPLICATED DYNAMICAL PHENOMENA. IF THE LEVITATED BODY IS ELASTIC, ITS PLURAL VIBRATION MODES MAY COUPLE THROUGH NONLINEAR TERMS OF THE MAGNETIC FORCE. THESE MODES CAN SHOW RESONANCE AT THE SAME TIME IF THEIR NATURAL FREQUENCIES ARE COMMENSURABLE. THIS PHENOMENON IS CALLED AN INTERNAL RESONANCE. THE FOCUS OF THIS RESEARCH IS PLACED ON EFFECT OF AN ADDITIONAL MASS ON THE INTERNAL RESONANCE. THE CONCEPT OF AN ADDITIONAL MASS IS EQUIPPED IN THE RESEARCH OF VARIOUS MACHINES.

FOR EXAMPLE, ADDITIONAL MASSES ARE PLACED TO REPRESENT PEOPLE OR MOTORS IN MAGLEV TRAINS, AS WELL AS ROTARY OBJECTS OR BEARINGS IN FLYWHEELS. THE LOAD OF THE ADDITIONAL MASS CHANGES THE DISTRIBUTION OF THE TOTAL WEIGHT IN THE MODELS. ACCORDINGLY, THE NATURAL FREQUENCIES OF THE VIBRATION MODES CAN ALSO CHANGE. AS A RESULT, IF TWO OF THEM SHOW INTEGER RATIO, INTERNAL RESONANCE CAN OCCUR BETWEEN THOSE MODES. IN THIS RESEARCH, USING A SIMPLIFIED MODEL OF AN ELASTIC BODY LEVITATED ABOVE SUPERCONDUCTORS, THE OCCURRENCE OF INTERNAL RESONANCE, WITH RESPECT TO THE WEIGHT AND THE POSITION OF THE ADDITIONAL MASS, WAS CLARIFIED THROUGH NUMERICAL ANALYSES AND EXPERIMENTS.

4LPA-06

STUDY OF THE LATERAL FORCE BEHAVIOR IN A FIELD COOLED SUPERCONDUCTING LINEAR BEARING ***D. H. N. DIAS***[1]*, G. G. SOTELO*[2]*, R. DE ANDRADE JR.*[1]*;* [1]FEDERAL UNIVERSITY OF RIO DE JANEIRO, [2]FLUMINENSE FEDERAL UNIVERSITY. — THE MAIN CHARACTERISTIC OF A LINEAR SUPERCONDUCTING MAGNETIC BEARING (SMB) IS THE STABLE LEVITATION BETWEEN THE SUPERCONDUCTOR AND THE MAGNETIC SOURCE, WHICH IS, IN MOST CASES, A PERMANENT MAGNETIC (PM) RAIL. A STABLE AND PASSIVE LEVITATION CAN BE REACHED WHEN THE SUPERCONDUCTING TRANSITION OCCURS IN THE PRESENCE OF MAGNETIC FIELD (FIELD COOLING - FC) DUE TO THE INCREASE OF MAGNETIC FLUX PINNED IN THE SUPERCONDUCTORS. THE COOLING PROCESS IS PERFORMED WITH THE SUPERCONDUCTOR NEAR TO THE PM RAIL IN A CERTAIN COOLING HIGH (CH). THIS WORK AIMS TO DEVELOP A TECHNIQUE, BASED ON THE CRITICAL STATE MODEL, WHICH CALCULATES THE MAGNETIC FORCES OF A SMB IN THE FC CASE AS THE SUPERCONDUCTOR BULK IS DISPLACED LATERALLY IN RELATION TO THE PM RAIL. THIS METHOD CONSISTS IN DETERMINING A MACROSCOPIC SCREENING CURRENT DENSITY THAT THE SUPERCONDUCTOR IS SUPPOSED TO CARRY. THIS ALGORITHM HAS ALREADY SHOWN SATISFACTORY RESULTS WHEN SIMULATED THE VERTICAL LEVITATION FORCE IN ZERO FIELD COOLING. HOWEVER, FOR REAL APPLICATIONS, IT IS NECESSARY TO CONSIDER ALSO THE FC CASE. THEREFORE, A STUDY OF THE LATERAL FORCE BEHAVIOR FOR DIFFERENT VALUES OF CH WAS PERFORMED CONSIDERING THE FC CASE. AN EXPERIMENTAL RIG WAS USED TO MEASURE THE MAGNETIC FORCE IN THE THREE SPACE DIRECTIONS. THE SIMULATED FORCE RESULTS SHOWED SATISFACTORY AGREEMENT WITH THE EXPERIMENTAL DATA, VALIDATING THE PRESENTED MODEL.

4LPA-07

VIBRATION REDUCTION OF A HIGH-TC SUPERCONDUCTING MAGNETIC LEVITATION SYSTEM WITH AN AUTOPARAMETRIC VIBRATION ABSORBER ***D. TAGUCHI****, T. SUGIURA;* KEIO UNIVERSITY. — HIGH-TC LEVITATION SYSTEMS HAVE VERY SMALL DAMPING AND STABLE LEVITATION WITHOUT CONTROL. THIS FEATURE CAN BE APPLIED TO CONTACTLESS FLYWHEELS, VEHICLES, AND SO ON. BUT IN SUCH LESS DAMPING SYSTEMS, THE RESONANT AMPLITUDE UNDER FORCED VIBRATION CAN BE LARGE. THIS RESEARCH PROPOSES STABILIZATION FOR A HIGH-TC SUPERCONDUCTING MAGNETIC LEVITATION SYSTEM USING AN AUTOPARAMETRIC VIBRATION ABSORBER.IN OUR MODEL A RIGID BODY WITH PERMANENT MAGNETS LEVITATES ABOVE HIGH-TC SUPERCONDUCTING BULKS. ON THE RIGID BODY A PENDULUM IS FIXED AS AN AUTOPARAMETRIC VIBRATION ABSORBER. NONLINEAR COUPLING BETWEEN THE MOTION OF THE RIGID BODY AND THAT OF THE PENDULUM CAN CAUSE NONLINEAR RESONANCE CALLED AUTOPARAMETRIC RESONANCE, LEADING TO REDUCTION OF THE VERTICAL AMPLITUDE OF THE LEVITATED BODY UNDER EXTERNAL EXCITATION. THE GOVERNING EQUATIONS IN Z AND Q DIRECTIONS ARE DERIVED, AND A POSSIBILITY OF ENERGY TRANSFER DUE TO THE AUTOPARAMETRIC RESONANCE IS DISCUSSED. NUMERICAL RESULTS AND ANALYTICAL SOLUTION BASED ON THESE EQUATIONS SHOW DECREASE IN THE VERTICAL AMPLITUDE OWING TO THE AUTOPARAMETRIC RESONANCE. EXPERIMENTS WERE ALSO CARRIED OUT. EXPERIMENTAL RESULTS ARE CONSISTENT WITH THE ANALYTICAL AND NUMERICAL RESULTS.THE ABOVE RESULTS CONFIRM THAT AN AUTOPARAMETRIC VIBRATION ABSORBER CAN EFFECTIVELY REDUCE THE RESONANT AMPLITUCE OF A LEVITATED BODY.

4LPA-08

DYNAMICS WITH MAGNETIC INTERACTION OF TWO COAXIAL SUPERCONDUCTING RINGS *K. BHAN*[1]*,* ***M. FEDORCHUK***[2]*, V. KOZOREZ*[3]*;* [1]KECK GRADUATE INSTITUTE, [2]COLGATE UNIVERSITY, [3]TARAS SHEVCHENKO NATIONAL UNIVERSITY OF KYIV. — THE ONE-DIMENSIONAL MOTION WITH MAGNETIC INTERACTION BETWEEN TWO COAXIAL SUPERCONDUCTING RINGS OF UNEQUAL RADII IS ANALYZED WITH TAKING INTO ACCOUNT THE RINGS' PERFECT ELECTRIC CONDUCTIVITY. THE EXISTENCE OF TWO MAGNETIC POTENTIAL ENERGY MINIMA AND ONE HILL IS DERIVED AND DYNAMIC BEHAVIOR OF THE MOTION WITH AND WITHOUT FRICTION IS ANALYZED.FRICTION FORCE SUPPOSED TO BE PROPORTIONAL TO THE VELOCITY COMPLICATES DYNAMIC ANALYSIS AND REQUIRES SOFTWARE ALLOWING OBTAINING SOLUTIONS BY VISUAL PLOTS. TWO MINIMA AND ONE HILL BETWEEN THEM SUFFICIENTLY DIVERSIFY DYNAMIC BEHAVIOUR. WITH FRICTION AND ONE MINIMUM, A MOTION ALWAYS ENDS AT ONE POSITION (COPLANAR POSITION BETWEEN RINGS). IN A CASE OF TWO MINIMA AND ONE HILL, THE DUMPED OSCILLATIONS CAN JUMP OVER FROM THE INITIAL POSITION NEAR ONE MINIMUM TO THE SECOND MINIMUM AND RESULT IN THE REST AT THE SECOND MINIMUM POSITION (NON-COPLANAR) WITH ZERO ELECTRIC CURRENT IN ONE SUPERCONDUCTING RING. HOWEVER, IT DOES NOT MEAN THAT MAGNETIC ENERGY STORED IN A PAIR OF ZERO RESISTANCE RINGS IS LOST FOR THE WORK AGAINST FRICTION FORCE. THE ENERGY SPENT TO WORK AGAINST FRICTION EQUALS THE DIFFERENCE BETWEEN STORED MAGNETIC ENERGIES AT A POSITION DETERMINED BY INITIAL CONDITION FOR RELATIVE DISLOCATION AND POSITION OF THE REST AS THE RESULT OF DUMPED OSCILLATIONS FULFILLED BY THE EXTERNAL SOURCE OF ENERGY DURING FORMATION OF THE RINGS INITIAL CONFIGURATION.

4LPA-09

INCREASED LEVITATION PROPERTY OF TWO-SET MODEL IN MAGNETIC LEVITATION SYSTEM USING MAGNETIC SHIELDING EFFECT OF HTS BULK ***T. TAKAO***[1], *S. SAITO*[1], *S. KAMEYAMA*[1], *T. DOI*[1], *N. TANOUE*[1], *H. KAMIJO*[2]; [1]SOPHIA UNIVERSITY, [2]RAILWAY TECHNICAL RESEARCH INSTITUTE. — WE HAVE STUDIED A LEVITATION SYSTEM WITH A MAGNETIC SHIELDING EFFECT OF A HIGH TEMPERATURE SUPERCONDUCTING BULK. IN THE SYSTEM, BY DEFORMATION OF MAGNETIC FIELD USING THE MAGNETIC SHIELDING EFFECT OF THE HTS BULK WHICH IS ZERO-FIELD COOLED, STABLE LEVITATION WITHOUT ACTIVE OR PASSIVE CONTROL IS POSSIBLE. A MOVING PART HAVING A PERMANENT MAGNET AND THE HTS BULK IS LEVITATED BY A FERROMAGNETIC RAIL LOCATED ON THE UPPER PART OF THE MOVING PART IN THIS LEVITATION SYSTEM. ADVANTAGE OF THIS LEVITATION SYSTEM ARE, (1) A COOLANT IS LIQUID NITROGEN NOT LIQUID HELIUM BECAUSE A SUPERCONDUCTOR IS THE HTS, AND (2) FACILITIES OF A GROUND SIDE ARE SIMPLIFIED AND LOW COST BECAUSE THE GROUND SIDE IS MADE OF ONLY FERROMAGNETIC RAILS. IN OUR PREVIOUS WORK, WE STUDIED ON A BASIC MODEL WHICH HAD A PERMANENT MAGNET, HTS BULKS MADE OF Y(DY)BCO AND A FERROMAGNETIC BAR. FOR EXPANDING THE LEVITATION PROPERTY, WE USED THE HTS BULKS MADE OF GDBCO HAVING HIGHER JC THAN Y(DY)BCO, AND WE ALSO USED 2-SET MODEL IN WHICH TWO BASIC MODELS WERE SET PARALLEL. THE EXPERIMENTAL RESULTS SHOWED THAT THE STABLE REGION EXPANDED EFFECTIVELY, AND THE PEAK LEVITATION FORCE INCREASED TWICE OR MORE COMPARED WITH THE BASIC MODEL. WE DISCUSS ON THOSE EXPERIMENTAL RESULTS.

4LPA-10

SUSPENSION FORCE TRANSITION OF HIGH-TC SUPERCONDUCTING BULKS IN A VARYING EXTERNAL MAGNETIC FIELD *L. LIU, J. S. WANG, J. LI, J. ZHENG, G. T. MA,* ***S. Y. WANG****;* SOUTHWEST JIAOTONG UNIVERSITY. — IN THE PRACTICAL APPLICATION OF A HIGH-TC SUPERCONDUCTING (HTS) MAGLEV VEHICLE, THE ONBOARD HTS BULKS ARE INEVITABLY EXPOSED TO A VARYING INHOMOGENEOUS MAGNETIC FIELD DUE TO ABNORMALITIES PRESENT IN THE PERMANENT MAGNETIC GUIDEWAY (PMG). THE DIFFERENCE BETWEEN THE SUSPENSION FORCE AND LEVITATION FORCE OF YBA2CU3O7-X BULK SAMPLES WITH RESPECT TO THE PMG IN SUCH CHANGING EXTERNAL MAGNETIC FIELDS WITH DIFFERENT FREQUENCIES ARE STUDIED EXPERIMENTALLY WITH THE AID OF A SPINNING CIRCULAR PMG. THE ROTATION OF THE CIRCULAR PMG SIMULATES TRANSLATIONAL MOVEMENT OF THE SUPERCONDUCTOR WITH RESPECT TO THE PMG AND THE ROTATIONAL SPEED IS EQUIVALENT TO THE FREQUENCY OF AN INHOMOGENEOUS MAGNETIC FIELD. THE PMG'S ROTATING SPEED, INCREASES THE SUSPENSION FORCE WAVES WHEN SPEEDING UP AND ATTENUATES SHARPLY WHEN SPEEDING DOWN. THIS OBSERVED PHENOMENON IS OF GREAT IMPORTANCE IN THE DESIGN AND APPLICATION OF THE HTS MAGLEV SYSTEM.

THIS WORK WAS SUPPORTED BY THE NATIONAL HIGH TECHNOLOGY RESEARCH AND DEVELOPMENT PROGRAM OF CHINA (GRANT NO. 2007AA03Z210), THE NATIONAL NATURAL SCIENCE FOUNDATION OF CHINA (50777053) AND THE NATIONAL LABORATORY OF RAIL TRANSIT GRANT (2009TPL_Z01).

4LPB-01

REMOVAL OF HG FROM HUMAN SERUM WITH NANO-SIZE MAGNETIC BEADS BY ARTIFICIAL DIALYZER WITH SUPERCONDUCTING MAGNETIC SEPARATOR ***T. OKAMOTO***[1], *O. MIURA*[1], *M. TAKEUCHI*[2]; [1]TOKYO METROPOLITAN UNIVERSITY, [2]KOMAZAWA JIN CLINIC. — RECENTLY, MERCURY HG CONCENTRATION IN HUMAN BLOOD INCREASES DUE TO EXPANDING THE GLOBAL MERCURY CONTAMINATION. EXCESS MERCURY BIOACCUMULATION POSES A SIGNIFICANT HEALTH RISK. IN ORDER TO DECREASE THE HG CONCENTRATION IN HUMAN BLOOD, WE HAVE DEVELOPED NANO-SIZE MAGNETIC ADSORBENT FOR MERCURY TO APPLY IT TO SUPERCONDUCTING MAGNETIC SEPARATION INSTEAD OF FILTRATION. THE SUPERCONDUCTING MAGNETIC SEPARATION CAN DECREASE THE TREATMENT TIME OF BLOOD PURIFICATION DRASTICALLY. THE NANO MAGNETIC BEADS NOT ONLY HAVE MAGNETITE NANO SIZE PARTICLES IN THE CORE BUT HAVE MANY SH RADICALS ON THE SURFACE TO ADSORB HG EFFECTIVELY. IN THE EXPERIMENT, 1G NANO BEADS WERE ABLE TO ADSORB METHYL MERCURY 6.3 MG IN THE WATER WITH A 0.5 T MAGNET IN A FEW MINUTES. DITHIOTHREITOL CAN BE REMOVED MERCURY FROM THE MAGNETIC BEADS, AND THE NANO BEADS CAN BE REUSABLE. INTRODUCTION OF A HIGH GRADIENT MAGNETIC SEPARATION SYSTEM WITH SUPERCONDUCTING MAGNET TO THE BLOOD PURIFICATION CYCLE HAS BEEN STUDIED TO DECREASE THE TREATMENT TIME FOR THE DIALYSIS SUBSTANTIALLY.

WE THANK MASAO YAMAZAKI AND SEIKO NAKAGAWA (TOKYO INDUSTRIAL TECHNOLOGY RESEARCH CENTER) FOR COOPERATING IN THE RESEARCH.

4LPB-03

STUDY ON HIGH GRADIENT MAGNETIC SEPARATION FOR SELECTIVE REMOVAL OF IMPURITY FROM HIGHLY VISCOUS FLUID ***S. HAYASHI****, F. MISHIMA, Y. AKIYAMA, S. NISHIJIMA;* OSAKA UNIVERSITY. — IT IS NECESSARY TO REMOVE THE METALLIC WEAR DEBRIS ORIGINATING FROM PIPE OR PROPELLER IN MANUFACTURING LINE OF INDUSTRIAL PLANT DEALING WITH HIGHLY VISCOUS FLUID SUCH AS FOODS OR INDUSTRIAL PRODUCTS. THE FERROMAGNETIC PARTICLE CAN BE REMOVED FROM HIGHLY VISCOUS FLUID BY HIGH GRADIENT MAGNETIC SEPARATION, WHICH IS ONE OF THE PROSPECTIVE TECHNIQUES FOR REMOVAL OF THE IMPURITY. THERE IS A PROBLEM IN PRESENT MAGNETIC SEPARATION THAT PARTICLES OTHER THAN OBJECT PARTICLE ARE SEPARATED TOGETHER WITH OBJECT PARTICLES, IN CASE THAT MULTIPLE KINDS OF PARTICLES ARE CONTAINED IN THE FLUID. IN THIS STUDY, WE TRIED TO SEPARATE THE OBJECT FERROMAGNETIC PARTICLE SELECTIVELY BY DIFFERENCE OF MAGNETIC PROPERTY. THE MAGNETIC SEPARATION

EXPERIMENT WAS CONDUCTED WITH FERROMAGNETIC AND PARAMAGNETIC STAINLESS PARTICLES AS THE MODEL MATERIALS. THE MIXTURE OF FERROMAGNETIC AND PARAMAGNETIC PARTICLES OF 1:1 IN WEIGHT RATIO WAS DISPERSED INTO POLYVINYL ALCOHOL WITH 1 PA•S IN VISCOSITY. THE SUPERCONDUCTING MAGNET AND THE HIGH GRADIENT MAGNETIC SEPARATION APPARATUS WHICH CONSISTS OF MAGNETIC FILTERS WERE USED AS THE EXPERIMENTAL SYSTEM. IT WAS SHOWN THAT THE FERROMAGNETIC PARTICLE CAN BE REMOVED SELECTIVELY BY CONTROLLING FLOW VELOCITY. ON THE BASIS OF THIS RESULT, THE POSSIBILITY OF THE SELECTIVE MAGNETIC SEPARATION OF TWO KINDS OF FERROMAGNETIC PARTICLES BY DIFFERENCE OF SATURATED MAGNETIZATION WAS EXAMINED.

4LPB-04

HIGH GRADIENT SUPERCONDUCTING MAGNETIC SEPARATION FOR IRON REMOVAL FROM THE GLASS POLISHING WASTE ***F. MISHIMA****, Y. AKIYAMA, S. NISHIJIMA;* GRADUATE SCHOOL OF ENGINEERING, OSAKA UNIVERSITY. — CERIUM OXIDE USED FOR GLASS POLISHING AGENT IS PROCESSED AS WASTEWATER MIXED WITH THE GRINDING SLUDGE OF THE GLASS. THE RECYCLE OF CERIUM OXIDE MAY HAVE A LARGE INFLUENCE ON REDUCTION OF ENVIRONMENTAL BURDEN AND RESOURCES RECYCLING. IN THE TREATMENT PROCESS OF WASTE WATER, THE COMPLEX OF CERIUM OXIDE AND IRON FLOCCULANT IS FORMED BY CO-PRECIPITATION TO CLEAR THE FLUID. IN ORDER TO RECYCLE THE CERIUM OXIDE, IT IS NECESSARY TO DESTROY THE COHESION AND THEN REMOVE THE IRON CONTENT. IN THIS STUDY, THE AGGREGATED SLUDGE WAS DISPERSED BY PH ADJUSTMENT, AND THE IRON CONTENT WAS SEPARATED BY THE DEVELOPED HIGH GRADIENT MAGNETIC SEPARATION SYSTEM WITH SUPERCONDUCTING MAGNET. THE OPTIMUM CONDITION WAS EXAMINED BY CALCULATION AND MODEL EXPERIMENT.

4LPB-05

HIGH GRADIENT MAGNETIC SEPARATION OF PNEUMATIC CONVEYED POWDER PRODUCTS ***Y. NAKAI****, F. MISHIMA, Y. AKIYAMA, S. NISHIJIMA;* OSAKA UNIVERSITY. — THE INTERFUSION OF FERROMAGNETIC IMPURITIES SUCH AS METALLIC WEAR DEBRIS HAS BEEN ONE OF THE PROBLEMS IN THE MANUFACTURING PROCESS OF POWDER PRODUCTS. TO REMOVE SUCH DEBRIS, WE DEVELOPED HIGH GRADIENT MAGNETIC SEPARATION SYSTEM (HGMS) UNDER DRY PROCESS WHICH HAS MANY ADVANTAGES AGAINST CONVENTIONAL TECHNOLOGY UNDER WET PROCESS. THE MAJOR PROBLEM OF DRY HGMS SYSTEM WAS THE BLOCKAGE OF MAGNETIC FILTER CAUSED BY PARTICLE COAGULATION OR DEPOSITION. IN OUR PREVIOUS STUDY, WE SUCCEEDED TO REDUCE THE BLOCKAGE UNDER DRY CONDITION BY USING PRISMATIC-SHAPED FILTER. 95% OF IMPURITIES WERE REMOVED FROM POWDER SAMPLES WHOSE CONTENT OF IMPURITY WAS 0.1WT%. IN ADDITION, HIGH COLLECTION RATE WAS OBTAINED BY USING PRISMATIC-SHAPED FILTER WHOSE SLOPE WAS STEEPER THAN REPOSE ANGLE OF THE POWDER SAMPLES. IN ORDER TO ACTUALIZE THE MAGNETIC SEPARATION WITHOUT BLOCKAGE, WE INTRODUCED THE MECHANISM OF PNEUMATIC CONVEYING OF POWDER. THE POWDER SAMPLES ARE DISPERSED ADEQUATELY, AND HIGH SEPARATION EFFICIENCY CAN BE OBTAINED WITH DEVELOPED SYSTEM. THE RESULTS SHOWED THAT SEPARATION EFFICIENCY FOR THE SAMPLE WITH 0.1WT% OF IMPURITY WAS 93%.

4LPB-06

DEVELOPMENT OF NUMERICAL ANALYSIS METHOD FOR ION SEPARATION WITH NOVEL MAGNETIC CHROMATOGRAPHY ***S. NOGUCHI****[1], S. KIM[2];* [1]HOKKAIDO UNIVERSITY, [2]OKAYAMA UNIVERSITY. — THE MAGNETIC CHROMATOGRAPHY (MC) IS A VERY USEFUL SYSTEM FOR THE ION SEPARATION DUE TO ITS STRONG MAGNETIC FIELD GRADIENTS IN A VERY SMALL FLOW CHANNEL. WE HAVE DEVELOPED THE MC SYSTEM TO SEPARATE THE IONS, AND WE HAVE ALSO DEVELOPED THE 2-D NUMERICAL ANALYSIS METHOD BASED ON THE FLUID DYNAMICS AND ELECTROMAGNETICS TO INVESTIGATE THE SEPARATING CHARACTERISTICS AND TO OPTIMIZE DESIGN OF MAGNETIC COLUMN. HOWEVER, THE 2-D SIMULATION OF THE ION SEPARATION IS INSUFFICIENT SINCE THE DIFFUSION OF THE ION IS TOO FAST AND THE FLOW VELOCITY ON THE COLUMN WALL IS ZERO. TO ACHIEVE THE ACCURATE SIMULATION OF THE ION DIFFUSION, THE 3-D SIMULATION CODE IS DEVELOPED. FOR THE 3-D SIMULATION, THE MAGNETIC MOMENT METHOD IS EMPLOYED AS AN ELECTROMAGNETIC FIELD ANALYSIS METHOD, THE FINITE VOLUME METHOD AS A FLUID DYNAMICS ANALYSIS METHOD. IN ORDER TO INVESTIGATE THE ACCURACY, THE NUMERICAL RESULTS OBTAINED BY THE PROPOSED METHOD ARE COMPARED WITH THE EXPERIMENTAL ONES. THE INFLUENCES OF THE STRENGTH OF MAGNETIC GRADIENT, FLOW VELOCITY AND COEFFICIENT OF VISCOSITY OF SOLVENT ARE INVESTIGATED BY THE PROPOSED METHOD. WE WOULD LIKE TO INVESTIGATE THE CHARACTERISTICS OF THE MAGNETIC SEPARATION WITH TWO DIFFERENT KINDS OF IONS, SIMULTANEOUS WITH CONSIDERING THE MAGNETIC INFLUENCE INTO EACH OTHER, USING THE PROPOSED 3-D NUMERICAL ANALYSIS METHOD.

4LPB-08

MAGNETIC SEPARATION OF PAPER PULP WASTEWATER ***D. KIM****, S. KWON, Y. CHOI, J. KIM;* KOREA BASIC SCIENCE INSTITUTE. — THE MAGNETIC SEPARATION METHOD IS TO SEPARATE AND CAPTURE MAGNETIC PARTICLE OR MAGNETIZED MATERIALS BY THE MAGNETIC FORCE IN A GRADIENT MAGNETIC FIELD.WITH THE DEVELOPMENT OF CRYO-COOLER, THE HIGH MAGNETIC FIELD BECOME TO GET EASY AND OPERATED CONTINUOUSLY MORE THAN SEVERAL MONTHS WITHOUT THE CRYOGEN BY CONDUCTION COOLED SUPERCONDUCTING MAGNET. THE STRONG MAGNETIC FIELD IS VERY EFFECTIVE TO SEPARATE MAGNETIZED NANO-SIZE PARTICLES BY HIGH GRADIENT MAGNETIC SEPARATION.IN THIS PAPER THE RESEARCH OF THE MAGNETIC SEPARATION OF PAPER PULP WASTEWATER IS PRESENTED .BY THE

MAGNETIC SEPARATION IN THE 5 T MAGNETIC FIELD, WE MAY GET VERY HIGH REMOVAL RATE OF SUSPENDED SOLID.

4LPC-01

STATOR DESIGN FOR A 1000KW HTSC MOTOR WITH AIR-GAP WINDING ***D. WU***[1]*, E. CHEN*[1]*, J. CHEN*[2]*;* [1]TECO-WESTINGHOUSE MOTOR COMPANY, [2]WUHAN INSTITUTE OF MARINE ELECTRIC PROPULSION. — AN AIR-CORE STATOR (OFTEN CALLED STATOR WITH AIR-GAP WINDING) FOR 1-MW 500-RPM HIGH TEMPERATURE SUPERCONDUCTING SYNCHRONOUS MOTOR HAS BEEN DEVELOPED BY GLOBAL R&D, TECO-WESTINGHOUSE MOTOR COMPANY.THIS HTSC (HIGH TEMPERATURE SUPERCONDUCTING) MOTOR CONSISTS OF A ROTOR, A STATOR AND AN ELECTROMAGNETIC (EM) SHIELDING RING IN THE AIR GAP. A SET OF FIELD COILS (QUANTITY SAME AS POLES NUMBER) IS WOUND ON THE ROTOR WITH HTSC G1 WIRE BY CHINESE VENDOR. THE ROTOR'S CRYOGENIC SYSTEM COOLS THE SUPERCONDUCTING FIELD COILS TO LOW TEMPERATURE. STATOR WINDING AND BACK IRON BOTH ARE IN A 'WARM STATOR'. THE EM SHIELD IS A CONDUCTIVE EDDY CURRENT SHIELDING 'DAMPER' TO SHIELD THE HTSC WIRE FROM HARMONIC FLUX, THEREBY REDUCING THE LOSSES AND PROTECTING THE HTSC MAGNETS FROM QUENCHING.THE STATOR COIL IS DESIGNED WITH LITZ-WIRE ROEBEL TRANSPOSITION TO MINIMIZE THE HARMONICS, COGGING TORQUE CAUSED BY SLOT OPENING, NOISE AND VIBRATION.AN ALGORITHM IS DEVELOPED TO DESIGN THE STATOR. ELECTROMAGNETIC AND MECHANICAL ANALYSIS IS BASED ON 3D FEA (FINITE ELEMENT ANALYSIS). THE THERMAL ANALYSIS BASED ON 2D FEA. NOVEL MANUFACTURING PROCESSING FOR LITZ WIRE ARE DEVELOPED FOR THIS PROJECT, E.G., COIL WINDING, WELDING, TESTING AND INSTALLATION. THE STATOR COILS ARE BEING MANUFACTURED NOW, AND THE MACHINE ASSEMBLY IS PLANNED TO BE COMPLETED IN AUGUST 2010 AND TESTED BY THE END OF 2010.

4LPC-02

DESIGN OF THE FIELD COIL FOR A 5 MW HTS SYNCHRONOUS MOTOR ***H. KIM***[1]*, Y. KWON*[1]*, J. SONG*[2]*, H. LEE*[2]*;* [1]KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE, [2]KOREA UNIVERSITY. — COMPARED WITH A CONVENTIONAL ROTATING MACHINE, A SUPERCONDUCTING ROTATING MACHINE FABRICATED BY HTS TAPE HAS THE SUPERIOR PERFORMANCE AND EFFICIENCY, BECAUSE THE HTS FIELD COIL OF THE ROTATOR CAN GENERATE HIGH MAGNETIC FLUX INTENSITY. THE TWO PRIMARY FACTORS TO BE CONCERNED FOR THE DESIGN OF THE HTS ROTATIONAL MACHINE ARE HOW TO CONSTRUCT OPTIMAL MAGNETIC FIELD PATH THROUGH THE AIR GAP LOCATED BETWEEN THE STATOR AND ROTOR COIL. A 5 MW HIGH TEMPERATURE SUPERCONDUCTING (HTS) MOTOR FOR SHIP PROPULSION IS PLANNED FOR DEVELOPMENT IN EARLY 2011 BY A KOREAN COLLABORATION GROUP OF KERI AND DOOSAN HEAVY INDUSTRY. AS A PART OF THIS R&D EFFORTS, WE PERFORMED THE DESIGN AND ANALYSIS OF THE FIELD COIL FOR A 5 MW HTS SYNCHRONOUS MOTOR. IN THIS PAPER, THE DYNAMIC FIELD ANALYSIS OF THE SUPERCONDUCTING ROTATING MACHINE WILL BE ALSO PRESENTED AND DISCUSSED.THIS WORK WAS SUPPORTED IN PART BY A GRANT FROM THE CENTER FOR APPLIED SUPERCONDUCTIVITY TECHNOLOGY OF THE 21ST CENTURY FRONTIER R&D PROGRAM FUNDED BY THE MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY, REPUBLIC OF KOREA.

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4LPC-03

DESIGN STUDIES ON A 1000KW HIGH TEMPERATURE SUPER-CONDUCTING MOTOR ***J. CHEN****, W. TANG, J. ZHENG, F. XIE;* WUHAN INSTITUTE OF MARINE ELECTRIC PROPUSION. — HIGH TEMPERATURE SUPER-CONDUCTING (HTS) SYNCHRONOUS MOTOR HAS ADVANTAGES OF HIGH EFFICIENCY, SMALL SIZE, LOW WEIGHT AND STABLE OPERATION COMPARE TO CONVENTIONAL MOTOR, ESPECIALLY IN SHIP ELECTRIC PROPULSION AND OFFSHORE WIND POWER. IN CHINA, WUHAN INSTITUTE OF MARINE ELECTRIC PROPULSION IS CONDUCTING RESEARCH ON A 1000KW 500R/MIN HTS MOTOR. THE SCHEME AND TECHNOLOGY DESIGNS ON THE MOTOR HAVE BEEN COMPLETED. THE MANUFACTURING AND TESTING WILL BE COMPLETED BY THE END OF 2010. THE HTS MOTOR IS SUPPLIED BY CONVERTER. LITZ-WIRE COILS ARE USED TO MANUFACTURE THE STATOR AIR-GAP ARMATURE WINDING. THE STATOR IS COOLED BY FRAME WATER COOLING AND THE END WINDING IS COOLED BY AIR. BI2223 WIRE IS APPLIED IN THIS MOTOR TO WRAP THE ROTOR MAGNET WINDINGS. THE ROTOR MAGNETS OPERATE AT CRYOGENIC TEMPERATURE OF 30K. LIQUID NEON IS USED TO DISSIPATE HEAT FROM THE HTS WINDINGS. TWO TORQUE TUBES ARE POSITIONED AT BOTH SIDES OF THE HTS MAGNETS TO TRANSMIT TORQUE AND INSULATE THE HEAT LEAKAGE. THE TUBE IS MADE BY JOINING THE COMPOSITE MATERIAL AND METAL. THE CRYOGENIC SYSTEM INCLUDE 3 CRYOCOOLERS : TWO GM AL330 AND 1 STIRLING SPC-1T. LIQUID NEON GOES INTO ROTOR FROM NON-DRIVE SIDE, AND THE NEON WORKS IN AN ENCLOSED-LOOP. BASED ON THESE RESEARCHES, WE DEVELOP THE TECHNOLOGIES OF ELECTROMAGNETIC DESIGN, AND OTHER KEY TECHNOLOGIES, SUCH AS AIR-GAP ARMATURE, HTS MAGNETS, ROTOR STRUCTURE, CRYOCOOLERS DESIGN INTEGRATION.

4LPD-01

A TUBULAR LINEAR MAGNETIC GEAR USING HTS BULKS FOR FIELD MODULATION ***W. LI****, K. CHAU, J. LI;* THE UNIVERSITY OF HONG KONG. — RECENTLY, A LINEAR MAGNETIC GEAR WHICH CAN TRANSMIT HIGH THRUST FORCE WITHOUT MECHANICAL CONTACT HAS BEEN PROPOSED TO INCREASE THE LINEAR MACHINE THRUST FORCE CAPACITY. HOWEVER, DUE TO THE FINITE PERMEANCE OF FERROMAGNETIC FIELD MODULATION RINGS, ITS PERFORMANCE IS NOT SATISFACTORY. THE PURPOSE OF THIS PAPER IS TO PROPOSE A LINEAR MAGNETIC GEAR USING HTS BULKS FOR FIELD MODULATION, WHICH CAN

OFFER MUCH HIGHER THRUST FORCE CAPACITY THAN THE EXISTING ONE.THE PROPOSED LINEAR MAGNETIC GEAR HAS A TUBULAR STRUCTURE, WHICH CONSISTS OF THE HIGH-SPEED MOVER, THE STATIONARY FIELD MODULATION RINGS AND THE HIGH-SPEED MOVER. BOTH OF THE HIGH-SPEED AND LOW-SPEED MOVERS HAVE PERMANENT MAGNETS MOUNTED ON THEIR IRON CORES. THE FIELD MODULATION RINGS NEWLY ADOPT HTS BULKS TO MODULATE BETWEEN THE HIGH-SPEED AIR-GAP FIELD AND THE LOW-SPEED AIR-GAP FIELD, HENCE AMPLIFYING THE THRUST FORCE AT THE LOW-SPEED MOVER. THE KEY IS THE USE OF HTS BULKS TO ELIMINATE THE FLUX LEAKAGE, WHICH IS INEVITABLE IN FERROMAGNETIC MATERIALS, IN THE FIELD MODULATION RINGS, HENCE SIGNIFICANTLY IMPROVING MAGNETIC FORCE TRANSMISSION.IN THIS PAPER, THE DESIGN CRITERIA AND FINITE ELEMENT ANALYSIS OF THE PROPOSED TUBULAR LINEAR MAGNETIC GEAR ARE PRESENTED. ALSO, A QUANTITATIVE COMPARISON BETWEEN THE PROPOSED HTS-BASED LINEAR MAGNETIC GEAR AND THE EXISTING ONE IS CONDUCTED, HENCE VERIFYING ITS EFFECTIVENESS.

THIS WORK WAS SUPPORTED IN PART BY A GRANT (PROJECT NO. HKU7105/07E) FROM THE HONG KONG RESEARCH GRANTS COUNCIL, AND THE INITIATIVE ON CLEAN ENERGY AND ENVIRONMENT OF THE UNIVERSITY OF HONG KONG, HONG KONG, CHINA.

4LPD-02

DESIGN AND ANALYSIS OF A HTS PERMANENT-MAGNET HYBRID BRUSHLESS MACHINE ***C. LIU****, K. T. CHAU, J. ZHONG, J. LI;* THE UNIVERSITY OF HONG KONG. — RECENTLY, A NEW PERMANENT-MAGNET HYBRID BRUSHLESS (PMHB) MACHINE HAS RECEIVED HIGH ATTRACTION, WHICH CAN ACHIEVE FLEXIBLE FLUX CONTROL USING HYBRID EXCITATIONS OF BOTH PMS AND DC FIELD WINDINGS. HOWEVER, DUE TO THE DC FIELD WINDINGS, IT SUFFERS FROM RELATIVELY LOW TORQUE DENSITY AND ADDITIONAL FIELD WINDING COPPER LOSS. THE PURPOSE OF THIS PAPER IS TO PROPOSE A NEW HTS PMHB MACHINE, WHICH CAN OFFER MUCH HIGHER TORQUE DENSITY AND ELIMINATE THE FIELD WINDING LOSS.THE PROPOSED HTS PMHB MACHINE COMPRISES AN OUTER ROTOR WITH 28 SALIENT POLES, AND A DOUBLE-LAYERED STATOR IN WHICH THE OUTER-LAYER STATOR HAS 24 SALIENT POLES WOUND WITH COPPER ARMATURE WINDINGS, WHILE THE INNER-LAYER STATOR INSTALLS BOTH PMS AND HTS FIELD WINDINGS FOR HYBRID-FIELD EXCITATION. IN ADDITION, HTS BULKS ARE INCORPORATED IN THE STATOR SLOTS SO AS TO ELIMINATE THE FLUX LEAKAGE WHICH IS INEVITABLE IN FERROMAGNETIC MATERIALS. HENCE, THE PROPOSED MACHINE CAN OPERATE WITH TWO MODES, NAMELY THE HTS-PM MODE AND THE PM MODE, IN WHICH THE HTS FIELD WINDING IS ACTIVE ONLY WHEN FLUX CONTROL IS PERFORMED OR HIGH TORQUE DENSITY IS DESIRED.IN THIS PAPER, THE DESIGN CRITERIA, TWO OPERATION MODES, AND FINITE ELEMENT ANALYSIS OF THE PROPOSED HTS-PMHB MACHINE ARE PRESENTED. ALSO, A QUANTITATIVE COMPARISON BETWEEN THE PROPOSED HTS-PMHB MACHINE AND THE EXCITING ONE IS CONDUCTED, HENCE VERIFYING ITS EFFECTIVENESS.

THIS WORK WAS SUPPORTED IN PART BY A GRANT (PROJECT NO. HKU7105/07E) FROM THE HONG KONG RESEARCH GRANTS COUNCIL, AND THE INITIATIVE ON CLEAN ENERGY AND ENVIRONMENT OF THE UNIVERSITY OF HONG KONG, HONG KONG, CHINA.

4LPD-03

DESIGN AND ANALYSIS OF A SUPERCONDUCTOR LINEAR GENERATOR FOR WAVE ENERGY CONVERTER ***M. MIRZAEI****[1], S. ABDOLLAHI[2];* [1]ELECTRICAL ENGINEERING DEPARTMENT, AMIRKABIR UNIVERSITY OF TECHNOLOGY, [2]ELECTRICAL ENGINEERING DEPARTMENT, UNIVERSITY OF TEHRAN. — RENEWABLE ENERGY RESOURCES ARE ALTERNATIVE FOR FOSSIL AND NUCLEAR ENERGY RESOURCES TO REDUCE THE AIR POLLUTION. RECENTLY MANY WORKS HAVE BEEN PRESENTED TO PRODUCE ELECTRICAL POWER FOR WAVE ENERGY USING LINEAR GENERATOR. PERMANENT MAGNET LINEAR GENERATORS HAVE A HIGH POTENTIAL USING RARE EARTH MAGNETS SUCH AS NDFEB TO GENERATE ELECTRICAL ENERGY FROM LINEAR MOTION OF WAVE. THE DISAVANTAGE OF PERMANENT MAGNET EXCITATION IS HIGH WEIGHT OF MOVING PART ESPECIALLY IN LARGE POWER RANGE. THIS MAKES THE WHOLE SYSTEM TO BE HEAVY AND DIFFICULT FOR INSTALLATION AND TRANSPORTATION.SUPERCONDUCTOR EXCITATION HAS HIGHER ENERGY DENSITY THAN PERMANENT MAGNETS WHICH MEANS HIGHER ENERGY PRODUCTION IN A COMPACT VOLUME. IN THIS PAPER, A NOVEL STRUCTURE OF AIR CORE LINEAR GENERATOR WITH SUPERCONDUCTING EXCITATION IN THE MOVING SIDE IS ANALYZED AND OPTIMIZED FOR HIGH POWER RANGE. THE AIR CORE STRUCTURE HELPS TO REDUCE THE ARMATURE EFFECT AND ALTERNATING FIELD ON SUPERCONDUCTOR WINDINGS. THE 3D FIELD DISTRIBUTIONS IN THE PROPOSED LINEAR GENERATOR NEEDS 3D ANALYSIS WHICH ARE DONE BY DEVELOPED ANALYTICAL METHOD AND 3D FINITE ELEMENT ANALYSIS. FINALLY A THERMAL CALCULATIONS ARE PRESENTED TO EVALUATE THE COPPER ARMATURE AND SUPERCONDUCTOR WINDINGS TEMPERATURE.

4LPD-04

EXPERIMENTAL MAGNETIZATION AND OPERATION OF A HIGH-TC SUPERCONDUCTING MOTOR ***W. XIAN****, Y. YAN, W. YUAN, T. A. COOMBS;* THE UNIVERSITY OF CAMBRIDGE. — A HIGH TEMPERATURE (77K) SUPERCONDUCTING (HTS) MAGNET SYNCHRONOUS MOTOR IS DESIGNED AND DEVELOPED IN CAMBRIDGE UNIVERSITY. THERE ARE 75 PIECES OF YBCO BULKS SURFACE MOUNTED ON THE ROTOR AND 6 RACETRACK COPPER WINDINGS ON STATOR. A PULSED FIELD MAGNETIZATION WAS APPLIED ON THE ROTOR TO TRAP A 4 POLES MAGNETIC FIELD OF 800 MT FOR MAXIMUM VALUE. THE DISTRIBUTION OF TRAPPED MAGNETIC FIELD ON YBCO BULKS ARRAY IS DETAILED. THE MOTOR SPEEDED UP TO 1000 RPM AND RUN SMOOTHLY IN NO-LOAD OPERATION. THE FLUX ATTENUATION CHARACTERISTICS OF YBCO BULKS ON ROTOR DUE TO AC LOSSES IN DIFFERENT OPERATION TIME AND SPEEDS ARE MEASURED AND ANALYZED IN THIS EXPERIMENT.

4LPD-05

A NOVEL HTS-PM VERNIER MOTOR FOR DIRECT-DRIVE PROPULSION ***J. LI****, K. CHAU;* THE UNIVERSITY OF HONG KONG. — THIS PAPER PROPOSES A NOVEL HIGH-TEMPERATURE-SUPERCONDUCTOR PERMANENT-MAGNET (HTS-PM) VERNIER MACHINE FOR DIRECT-DRIVE SHIP OR SUBMARINE PROPULSION, WHICH CAN OFFER LOW-SPEED HIGH-TORQUE DRIVELINE TO IMPROVE THE TRANSMISSION EFFICIENCY AND HIGH-SPEED ROTATING FIELD DESIGN TO MAXIMIZE THE POWER DENSITY. THE KEY IS TO NEWLY INTRODUCE HTS BULKS AS FLUX MODULATION POLES (FMPS) WHICH CAN EFFECTIVELY MODULATE THE HIGH-SPEED ROTATING FIELD OF THE ARMATURE WINDINGS AND THE LOW-SPEED ROTATING FIELD OF THE PM OUTER ROTOR.THE PROPOSED MOTOR ADOPTS THE OUTER-ROTOR CONFIGURATION. THERE ARE 9 SLOTS IN THE INNER STATOR, WHICH ARE OCCUPIED BY 3-PHASE ARMATURE WINDINGS WITH 6 POLES. EACH STATOR TOOTH HAS 3 FMPS, THUS CONSTITUTING TOTALLY 27 FMPS. THE SLOTS OF THE FMPS ARE PASTED WITH HTS BULKS TO PERFORM LEAKAGE-FREE FLUX MODULATION. THERE ARE 48 PIECES OF PM BULKS MOUNTED ON THE OUTER ROTOR TO FORM 48 PM POLES. THUS, THE ROTOR SPEED IS 1/8 OF AND HENCE THE OUTPUT TORQUE IS 8 TIMES THAT IN A CONVENTIONAL MOTOR WITH THE SAME NUMBER OF ARMATURE WINDING POLE-PAIRS.BY USING FINITE ELEMENT ANALYSIS, THE PROPOSED MOTOR IS QUANTITATIVELY COMPARED WITH VARIOUS LOW-SPEED HIGH-TORQUE MOTORS, NAMELY THE PM BRUSHLESS MOTOR WITH OR WITHOUT A MECHANICAL GEAR, MAGNETIC-GEARED PM MOTOR AND PM VERNIER MOTOR, HENCE VERIFYING ITS MERITS OF HIGH TRANSMISSION EFFICIENCY AND HIGH POWER DENSITY.

THIS WORK WAS SUPPORTED IN PART BY A GRANT (PROJECT NO. HKU7105/07E) FROM THE HONG KONG RESEARCH GRANTS COUNCIL, AND THE INITIATIVE ON CLEAN ENERGY AND ENVIRONMENT OF THE UNIVERSITY OF HONG KONG, HONG KONG, CHINA.

4LPD-06

PULSE FIELD MAGNETIZATION PROPERTIES OF BULK RE-BA-CU-O AS POLE-FIELD MAGNETS FOR HTS ROTATING MACHINES ***Z. DENG***[1]*, M. MIKI*[1]*, B. FELDER*[1]*, K. TSUZUKI*[1]*, R. TAGUCHI*[1]*, N. SHINOHARA*[1]*, H. HAYAKAWA*[2]*, M. IZUMI*[1]*;* [1]TOKYO UNIVERSITY OF MARINE SCIENCE AND TECHNOLOGY, [2]KITANO SEIKI CO. LTD.. *— AIMING AT EXPLOITING THE HIGH TRAPPED FIELD ABILITY OF BULK HIGH-TEMPERATURE RE-BA-CU-O (RE: RARE-EARTH ELEMENTS) SUPERCONDUCTORS (HTS), A BRUSHLESS AXIAL-GAP TYPE HTS SYNCHRONOUS MOTOR AS A TECHNOLOGY DEMONSTRATOR HAS BEEN SUCCESSFULLY DEVELOPED USING 8 MELT-TEXTURED* $GDBA_2CU_3O_Y$ *(GD-123) BULKS AS POLE-FIELD MAGNETS, AND AN OUTPUT POWER OF 10 KW AT 720 RPM HAS BEEN REALIZED BY AN AVERAGE MAXIMUM TRAPPED FIELD 0.56 T OF EIGHT BULKS ON THE SURFACE OF ARMATURE COILS UNDER A PULSED FIELD EXCITATION IN LIQUID NITROGEN (LN2) TEMPERATURE. FOR SUCH MOTORS, TO IMPROVE THE TRAPPED FLUX OF BULKS IS A DIRECT-WAY TO ENHANCE THE MOTOR PERFORMANCE. IN ORDER TO OBTAIN A HIGH TRAPPED FLUX DENSITY WITH REGULAR SHAPE FOR THE HIGH PERFORMANCE MOTOR UTILIZATION, THE PULSED FIELD MAGNETIZATION (PFM) PROPERTIES OF TWO KINDS OF HTS BULKS HAVE BEEN INVESTIGATED IN THE PAPER. BY A REASONABLE MULTI-PFM PROCESS WITH A PAIR OF VORTEX-TYPE PULSE COILS, IT WAS FOUND THAT THE MULTI-SEED Y-BA-CU-O BULK CAN BRING A HIGH AVERAGE TRAPPED FIELD, WHILE THE MULTI-RING GD-BA-CU-O BULK CAN BRING A VERY REGULAR TRAPPED FIELD DISTRIBUTION. THESE RESULTS WILL BE USEFUL TO THE FOLLOWING OPTIMIZATION OF THE MOTOR SYSTEM. INDEX WORDS: HIGH TEMPERATURE SUPERCONDUCTORS, POLE-FIELD MAGNETS, PULSE FIELD MAGNETIZATION, ROTATING MACHINES, TRAPPED FIELD*

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4LPD-07

INFLUENCE OF AC MAGNETIC FIELD ON AN HTS ROTATING MACHINE WITH GD-BULK HTS FIELD-POLE MAGNETS ***M. MIKI***[1]*, B. FELDER*[1]*, Z. DENG*[1]*, K. TSUZUKI*[1]*, N. SHINOHARA*[1]*, M. IZUMI*[1]*, T. IDA*[2]*, H. HAYAKAWA*[3]*;* [1]TOKYO UNIVERSITY OF MARINE SCIENCE AND TECHNOLOGY, [2]HIRISHIMA NATIONAL COLLEGE OF MARINE TECHNOLOGY, [3]KITANO SEIKI CO. LTD.. — 1G OR 2G HTS WIRE WINDING COILS ARE USUALLY ADOPTED AS FIELD POLES IN HTS ROTATING MACHINES. IN THAT CASE, AC MAGNETIC FIELD COMING FROM THE STATOR DECREASES THE PERFORMANCE OF THE HTS COILS. TO PREVENT THE AC LOSSES, MANY RESEARCHES HAVE BEEN CONDUCTED WORLDWIDE. ELECTRO-MAGNETIC SHIELDING BY USING ALUMINUM AND/OR COPPER PLATES IS THE MOST CONVENTIONAL METHOD TO PREVENT AN AC MAGNETIC FIELD FROM INTERFERING. AN AXIAL-GAP TYPE HTS SYNCHRONOUS MOTOR WITH GD-123 BULK HTS FIELD-POLE MAGNETS FOR SHIP PROPULSION HAS BEEN DEVELOPED IN OUR GROUP SINCE 2001. IN THE CASE OF BULK HTS MAGNETS, AN AC MAGNETIC FIELD FROM THE STATOR COILS ALSO HAS AN IMPACT, WHICH IS THE DECAY OF THE TRAPPED FIELD. GENERALLY SPEAKING, THE MECHANISM OF DECAY OF THE TRAPPED FIELD COMES FROM FLUX PENETRATION INTO THE BULK MATERIAL. ESPECIALLY, THE AC EXTERNAL MAGNETIC FIELD WHOSE DIRECTION IS PERPENDICULAR TO THE BULK SURFACE AFFECTS THE TRAPPED FIELD DRASTICALLY BECAUSE THE J_C ON THE C-AXIS IS SMALLER THAN A-B PLANE'S. CLARIFICATION OF THIS PHENOMENON INSIDE THE MOTOR IS CONSIDERED TO BE VERY IMPORTANT DUE TO THE PROBLEM OF RE-MAGNETIZATION FOR BULK HTS MAGNETS. CURRENTLY, WE HAVE BEEN CONDUCTING A ROTATION TEST ON THE BULK-HTS MOTOR WHILE ADDING AN AC EXTERNAL MAGNETIC FIELD WITH AN INVERTER. IN THIS PAPER, WE WILL REPORT THE INFLUENCE OF AC EXTERNAL MAGNETIC FIELD ON THE BULK HTS MAGNETS INSIDE THE MOTOR DURING ROTATION.

4LPD-08

TORQUE DENSITY COMPARISON OF DOUBLE-STATOR AND TRADITIONAL PERMANENT MAGNET BRUSHLESS MOTORS ***Y. WANG***[1]*, M. CHENG*[1]*, K. CHAU*[2]*;* [1]SOUTHEAST UNIVERSITY,

[2]HONG KONG UNIVERSITY. — DUE TO THE ADVANTAGES OF HIGH EFFICIENCY AND HIGH TORQUE DENSITY, PERMANENT MAGNET BRUSHLESS (PMBL) MOTORS HAS BECOME A PREFERRED CANDIDATE FOR PROPULSION SYSTEMS OF ELECTRIC VEHICLES AND HYBRID VEHICLES. RECENTLY, THE DOUBLE-STATOR PMBL (DS-PMBL) MOTOR HAS BEEN PROPOSED, WHICH IS CLAIMED TO OFFER MUCH HIGHER TORQUE DENSITY. THE PURPOSE OF THIS PAPER IS TO PROPOSE A NEW DESIGN CRITERION TO OPTIMIZE THE TORQUE DENSITY OF VARIOUS PMBL MOTORS, AND HENCE TO QUANTITATIVELY COMPARE THE DS-PMBL MOTOR WITH ITS TRADITIONAL COUNTERPARTS.THE KEY OF THE PROPOSED DESIGN CRITERION IS BASED ON THE OPTIMAL SPLIT RATIO. THE SPLIT RATIOS OF THE TRADITIONAL INNER-ROTOR PMBL MOTOR, TRADITIONAL OUTER-ROTOR PMBL MOTOR AND DS-PMBL MOTOR ARE DEFINED AS THE RATIO OF STATOR INSIDE DIAMETER TO STATOR OUTSIDE DIAMETER, THE RATIO OF INNER-STATOR YOKE DIAMETER TO INNER-STATOR OUTSIDE DIAMETER AND THE RATIO OF INNER-STATOR OUTSIDE DIAMETER TO OUTER-STATOR OUTSIDE DIAMETER, RESPECTIVELY. ACCORDINGLY, THEIR OPTIMAL SPLIT RATIOS CAN BE MATHEMATICALLY DEDUCED. THE CORRESPONDING OPTIMAL TORQUE DENSITIES ARE THEN VERIFIED BY USING FINITE ELEMENT ANALYSIS. ADDITIONALLY, THE ANALYSIS SHOWS THAT THE DS-PMBL MOTOR NOT ONLY CAN PROVIDE HIGHER TORQUE DENSITY THAN ITS COUNTERPARTS, BUT ALSO CAN EFFECTIVELY REDUCE THE CONSUMPTION OF PM MATERIAL.

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4LPE-01

RESEARCH OF MAGLEV PROJECT FOR HTS MAGLEV LUANCH ***F. GUO****, Y. J. TANG;* HUAZHONG UNIVERSITY OF SCIENCE AND TECHNOLOGY. — MAGNETIC LEVITATION LAUNCH COULD AVOID THE CONTACT BETWEEN THE PROJECTILE AND RAIL, DECREASE FRICTION, REDUCE LOSSES AND IMPROVE THE LAUNCH EFFICIENCY. THE SELECTION OF MAGLEV PROJECT FOR THE HTS (HIGH TEMPERATURE SUPERCONDUCTIVE) MAGLEV LAUNCH IS MAINLY DISCUSSED IN THIS PAPER. THREE TYPES OF MAGNETIC MAGLEV RAILS (TWO TRADITIONAL STRUCTURES RAIL AND HALBACH ARRAY RAIL) ARE INTRODUCED AT FIRST. THE ABILITIES OF PROVIDE LEVITATION FORCE ARE COMPARED THOUGH COMPARING THE MAGNETIC FIELD AND MAGNETIC FIELD GRADIENT. THE RESULTS SHOW THAT, HALBACH ARRAY HAS OBVIOUS ADVANTAGES ON THE SURFACE MAGNET FIELD DISTRIBUTION THAN THE TWO TRADITIONAL STRUCTURES. HALBACH ARRAY COULD PROVIDE A STRONG LEVITATION FORCE , AND IS MORE SUITABLE FOR APPLICATION IN THE DESIGN OF THE MAGLEV RAIL.

THIS WORK WAS SUPPORTED IN PART BY SCHOOL FUND.

4LPE-02

RECENT DEVELOPMENTS OF HIGH TEMPERATURE SUPERCONDUCTING MAGLEV AT THE ASCLAB ***J. S. WANG****, S. S. WANG, J. ZHENG, F. YEN, G. T. MA;* SOUTHWEST JIAOTONG UNIVERSITY. — RESEARCH AND DEVELOPMENT IN THE FIELD OF HIGH TEMPERATURE SUPERCONDUCTING (HTS) MAGLEV IS TAKING PLACE MORE AND MORE IN INSTITUTIONS AROUND THE WORLD. WE REPORT THE RECENT HIGHLIGHTS AND ONGOING EXPERIMENTS ON THE HTS MAGLEV AT THE APPLIED SUPERCONDUCTIVITY LABORATORY AT SOUTHWEST JIAOTONG UNIVERSITY. THE STABILITY OF THE MAGLEV IS IMPROVED THROUGH THE USAGE OF BULK HTS SAMPLES AS MAGNETS OVER A PERMANENT MAGNET GUIDEWAY (PMG). A 3-D MODEL OF THE SUPERCONDUCTOR FOR THE MAGLEV APPLICATION HAS BEEN ESTABLISHED BASED ON THE CURRENT POTENTIAL VECTOR AND MAGNETIC FIELD INTENSITY METHODS. DYNAMIC EXPERIMENTS HAVE BEEN PERFORMED TO STUDY THE EFFECTS OF SPEED ON THE PERFORMANCE ON THE MAGLEV WITH THE AID OF A CIRCULAR ROTATING PMG. LASTLY, THE TRACTION ASPECT OF THE MAGLEV HAS BEEN DESIGNED EMPLOYING HTS COATED CONDUCTORS AND UNDERGOING THROUGH PRELIMINARY EXPERIMENTS.

THIS WORK WAS MADE POSSIBLE BY THE SUPPORT OF THE NATIONAL LABORATORY OF RAIL TRANSIT OF THE PEOPLE'S REPUBLIC OF CHINA GRANT NUMBERS 2009TPL_Z01 & 2009TPL_Z02 AND THE NATIONAL NATURAL SCIENCE FOUNDATION OF CHINA GRANT NUMBERS 50677057 & 50777053.

4LPE-03

MAGNETIC POTENTIAL WELL AS A NEW MAGNETIC LEVITATION PHENOMENON ***V. KOZOREZ****;* TARAS SHEVCHENKO NATIONAL UNIVERSITY OF KYIV. — AMONG FUNDAMENTAL INTERACTIONS, ONLY NUCLEAR PAIRWISE INTERACTION HAS A LOCAL MINIMUM OF POTENTIAL ENERGY. OTHERS ARE DESCRIBED BY MONOTONICALLY CHANGING FUNCTIONS OF DISTANCE. SOME EXAMPLES OF THIS MONOTONICITY ARE THE INVERSE DISTANCE LAW OF THE POTENTIAL ENERGY OF TWO GRAVITATING MASSES OR ELECTRIC CHARGES, AND THE INVERSE CUBIC LAW FOR TWO MAGNETIC DIPOLES INTERACTION.THE POTENTIAL ENERGY MONOTONICITY IS A KEYSTONE TO THE STABILITY PROBLEM. EARNSHAW'S THEOREM DECLARES THE FREE EQUILIBRIUM INSTABILITY OF A PERMANENT MAGNET SUSPEND BY OTHER PERMANENT MAGNETS.BRAUNBECK FOUND EXCLUSION FORM THIS RULE BY THE USE OF DIAMAGNETIC. SUPERCONDUCTING REPULSIVE LEVITATION OF A BULK AND ELECTRODYNAMIC LEVITATION ARE EXAMPLES OF STABLE LEVITATION.THE SECOND EXCEPTION IS THE MAGNETIC POTENTIAL WELL (MPW) OR THE PROPERTY OF TWO REMOVED MAGNETS TO CHANGE ATTRACTION INTO REPULSION BY ONLY DECREASING SPACING. FOR TWO CLOSED THIN SUPERCONDUCTING LOOPS, THE CONDITIONS OF THE MPW-EXISTENCE ARE REPRESENTED. TESTING MPW-CONDITIONS AND MPW-LEVITATION ARE REPRESENTED.

4LPE-04

A DRIVEN MODE RESEARCH OF A HTS MAGLEV PARALLEL COIL GUN ***F. GUO****, Y. J. TANG;* HUAZHONG UNIVERSITY OF SCIENCE AND TECHNOLOGY. — COMPARED WITH THE COAXIAL COIL GUN, THE STRUCTURE OF PARALLEL COIL GUN IS CONDUCIVE TO RELEASE THE EFFECTIVE LOAD WHICH CARRIED BY THE EMITTER, AND EASY TO ADD THE SUSPENSION DEVICE. SO, FOR SOME MASSIVE EMITTER WHICH COULD NOT BE EASY WRAPPED INSIDE OF THE BARREL, TO DESIGN AN OPEN PARALLEL COIL GUN WITH A HIGH TEMPERATURE SUPERCONDUCTING (HTS) MAGLEV IS GREAT SIGNIFICANCE. MAGNETIC LEVITATION LAUNCH COULD AVOID THE CONTACT BETWEEN THE PROJECTILE AND RAIL, DECREASE FRICTION, REDUCE LOSSES AND IMPROVE THE LAUNCH EFFICIENCY. THE HALBACH ARRAY PERMANENT MAGLEV RAIL COULD BE USED IN THE MAGNETIC LEVITATION LAUNCH SYSTEM. THE MAGNETIC FIELD ALONG THE LAUNCH DIRECTION PROVIDED BY THE RAIL IS EVEN. SO THE RAIL DOES NOT PROVIDE MAGNETIC RESISTANCE. THE DRIVE SYSTEM CAN BE SOLELY ANALYZED. FOR THE PARALLEL COIL GUN, THE DIRECTIONS OF DRIVING FORCE ARE INCONSISTENT DURING THE DRIVE CURRENT PULSE UP AND DOWN UNDER ONLY ONE COIL DRIVEN. ELIMINATING THE RESISTANCE IS AN EFFECTIVE WAY TO IMPROVE THE EMISSION EFFICIENCY. A NEW MODE OF SINGLE-STAGE AND MULTI-STAGE DRIVEN IS DESIGNED IN THIS PAPER. THE PULSE LINK UP METHOD BETWEEN THE VARIOUS COILS IS ANALYZED. A SMALL PARALLEL COIL GUN MODEL IS ESTABLISHED IN THE FINITE ELEMENT SOFTWARE ANSOFT. THE PROPULSION EFFECTS OF SINGLE-STAGE AND TWO-STAGE DRIVEN ARE SIMULATED. AND THE SIMULATION RESULTS VERIFY THE FEASIBILITY OF THIS DRIVEN MODE.

THIS WORK WAS SUPPORT BY SCHOOL FUND.

4LPE-05

CHARACTERISTIC ANALYSIS ON GROUND CONDUCTORS IN HTS EDS SYSTEM ***D. BAE***[1]*, H. KANG*[1]*, Y. CHUNG*[2]*, T. KO*[3]*;* [1]CHUNGJU NATIONAL UNIVERSITY, [2]SUWON UNIVERSITY, [3]YONSEI UNIVERSITY. — ELECTRODYNAMIC SUSPENSION (EDS) MAGNETIC LEVITATION (MAGLEV) TRAIN IS A STRONG CANDIDATE FOR A ULTRA HIGH SPEED GROUND TRANSIT SYSTEM. A HIGH-TC SUPERCONDUCTING (HTS) MAGNET IS THE MOST SUITABLE LEVITATION MAGNET FOR A HIGH SPEED EDS MAGLEV TRAIN. THE SOURCE OF THE LEVITATION FORCE IN THE EDS SYSTEM IS THE MAGNETIC INTERACTION BETWEEN MOVING LEVITATION MAGNET AND GROUND CONDUCTOR. THE LEVITATION MAGNETS ARE MOUNTED ON THE TRAIN AND THE GROUND CONDUCTORS ARE MOUNTED THE WHOLE GUIDE WAY. THE CHARACTERISTIC ANALYSIS ON THE GROUND CONDUCTOR SHOULD IMPLEMENT TO DESIGN THE POWERFUL AND ECONOMICAL MAGLEV TRAIN SYSTEM. THIS PAPER DEALS WITH THE CHARACTERISTICS OF THE GROUND CONDUCTORS IN HTS EDS SYSTEM. THE STATIC EDS SIMULATOR WAS USED IN THE ANALYSIS. THE CURRENT DISTRIBUTION AND MAGNETIC CHARACTERISTICS OF VARIOUS GROUND CONDUCTORS WERE STUDIED BOTH BY NUMERICAL SIMULATION AND EXPERIMENTAL TEST.

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4LPE-06

TRIAL MANUFACTURE OF SMALL HTS MAGNET USING 2G WIRES FOR MAGLEV TRAIN APPLICATION ***M. OGATA****, K. MIZUNO, Y. ARAI, H. HASEGAWA, T. SASAKAWA, K. NAGASHIMA;* RAILWAY TECHNICAL RESEARCH INSTITUTE. — THERE ARE SEVERAL ADVANTAGES BY APPLYING A HIGH TEMPERATURE SUPERCONDUCTING WIRE TO AN ON-BOARD SUPERCONDUCTING MAGNET FOR THE MAGLEV TRAIN. AT FIRST, AN INCREASE OF THERMAL CAPACITY OF SUPERCONDUCTING COILS CONTRIBUTES A STABILITY OF THE SUPERCONDUCTING STATE OF THE COILS. IN ADDITION, A RELIABILITY OF SUPERCONDUCTING MAGNET IMPROVES BY SIMPLIFICATION OF THE MAGNET STRUCTURE. AND THE WEIGHT OF THE SUPERCONDUCTING MAGNET AND THE ENERGY CONSUMPTION OF THE ON-BOARD CRYOCOOLER WILL DECREASE. THEREFORE, WE HAVE CARRIED OUT THE NEXT STEPS, EVALUATION OF 2G WIRES, SINGLE COIL WINDING USING 2G WIRES, EVALUATION OF SINGLE COILS, STACKING THE SINGLE COILS, EVALUATION OF STACKED COIL AND TRIAL MANUFACTURE OF SMALL HTS MAGNET USING STACKED COIL. IN THIS PAPER, WE REPORT THE MERITS OF APPLYING 2G WIRES TO SUPERCONDUCTING MAGNET FOR MAGLEV TRAIN, AND THE TEST RESULTS OF TRIAL MANUFACTURE OF SMALL HTS MAGNET.

THIS STUDY IS FINANCIALLY SUPPORTED BY THE MINISTRY OF LAND, INFRASTRUCTURE AND TRANSPORT, JAPAN.

4LPE-07

DESIGN AND ANALYSIS OF A SUPERCONDUCTING LINEAR SYNCHRONOUS MOTOR FOR MAGLEV TRANSPORTATION SYSTEM *S. E. ABDOLLAHI*[1]*,* ***M. MIRZAEI***[2]*;* [1]UNIVERSITY OF TEHRAN, [2]AMIRKABIR UNIVERSITY OF TECHNOLOGY. — MAGLEV SYSTEMS ARE DEPLOYING TRANSPORTATION SYSTEMS AROUND THE WORLD. TYPE OF PROPULSION MOTOR USED IN THESE SYSTEMS VARIES FROM LINEAR INDUCTION MOTORS UP TO DIFFERENT TYPES OF LINEAR SYNCHRONOUS ONES. THESE DIFFERENT MOTORS HAVE THEIR OWN DRAWBACK AND ADVANTAGES ESPECIALLY IN MAGLEV TRANSPORTATION APPLICATION. IN THIS PAPER HIGH T_C SUPERCONDUCTING (HTS) WIRES WERE EMPLOYED IN SECONDARY COILS OF A LINEAR SYNCHRONOUS MOTOR WITH NEW TOPOLOGY. BECAUSE OF LARGE CURRENT DENSITIES IN HTS EXCITATION COILS LARGE THRUST FORCE IS GENERATED IN COMPARISON TO CONVENTIONAL LINEAR MOTORS THAT REDUCE ONBOARD EQUIPMENT SIZE AND WEIGHT IN MAGLEV TRAINS WITH GENERATION OF SUFFICIENT PROPULSION FORCE. DESIGN AND PERFORMANCE ANALYSIS OF THE DESIRED MOTOR IS PRESENTED. ANALYTICAL APPROACH IS EMPLOYED TO EVALUATE THRUST AND LIFT FORCES. INDEED DISCUSSION RELATION AND EQUATIONS ARE PRESENTED. AT THE END SIMULATION RESULTS ARE COMPARED WITH CONVENTIONAL TOPOLOGY PERFORMANCE SPECIFICATIONS.

4LPE-09

CONCEPTUAL DESIGN OF HTS COIL IN SUPERCONDUCTING ELECTROMAGNET FOR MAGLEV ***C. LEE***[1]*, J. KIM*[1]*, D. BAE*[2]*, Y. YOON*[3]*, J. JANG*[4]*, T. KO*[4]*;* [1]KOREA RAILROAD RESEARCH INSTITUTE, [2]CHUNGJU NATIONAL UNIVERSITY, [3]ANSAN COLLEGE OF TECHNOLOGY, [4]YONSEI UNIVERSITY. — IN A PROTOTYPE HTS-EM MODEL FOR THE ELECTROMAGNETIC SUSPENSION(EMS)-BASED MAGLEV, THIS STUDY PRESENTS A CONCEPTUAL DESIGN OF HTS COIL USING YBCO WIRE. BECAUSE THE SIZE OF HTS COIL AND THE POWER CONSUMPTION TO OPERATE IT ARE VERY CRITICAL FACTORS IN DESIGN THE HTS-EM, WE FOCUS ON ITS FEASIBLE WINDING GEOMETRY AND OPERATING CONDITION TO GENERATE THE REQUIRED MAGNETO-MOTIVE FORCE(MMF) EFFECTIVELY. THE WINDING GEOMETRY IS FOUND FROM THE SHAPE OF SAMPLE HTS COIL HAVING THE LARGEST CRITICAL CURRENT, WHICH IS MEASURED AT AN IRON CORE TO DEMONSTRATE THE HTS-EM. WITH THE GIVEN SPECIFICATION OF YBCO WIRE, THE COIL CAN BE DESIGNED AS THE CROSS-SECTIONAL LENGTH OF 50MM IN CRYOSTAT. WHEN WE CONSIDER THE MAXIMUM CURRENT SUPPLIED FROM DC CURRENT SOURCE AS 100A, FEASIBLE COIL TURNS TO GENERATE THE REQUIRED MMF EFFECTIVELY MUST BE MORE THAN ABOUT 400 TURNS AT OPERATING TEMPERATURE OF ABOUT 65K.

4LPF-01

A CRYO-FREE 10 T HIGH-FIELD MAGNET SYSTEM FOR A NOVEL SUPERCONDUCTING APPLICATION ***W. STAUTNER****, K. HARAN, S. MINE, J. ROCHFORD;* GE GLOBAL RESEARCH. — WE PRESENT THE ENGINEERING ASPECTS OF A CRYO-FREE 10 T HIGH-FIELD MAGNET SYSTEM FOR A COMPLETELY NEW TYPE OF SUPERCONDUCTING APPLICATION.DESIGN CRITERIA AND SPECIFICATIONS FOR THE RACE-TRACK SHAPED CONDUCTION-COOLED MAGNET, AND THE CRYOSTAT ARE DISCUSSED AND DISCLOSED.WE SHOW FIRST RESULTS ON CRYOSTAT AND MAGNET COOLDOWN AS WELL AS ON MAGNET PERFORMANCE OF THIS ENGINEERING PROTOTYPE.

4LPF-02

HIGH TEMPERATURE SUPERCONDUCTING DEGAUSSING FROM FEASIBILITY STUDY TO FLEET ADOPTION ***J. KEPHART****, B. FITZPATRICK, M. PYRYT;* NAVAL SURFACE WARFARE CENTER - CARDEROCK DIVISION. — THE NEED FOR INCREASED MAGNETIC SIGNATURE CONTROL ON NAVY SHIPS HAS LEAD TO THE DEVELOPMENT AND ADOPTION OF THREE AXIS ADVANCED DEGAUSSING SYSTEM. WHILE THIS SYSTEM IS EFFECTIVE IN REDUCING THE SHIP MAGNETIC SIGNATURE, IT REQUIRES SIGNIFICANTLY MORE COPPER CABLE THAN THE LEGACY TWO AXIS SYSTEMS. DEGAUSSING ONLY REQUIRES DC CURRENTS FOR FIELD MANIPULATION. SINCE DC APPLICATIONS ARE WHERE HTS USE EXCELS, A FEASIBILITY STUDY WAS CONDUCTED IN FY04 TO DETERMINE THE BENEFITS OF HTS WHEN USED IN AN ADVANCED DEGAUSSING SYSTEM. RESULTS SHOWED REDUCED SYSTEM SIZE AND WEIGHT WHILE REMAINING COST NEUTRAL. A SERIES OF LAB BASED DEMONSTRATIONS WERE CONDUCTED PROVING OUT KEY ASPECTS OF AN HTS DG SYSTEM, MOST NOTABLY COOLING A LONG LENGTH OF FLEXIBLE CRYOSTAT WITH GASEOUS HELIUM. THIS LED TO AN AT SEA DEMONSTRATION OF SINGLE HTS DG LOOP ABOARD THE USS HIGGINS. THIS WAS THE FIRST HTS SYSTEM INSTALLED ON AN ACTIVE COMBATANT, AND IT MADE A SUCCESSFUL MAGNETIC RANGE RUN IN APRIL 2009 DEMONSTRATING ITS' CAPABILITY TO PERFORM IN A NAVAL ENVIRONMENT. THIS PAPER DETAILS THE DEVELOPMENT OF THE HTS DG SYSTEM FROM THE INITIAL FEASIBILITY STUDY THROUGH THE SUCCESSFUL DEMONSTRATION ONBOARD THE USS HIGGINS.

THE AUTHORS WOULD LIKE TO ACKNOWLEDGE THE SUPPORT OF PROVIDED BY THE OFFICE OF NAVAL RESEARCH AND IN PARTICULAR, GEORGE STIMAK.

4LPF-03

SUITABLE STRUCTURE OF PM-PM SYSTEM WITH A COPPER PLATE FOR REDUCING VIBRATION TRANSMISSION AND IMPROVING DAMPING EFFECT IN A SUPERCONDUCTING SEISMIC ISOLATION DEVICE ***S. SASAKI***[1]*, K. SHIMADA*[1]*, T. YAGAI*[1]*, M. TSUDA*[1]*, T. HAMAJIMA*[1]*, N. KAWAI*[2]*, K. YASUI*[2]*;* [1]TOHOKU UNIVERSITY, [2]OKUMURA CORPORATION. — WE HAVE INVESTIGATED THE BASIC PROPERTIES OF LEVITATION FORCE AND VIBRATION TRANSMISSION IN A MAGNETIC LEVITATION TYPE SUPERCONDUCTING SEISMIC ISOLATION DEVICE. SINCE IT IS VERY DIFFICULT IN A REAL DEVICE TO KEEP THE STATIONARY LEVITATION OF A SEISMIC ISOLATION DEVICE STABLY AGAINST ANY HORIZONTAL DISTURBANCES, WE HAVE DEVISED A PM-PM SYSTEM WITH A COPPER PLATE AND VERIFIED THAT THE STABLE STATIONARY LEVITATION OF THE SEISMIC ISOLATION OBJECT COULD BE ACHIEVED BY USING IT. WE HAVE INVESTIGATED THE BASIC TRANSMISSION PROPERTIES OF VIBRATION AND DAMPING EFFECT IN THE DEVICE. THE MODEL DEVICE, HOWEVER, HAS A TRADE-OFF CHARACTERISTIC BETWEEN THE REDUCTION OF THE VIBRATION TRANSMISSION AND THE IMPROVEMENT OF THE DAMPING EFFECT DUE TO THE MAGNETIC INTERACTION BETWEEN THE COPPER PLATE AND THE PERMANENT MAGNET. IN THIS PAPER, WE INVESTIGATED THE RELATIONSHIP BETWEEN THE MAGNETIC INTERACTION AND THE GAP BETWEEN THE COPPER PLATE AND THE PERMANENT MAGNET. WE OBTAINED THE SUITABLE GAP, SIZE, AND ARRANGING METHOD OF THE COPPER PLATE AND THE PERMANENT MAGNET FOR REDUCING THE VIBRATION TRANSMISSION AND IMPROVING THE DAMPING EFFECT.

4LPF-04

CONDUCTION-COOLED SUPERCONDUCTING MAGNET WITH PERSISTENT CURRENT SWITCH OPERATION ***Q. WANG****;* INSTITUTE OF ELECTRICAL ENGINEERING, CHINESE ACADEMY OF SCIENCES. — A SUPERCONDUCTING MAGNET WITH THE CENTER FIELD OF 4.5T COOLED BY GM AND OPERATING IN PERSISTENT CURRENT MODE HAS BEEN DESIGN AND FABRICATED FOR THE GYROTRON. THE SUPERCONDUCTING MAGNET HAS THE WARM BORE SIZE OF 90 MM, THE HOMOGENEITY REGION WITH THE DIAMENTER 40 MM AND LENGTH IN 230 MM. THE RATIO OF THE RADIUS FIELD TO THE CENTER FIELD LOACATED AT 180 MM IS OVER THAN 88%. IN THE OTHER SPECIAL POINTS, THE RATIOS OF THE RADIUS FIELD

TO AXIAL FIELD SHOULD LESS THAN FROM 3% TO 11%. THE SUPERCONDUCTING SWITCH WITH SUPERCONDUCTING JOINT IS CONNECTED TO SUPERCONDUCTING MAGNET. IN THE PAPER, THE DETAILED DESIGN, FABRICATED AND QUENCH CHARACTERISTICS ARE REPORTED.

4LPF-05**DEVELOPMENT AND TEST OF MODEL APPARATUS UTILIZING HTS MAGNETIC LEVITATION FOR NON-CONTACT SPINNING CLEAN-UP PROCESSORS OF PHOTO MASK PRODUCTION** ***S. FUKUI***[1]*, J. OGAWA*[1]*, T. OKA*[1]*, T. SATO*[1]*, K. SAITO*[2]*, S. SORIMACHI*[2]*;* [1]NIIGATA UNIVERSITY, [2]MTC CO. LTD.. — RECENTLY, THE RESEARCH AND DEVELOPMENT FOR FABRICATION PROCESS BASED ON 32-NM AND SMALLER ARCHITECTURES HAS BEEN IN PROGRESS. CORRESPONDING TO THE MINIMIZATION OF SEMICONDUCTOR DEVICES, VERY TIGHT PATTERN TOLERANCE IS REQUIRED FOR THE PHOTO MASKS USED IN THE PHOTOLITHOGRAPHY PROCESS IN WHICH CIRCUIT PATTERNS ARE TRANSCRIBED ONTO WAFERS. IN THE SPIN PROCESSES OF THE PHOTO MASK PRODUCTION, PARTICULATE DUST IS DISCHARGED FROM THE MECHANICAL BEARINGS OF SPIN PROCESSORS AND IT DECREASES THE CLEANLINESS AROUND THE PHOTO MASKS TO BE PROCESSED. CONSEQUENTLY, THE PARTICULATE DUST ENTERS THE SPACE BETWEEN PATTERNS AND REMAINS THERE. IT HAS BEEN CONSIDERED THAT THIS IS ONE OF THE MAIN CAUSES OF DETERIORATION OF THE MASK QUALITY AND DECREASE IN PRODUCT YIELD. APPLICATION OF THE MAGNETIC LEVITATION TO THE SPIN PROCESSORS IS A PROMISING SOLUTION TO PREVENT THE PARTICULATE DUST DEPOSITION IN THE PATTERN OF PHOTO MASK. IN THIS JOINT WORK, WE HAVE PROPOSED TO APPLY THE MAGNETIC LEVITATION UTILIZING HTS BULKS TO THE SPIN PROCESSORS FOR THE PHOTO MASK PRODUCTION. IN THIS WORK, WE DEVELOP A TEST APPARATUS WHICH IS DESIGNED TO DEMONSTRATE THE APPLICABILITY TO THE SPINNING CLEAN-UP PROCESSES OF THE ACTUAL PHOTO MASK PRODUCTION. THE DESIGN AND SPECIFICATIONS OF THE TEST APPARATUS ARE PRESENTED AND THE TEST RESULTS USING THIS TEST APPARATUS ARE REPORTED.

4LPF-06

DESIGN OF A SUPERCONDUCTING DIAMAGNETIC TORQUER SYSTEM ***C. CUI****;* INSTITUTE OF ELECTRICAL ENGINEERING,CHINESE ACADEMY OF SCIENCES. — A SUPERCONDUCTING DIAMAGNETIC TORQUER SYSTEM BASED ON MEISSNER EFFECT FOR THE SUPERCONDUCTING SPHERICAL ROTOR SUSPENDED IN A VACUUM HOUSING IS STUDIED. DURING THE ROTATION THE SPIN AXIS OF THE ROTOR WILL DEVIATE FROM THE INITIAL POSITION DUE TO INFLUENCE OF THE DISTURBANCE TORQUE. THE TORQUER SYSTEM IS USED TO ERECT THE ROTOR PRIOR TO AND DURING SPIN-UP AND THEN ALSO USED TO COMPENSATE FOR ERROR TORQUES. THE PRINCIPLE AND DESIGN OF THE TORQUER SYSTEM ARE DESCRIBED IN THIS PAPER. THE ANALYSIS OF ELECTROMAGNETIC CONFIGURATION ON THE TORQUER SYSTEM IS CARRIED OUT WITH FEM METHOD AND WE OBTAIN THE RELATIONSHIP BETWEEN TORQUER CURRENTS AND DECLINATION ANGLE OF POLAR AXIS. THE RESULTS PROVIDES THE PROOF FOR THE ATTITUDE CONTROL OF THE SUPERCONDUCTING ROTOR.

4LPG-01

DESIGN ALGORITHM OF HIGH HOMOGENOUS MULTI-LAYER HIGH MAGNETIC SUPERCONDUCTING MAGNET ***Q. WANG****;* INSTITUTE OF ELECTRICAL ENGINEERING, CHINESE ACADEMY OF SCIENCES. — AN OPTIMIZATION DESIGN METHOD OF SHORT-LENGTH ACTIVELY SHIELDED AND OPEN STRUCTURE SUPERCONDUCTING MAGNETS FOR THE HEAD IMAGNING IS DEVELOPED. FIRSTLY, THE COIL IS EQUIVALENT TO A CURRENT LOOP WITH ZERO SECTION TO SOLVE A LINEAR PROGRAMMING PROBLEM. THEN, THE CROSS-SECTION OF THE COIL IS OPTIMIZED WITH A GENETIC ALGORITHM TO GET APPROPRIATE SECTION SIZE. THE METHOD OF LINEAR PROGRAMMING, ESPECIALLY COMBINING WITH GENETIC ALGORITHM, REDUCES OPTIMIZING VARIABLES, WHICH MAKES THE DESIGN OF A MAGNET FEASIBLE. THE PAPER REPORTS THE NUMERICAL METHODS AND DESIGN RESULTS.

4LPG-02

THIXOTROPIC GEL FLOW UNDER SUPERCONDUCTING MAGNETS: ANALYTICAL AND NUMERICAL STUDIES, EXPERIMENTAL PROJECT ***L. HEYRENDT****, J. LÉVÊQUE, D. NETTER;* GREEN - NANCY UNIVERSITÉ. — THIXOTROPIC GELS SUCH AS BENTONITE SUSPENSIONS ARE VISCOUS UNDER NORMAL CONDITIONS BUT FLOW OVER TIME WHEN SHAKEN OR STRESSED. BENTONITE IS AN ABSORBENT ALUMINUM PHYLLOSILICATE, A CLAY CONSISTING MOSTLY OF MONTMORILLONITE. AT HIGH CONCENTRATIONS, BENTONITE SUSPENSIONS BEGIN TO TAKE ON THE CHARACTERISTICS OF A THIXOTROPIC GEL. MUCH OF BENTONITE'S USEFULNESS IS IN THE DRILLING AND GEOTECHNICAL ENGINEERING INDUSTRY TO REDUCE DRILLING FLUID INVASION FOR INSTANCE AND IN THE COSMETIC INDUSTRY AS A TEXTURAL AGENT.THE AIM OF OUR STUDY IS TO STRESS A BENTONITE SUSPENSIONS FLOW USING SUPERCONDUCTING MAGNETS. MAGNETIC FORCES USED IN MAGNETIC LEVITATION CAN CHANGE A LOW VELOCITY GEL FLOW WITH NO SUPPORT OTHER THAN MAGNETIC FIELDS. THE STRESS INDUCED WOULD THEREFORE CHANGE THE PROPERTIES OF THE GEL AND MAKE IT BECOME LESS VISCOUS. THE FLOW WOULD CONSEQUENTLY LOOSE LESS ENERGY AND POTENTIAL BLOCKS IN THE PIPES COULD BE AVOIDED. THIS DEVICE COULD PROVIDE A PARTICULARLY INNOVATIVE APPLICATION IN HYDRAULIC CIRCUITS.IN THIS PAPER, WE PRESENT AN ANALYTICAL STUDY OF THE MAGNETIC FIELD FORCES GENERATED BY A SUPERCONDUCTING DEVICE MADE OF TWO SURFACES FLOWED BY SPACE-DEPENDENT CURRENT DENSITIES. A NUMERICAL INVESTIGATION SHOWS THE FLUID FLOW MODIFICATIONS AND AN EXPERIMENTAL PROJECT USING SEVERAL YBACUO BULKS IS INTRODUCED.

THE COLLABORATIVE RESEARCH PROJECT RHEOMAX IS SUPPORTED BY THE ETABLISSEMENT PUBLIQUE DE COORDINATION SCIENTIFIQUE FROM NANCY UNIVERSITÉ.

4LPG-03

SIMULATION OF GRAVITY CONTROLL EFFECTS ON PROTEIN CRYSTAL GROWTH USING MAGNETIC FORCE ***H. OKADA****, N. HIROTA, S. MATSUMOTO, H. WADA;* NATIONAL INSTITUTE FOR MATERIALS SCIENCE. — HIGH QUALITY PROTEIN CRYSTALS ARE ESSENTIAL FOR X-RAY ANALYSIS OF PROTEIN MOLECULE STRUCTURES AND MAY BE GROWN UNDER MICROGRAVITY ENVIRONMENT. IT IS THUS REGARDED AS ONE OF THE MOST IMPORTANT SUBJECTS IN SPACE SHUTTLES TO GROW HIGH QUALITY PROTEIN CRYSTALS. HOWEVER, EXPERIMENTS IN SPACE SHUTTLES ARE DIFFICULT IN TERMS OF COSTS, TIME, EXPERIMENTAL EQUIPMENTS, AND TRANSPORTATION, ETC. WE ARE DEVELOPING A SUPERCONDUCTING MAGNET SYSTEM WHICH CAUSES STRONG MAGNETIC FORCES AND REALIZES GRAVITY CONTROLLED ENVIRONMENT FAVORABLE ON EARTH.THE GRAVITY CONTROLLED ENVIRONMENT BASED ON MAGNETIC FORCES GIVES RISE TO A VARIETY OF EFFECTS, SUCH AS MOTIONS OF LIQUID, SOLID, GAS AND THEIR MIXTURES IN THE GROWING PROCESS OF CRYSTALS; THESE EFFECTS MAY NOT HAPPEN UNDER MICROGRAVITY IN SPACE AND HAVE SO FAR NOT SERIOUSLY BEEN CONSIDERED. WE EVALUATE EFFECTS OF THE GRAVITY CONTROLLED ENVIRONMENT BY MAGNETIC FORCES ON THE CRYSTAL GROWTH PROCESS, CONVECTION AND DIFFUSION, ETC, BY COMPUTER SIMULATION, WHEREBY WE CONSIDER INHOMOGENEITY AND ANISOTROPY OF MAGNETIC FORCE. WE WILL PRESENT THE DETAIL OF THE SIMULATION RESULTS AND SUGGEST A SUITABLE DESIGN OF SUPERCONDUCTING MAGNET SYSTEM FOR PROTEIN CRYSTAL GROWTH.

PART OF THIS WORK IS SUPPORTED BY "DEVELOPMENT OF SYSTEMS AND TECHNOLOGY FOR ADVANCED MEASUREMENT AND ANALYSIS" OF JAPAN SCIENCE AND TECHNOLOGY AGENCY.

4LPG-04

DEVELOPMENT OF THE HIGH SENSITIVITY INSTRUMENT FOR IN-VIVO AND FAST EXAMINATION OF IRON DISTRIBUTION WITHIN THE ANIMAL TORSO ***J. J. CHIEH****[1], S. YANG[2], H. HORNG[1], C. HONG[3], H. YANG[4], C. WU[5], W. TSENG[6];* [1]NATIONAL TAIWAN NORMAL UNIVERSITY, [2]MAGQU CO. LTD, [3]NATIONAL CHUNG HSING UNIVERSITY, [4]NATIONAL TAIWAN UNIVERSITY, [5]NATIONAL TAIWAN UNIVERSITY HOSPITAL, [6]E-DA HOSPITAL. — RECENTLY THE WORKS OF THE IN-VIVO MAGNETIC LABELING USING THE MAGNETIC NANOPARTICLES WITH THE BIO-PROBE COATING AND WITH THE MEDICINE ARE FOCUSED. HOWEVER, WHETHER THE MAGNETIC PARTICLES COULD REACH THE TARGET REGION OR BE METABOLIC WITH THE BLOOD CIRCULATION, THE SUBJECT NEEDS A HIGH-SENSITIVITY INSTRUMENT, THE WELL-KNOWN SQUID, TO TRACK THE MAGNETIC NANOPARTICLES WITHIN THE BODY. HOWEVER, THE CURRENT SQUID SYSTEMS IN TRADITIONAL SCHEME OF DIRECT SENSING NECESSARILY EXAMINE PATIENTS IN EXPENSIVE SHIELDING ROOM. AND THE PATIENTS ARE IN UNEASY POSTURE IN ORDER TO CLOSE THE SENSING REGION OF THIS INSTRUMENT. THE DRAWBACKS OF COMPLICATE OPERATION AND HIGH COST INCREASE THE POPULATION DIFFICULTY. THIS WORK SHOWS THE IN-VIVO AND EX-VIVO RESULTS OF THE RATS INJECTED BY MAGNETIC FLUIDS BY THE NOVEL SCHEME USING HIGH T_C SQUID SYSTEM. IN THIS SYSTEM, THERE ARE TWO PARTS, A HANDY PROBE COMPOSED OF EXCITATION AND PICKUP COILS, AND A SQUID UNIT WITH THE SQUID SENSOR SURROUNDED BY THE INPUT COIL LINKED TO THE PICKUP COIL. AND THE SENSITIVITY OF THIS SYSTEM IS AS HIGH AS SEVERAL PT AT SEVERAL HUNDRED HZ. THE DOCTORS COULD OPERATE IT LIKE ULTRASONIC INSTRUMENTS TRANSFERRING THE SIGNAL OF THE SENSING PROBE TO PC USER INTERFACE. THE OPERATING COULD BE IN SHIELDING ENVIRONMENT, AND THE MANUFACTURING AND *MAINTENANCE* COST ARE NOT HIGH. SO IT HAS THE POTENTIAL TO POPULATE IN THE LABORATORIES, CLINICS AND HOSPITALS.

ACKNOWLEDGEMENTS FOR THE SUPPORT OF NATIONAL SCIENCE COUNCIL, TAIWAN , REPUBLIC OF CHINA

4LPG-05

ADVANCED APPLICATIONS BASED ON THE MAGNETIC POTENTIAL WELL (MPW) *O. KOZOREZ[1],* ***H. FRANKLIN****[2];* [1]KOZORIZ-FRANKLIN CALIFORNIA MAGLEV INC., [2]KOZORIZ-FRANKLIN CALIFORNIA MAGLEV, INC.. — DIAMAGNETISM AND ZERO ELECTRIC RESISTANCE AS TWO MACROSCOPIC DEMONSTRATIONS OF SUPERCONDUCTIVITY ATTRACT ATTENTION BECAUSE BOTH ASSIST WITH LEVITATION STABILITY ALTHOUGH DO NOT GUARANTEE IT. THE MEISSNER'S REPULSIVE LEVITATION BASED ON THE SUPERCONDUCTOR DIAMAGNETISM, AND MPW-LEVITATION BASED ON ZERO RESISTANCE OF A CLOSED CURRENT CARRYING LOOP ARE TWO VERSIONS OF SUPERCONDUCTING LEVITATION DIFFERENT IN PHYSICAL MECHANISM LEADING TO THE FREE EQUILIBRIUM STABILITY, AND IN LEVEL OF FORCE CHARACTERISTICS. THE REPULSIVE LEVITATION IS RESTRICTED FROM ABOVE BY LOWER CRITICAL FIELD EXCLUDING MAGNETIC FIELD PENETRATION INSIDE SUPERCONDUCTOR. THIS FILED IS NO MORE THAN 1.5 TESLA AT 4 K THAT CORRESPONDS WITH PRESSURE OF APPROXIMATELY 10^4 N/M^2, TOO SMALL IN MAGNITUDE TO BE COMPETITIVE WITH PRESSURE REQUIRED FOR MANY APPLICATIONS. THE MPW-LEVITATION CAN USE HIGH CURRENT DENSITY LOW OR HIGH TEMPERATURE SUPERCONDUCTING WIRE KEEPING ZERO THAT RESULTING IN APP.10^8 N/M^2 AND HIGHER PRESSURE, VERY ATTRACTING MAGNITUDES TO BE PONDERED OVER MANY APPLICATIONS. SOME OF THEM ARE CONSIDERED HERE: ZERO ELECTRIC LOSS LEVITATION, ACCELERATION AND/OR BRAKING, INERTIAL NAVIGATION, AIRCRAFT TAKE-OFF AND LANDING, DOCKING IN THE OUTER SPACE, ENERGY PRODUCTION FROM MOVING WATER.

4LPG-06

2-AXIS ELECTROMAGNETIC STIRRING SYSTEM WAS PRODUCED EXPERIMENTALLY, AND ESTIMATED WITH AC SUPERCONDUCTING MAGNETS ***H. KASAHARA****[1], S. TANIGUCHI[2], S. SHIMASAKI[2], K. UENO[2], K. MIYASHITA[3];* [1]CRIEPI, [2]TOHOKU UNIV., [3]HITACHI CABLE LTD.. — IT'S ENABLE TO APPLY AC HIGH MAGNETIC FIELD BY AC SUPERCONDUCTING TECHNOLOGY. THIS HIGH MAGNETIC FIELD MAKES A STRONG ELECTROMAGNETIC FORCE, AND MAY PRODUCE INNOVATIVE

TECHNOLOGY OF MATERIALS PROCESSING. THEREFORE THE TWO AXES ELECTROMAGNETIC STIRRING SYSTEM WAS EXPERIMENTALLY MANUFACTURED BY A SUPERCONDUCTING MAGNETS. IT PERFORMED A STIRRING EXPERIMENT USING THE MOLTEN GALLIUM. AS A RESULT, IT WAS ABLE TO GIVE A VERY STRONG ROTATION BY THE ROTATING MAGNETIC FIELD. FURTHERMORE, IT WAS ABLE TO PERFORM THE STIRRING THAT CONTROLLED SURFACE TRANSFORMATION AGAINST THE CENTRIFUGAL FORCE BY APPLY PERPENDICULAR LINEAR DRIVE MAGNETIC FIELD.

4LPH-01

PITCH DESIGN OF HTS CABLE CORE COMPOSED OF COATED CONDUCTORS WITH NIW SUBSTRATE ***K. SIM***[1]*, J. CHO*[1]*, T. KO*[2]*;* [1]KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE, [2]YONSEI UNIVERSITY. — THE FERROMAGNETIC NIW ALLOY IS USED FOR THE SUBSTRATE OF THE SUPERCONDUCTING COATED CONDUCTOR MADE BY RABITS PROCESS.THE MAGNETIC PROPERTY OF THE NIW SUBSTRATE MAKES THE INDUCTANCE OF THE SUPERCONDUCTING LAYERS NONLINEAR TO THE TRANSPORT CURRENT. THUS, THIS PROPERTY MUST BE CAREFULLY CONSIDERED IN ADJUSTING THE PITCH OF EACH SUPERCONDUCTING LAYER WITH WHICH THE CURRENT DISTRIBUTION IS CONTROLLED TO BE EQUIVALENT BY SOLVING A CIRCUIT EQUATION COMPOSED OF THE INDUCTANCES.THE EFFECT OF THE MAGNETIC SUBSTRATE ON THE VARIATION OF CURRENT DISTRIBUTION WAS INVESTIGATED WITH THE FINITE ELEMENT METHOD (FEM) AND A DESIGNING METHOD FOR FINDING OUT THE OPTIMAL PITCH COMBINATIONS TO ACCOMPLISH THE EQUIVALENT CURRENT DISTRIBUTION ON EACH SUPERCONDUCTING LAYER WAS INTRODUCED. WE APPLIED THE PITCH CALCULATION METHOD TO THE DESIGN OF 154KV/1GVA CLASS HTS POWER CABLE AND THE RESULTS ARE INTRODUCED IN THIS PAPER.

THIS RESEARCH WAS SUPPORTED BY A GRANT FROM CENTER FOR APPLIED SUPERCONDUCTIVITY TECHNOLOGY OF THE 21ST CENTURY FRONTIER R&D PROGRAM FUNDED BY THE MINISTRY OF SCIENCE AND TECHNOLOGY, REPUBLIC OF KOREA

4LPH-02

HYSTERESIS LOSS IN POWER CABLES MADE OF 2G HTS WIRES WITH NIW ALLOY SUBSTRATE ***V. ZUBKO****, S. FETISOV, A. NOSOV, N. POLYAKOVA, V. VYSOTSKY;* RUSSIAN SCIENTIFIC R&D CABLE INSTITUTE. — 2G HTS WIRES PRODUCED WITH THE MOD/RABITS™ PROCESS WITH NIW SUBSTRATES HAVE WEAK MAGNETISM AND THEREFORE EXTRA LOSSES IN A SUBSTRATE [1]. TWO-DIMENSIONAL NUMERICAL ELECTROMAGNETIC FIELD ANALYSIS HAS BEEN MADE OF TWO-LAYER CABLES MADE OF 2G HTS CONDUCTORS WITH MAGNETIC SUBSTRATES FOR DIFFERENT ORIENTATIONS OF SUBSTRATE IN LAYERS. TWO ARRANGEMENTS WERE USED FOR THE 2G CONDUCTORS BETWEEN THE INNER AND OUTER LAYERS: TAPE-ON-TAPE AND TAPE-ON-GAP. THE INFLUENCE OF THE ORIENTATIONS OF SUBSTRATE IN LAYERS ON THE AC LOSS CHARACTERISTICS IS DISCUSSED. COMPARISONS OF CALCULATIONS WITH MEASUREMENTS ARE PRESENTED.[1] V. VYSOTSKY, V. SYTNIKOV, A. NOSOV ET AL, «AC LOSS OF A MODEL 5M 2G HTS POWER CABLE USING WIRES WITH NIW SUBSTRATES», PAPER 191 PRESENTED AT EUCAS-2009, DRESDEN, GERMANY, 13-17 SEPTEMBER, 2009, IN PRESS IN JOURNAL OF PHYSICS: CONFERENCE SERIES

4LPH-03

THERMAL ANALYSIS OF CO-AXIAL MULTI-LAYERED BSCCO HTS POWER CABLE ***D. MIYAGI****, N. TAKATA, N. TAKAHASHI;* OKAYAMA UNIVERSITY. — BSCCO HIGH-TEMPERATURE SUPERCONDUCTOR (HTS) POWER CABLE HAS BEEN DEVELOPED BECAUSE OF LOW LOSS AND COMPACT THAN CONVENTIONAL COPPER CABLES. HTS POWER CABLE TYPICALLY CONSISTS OF A CU FORMER, AN HTS CONDUCTOR LAYER, AN ELECTRICAL INSULATION LAYER, AN HTS SHIELD LAYER AND A CU SHIELD LAYER. THE POLYPROPYLENE LAMINATED PAPER (PPLP) IS TYPICALLY USED FOR AN ELECTRICAL INSULATION LAYER, BUT THE HEAT CONDUCTANCE OF THE PPLP IS BAD. THEREFORE, IT IS VERY IMPORTANT TO ESTIMATE THE THERMAL DIFFUSION IN EACH LAYER OF A HTS POWER CABLE IN ORDER TO COOL THE WHOLE CABLE EFFICIENTLY.IN THIS PAPER, THE DETAILED BEHAVIOR OF THE AC LOSS AND THE TEMPERATURE DISTRIBUTION IN A CO-AXIAL MULTI-LAYERED BSCCO HTS POWER CABLE, WHICH CONSIST OF A CU FORMER, TWO HTS CONDUCTOR LAYERS, AN ELECTRICAL INSULATION LAYER (PPLP), AN HTS SHIELD LAYER, AND A CU SHIELD LAYER, ARE ANALYZED BY THE MAGNETO-THERMAL COUPLED METHOD CONSIDERING THE TEMPERATURE DEPENDENCE OF THE CRITICAL CURRENT DENSITY AND THE CU ELECTRICAL RESISTANCE. MOREOVER, THE TEMPERATURE RISE BY THE AC LOSS AND THE OHMIC LOSS IN EACH LAYER UNDER THE OVERCURRENT IS CALCULATED AND THE COOLING NECESSITY FROM THE INSIDE OF A CU FORMER IS EXAMINED.

4LPH-04

MEASUREMENTS OF AC LOSS AND CURRENT DISTRIBUTION IN SUPERCONDUCTING CABLES ***D. NGUYEN***[1]*, S. P. ASHWORTH*[1]*, R. DUCKWORTH*[2]*, S. FLESHLER*[3]*;* [1]LOS ALAMOS NATIONAL LABORATORY, [2]OAKRIDGE NATIONAL LABORATORY, [3]AMERICAN SUPERCONDUCTOR CORP. DEVENS, MA, USA. — THIS PAPER PRESENTS OUR NEW EXPERIMENTAL FACILITY AND TECHNIQUES TO MEASURE AC LOSS AND CURRENT DISTRIBUTION BETWEEN THE LAYERS FOR HIGH TEMPERATURE SUPERCONDUCTING (HTS) CABLES. THE FACILITY IS POWERED WITH A 45 KVA THREE-PHASE POWER SUPPLY WHICH CAN PROVIDE THREE-PHASE CURRENTS UP TO 5 KA EACH PHASE, VIA HIGH CURRENT TRANSFORMERS. THE SYSTEM IS SUITABLE FOR MEASUREMENTS AT ANY FREQUENCY BETWEEN 30 AND 500 HZ FOR BETTER UNDERSTANDING OF AC LOSS MECHANISMS IN HTS CABLES. IN THIS PAPER, WE WILL REPORT TECHNIQUES AND RESULTS FOR AC LOSS MEASUREMENTS CARRIED OUT ON SEVERAL HTS CABLES WITH AND WITHOUT HTS SHIELDING LAYER. FOR CABLE WITHOUT SHIELDING LAYER, THE SPITTED RETURN CURRENT IS NEEDED TO MINIMIZE THE EFFECT OF MAGNETIC FIELD FROM THE RETURN CURRENT ON

AC LOSS MEASUREMENTS IN CABLE. WAVEFORM OF THE AXIAL MAGNETIC FIELD WAS ALSO MEASURED BY A SMALL PICK-UP COIL PLACED INSIDE A TWO-LAYER CABLE. THE TEMPORAL CURRENT DISTRIBUTION BETWEEN THE LAYERS THEREFORE CAN BE CALCULATED FROM THE WAVEFORM OF AXIAL FIELD.

4LPH-05

STUDY OF ELECTRIC MEASUREMENT METHOD OF AC LOSS IN MULTI-LAYER HTS CABLE WITH HTS MAGNETIC SHIELD ***S. FUKUI****[1], J. OGAWA[1], H. KATO[1], T. SATO[1], T. OKA[1], K. RYU[2];* [1]NIIGATA UNIVERSITY, [2]CHONNAM NATIONAL UNIVERSITY. — HTS CABLE IS THE NEXT CANDIDATE FOR THE LARGE CAPACITY POWER TRANSMISSION CABLE. FOR THE DEVELOPMENT OF THE HTS POWER CABLES, IT IS IMPORTANT TO ESTABLISH A RELIABLE MEASUREMENT METHOD OF THE AC TRANSPORT CURRENT LOSSES. GENERALLY IN THE MULTI-LAYER CABLE, BECAUSE OF THE DIFFERENCE OF THE MAGNETIC COUPLING BETWEEN THE SUPERCONDUCTOR LAYERS, THERE SHOULD BE THE POWER FLOW BETWEEN THE SUPERCONDUCTOR LAYERS OF THE CABLE. WHEN THE AC LOSS IN A SUPERCONDUCTING LAYER OF THE MULTI-LAYER CABLE IS MEASURED BY THE FOUR PROBE METHOD, THE POTENTIAL LEAD LOOP PICKS UP THIS POWER FLOW. THEREFORE, IT IS IMPORTANT TO IDENTIFY THE EFFECT OF THE POWER FLOW AND TO ESTABLISH THE MEASUREMENT METHOD WHICH CAN EXCLUDE THE INFLUENCE OF THE POWER FLOW. TO ADDRESS THIS ISSUE, THE PROPER ARRANGEMENT OF THE POTENTIAL LEAD LOOP TO AVOID THE SPURIOUS LOSS COMPONENTS DUE TO THE POWER FLOW IS NUMERICALLY STUDIED. THE CURRENT DISTRIBUTION AND THE AC TRANSPORT CURRENT LOSS IN THE CYLINDRICALLY ASSEMBLED CONDUCTOR OF THE HTS TAPES IN THE MULTI-LAYER ARRANGEMENT ARE NUMERICALLY CALCULATED BY USING THE MODEL DEVELOPED IN OUR PREVIOUS WORK. USING THE CALCULATED CURRENT DISTRIBUTION IN THE CONDUCTOR, THE VOLTAGE INDUCED IN THE LEAD LOOP IS CALCULATED AND THE AC LOSS IS OBTAINED SIMULATING THE MEASUREMENT SITUATION. BASED ON THIS NUMERICAL EXPERIMENT, THE PROPER ARRANGEMENT OF THE POTENTIAL LEAD LOOP IS DISCUSSED.

4LPH-06

AC LOSS STUDY WITH 5 M HTS MODEL CABLES *V. VYSOTSKY,* ***K. SHUTOV****, A. NOSOV, S. FETISOV, V. SYTNIKOV;* RUSSIAN SCIENTIFIC R&D CABLE INSTITUTE. — THE TEST FACILITY DEVELOPED IN RUSSIAN SCIENTIFIC R&D CABLE INSTITUTE PERMITS TO PERFORM EXTENSIVE TESTS OF HEAVILY INSTRUMENTED HTS CABLE MODELS WITH LENGTH UP TO 5 M. SEVERAL HTS CABLES WITH DIFFERENT DESIGN HAVE BEEN DEVELOPED AND TESTED AT THIS FACILITY [1, 2]. THE TEST PROGRAMS INCLUDED, BESIDES USUAL CRITICAL CURRENT MEASUREMENTS, CURRENT DISTRIBUTION MEASUREMENTS AMONG LAYERS, JOINT RESISTANCE TEST, ETC. THE FACILITY'S EQUIPMENT PERMITS DIGITAL MEASUREMENTS OF VOLTAGE AND CURRENT WITH HIGH ACCURACY AND, THEREFORE, DIGITAL AC LOSS ANALYSIS IN MODEL CABLES. IN THIS PAPER WE PRESENT THE DETAIL OF THE TEST FACILITY AND RESULTS OF TESTS AND AC LOSS MEASUREMENTS IN FEW 5M MODEL CABLES. AC LOSSES IN MODEL CABLES MADE OF 1G AND 2 G WIRES AND OTHER CABLE PARAMETERS ARE DISCUSSED AND COMPARED.1. V.E. SYTNIKOV, ET AL, IEEE TRANSACTIONS ON APPLIED SUPERCONDUCTIVITY, VOL.19, N3, 2009, PP.1706-17092. V.VYSOTSKY, ET AL, «AC LOSS OF A MODEL 5M 2G HTS POWER CABLE USING WIRES WITH NIW SUBSTRATES», PAPER 191 PRESENTED AT EUCAS-2009, DRESDEN, GERMANY, 13-17 SEPTEMBER, 2009

4LPH-07

AC LOSS MEASUREMENT OF A SHORT HTS CABLE WITH SHIELD BY ELECTRICAL METHOD ***Z. LI****[1], Y. MA[1], K. RYU[1], S. FUKUI[2], S. HWANG[3];* [1]CHONNAM NATIONAL UNIVERSITY, [2]NIIGATA UNIVERSITY, [3]KOREA ELECTRIC POWER RESEARCH INSTITUTE. — RECENTLY, A STUDY ON A HIGH TEMPERATURE SUPERCONDUCTOR (HTS) CABLE COMPOSED OF A SHIELD AND A CONDUCTOR WITH A MULTILAYER STRUCTURE IS BEING ACTIVELY PERFORMED, AND THE HTS CABLE IS AT THE PHASE OF FIELD TEST IN POWER NETWORKS. IN COMMERCIALIZATION OF THIS HTS CABLE, AC LOSS IS A CRITICAL FACTOR. BUT OWING TO THE COMPLEX STRUCTURE OF THE HTS CABLE WITH THE SHIELD, THE ELECTRICAL MEASUREMENT OF AC LOSS IS VERY DIFFICULT AND NOT ELUCIDATED COMPLETELY YET. THEREFORE, WE HAVE ELECTRICALLY INVESTIGATED THE AC LOSS OF THE 5 M SHORT CABLE, WHICH IS THE SAME AS THE 91 M 50 MVA HTS CABLE UNDER THE OPERATION AT THE TEST YARD OF KOREA ELECTRIC POWER CORP. (KEPCO).IN THIS PAPER, TWO VOLTAGE-LEADS (CONDUCTOR-LEAD, SHIELD-LEAD) WERE ATTACHED ON THE SHORT-RINGS WHICH ARE SOLDERED TO THE CONDUCTOR AND THE SHIELD OF THE 5 M CABLE, RESPECTIVELY, AND THEN ARRANGED ALONG ITS OUTERMOST SURFACE. USING THESE VOLTAGE-LEADS, THE AC LOSSES OF BOTH THE CONDUCTOR AND THE SHIELD WERE ELECTRICALLY MEASURED AT 77 K. THE CONDUCTOR, SHIELD, AND TOTAL LOSSES MEASURED FOR THE 5 M CABLE WERE COMPARED WITH CALCULATED RESULTS BASED ON A NUMERICAL ANALYSIS CONSIDERING THE WIRE TWIST AND THE GAP BETWEEN LAYERS. MOREOVER, THE TOTAL AC LOSS OF THE 91 M KEPCO CABLE MEASURED CALORIMETRICALLY AT 66 K WAS ALSO COMPARED WITH THE NUMERICAL ANALYSIS. THE EXPERIMENTAL AND NUMERICAL DETAILS WILL BE DISCUSSED AND PRESENTED IN THIS PAPER.

THIS STUDY WAS PARTIALLY SUPPORTED BY THE ELECTRIC POWER INDUSTRY TECHNOLOGY EVALUATION AND PLANNING (ETEP), AN AGENCY OF THE KOREAN GOVERNMENTS MINISTRY OF KNOWLEDGE ECONOMY (MKE).

4LPH-08

DESIGN AND EVALUATION OF 66 KV CLASS HTS POWER CABLE USING REBCO WIRES ***M. OHYA****[1], T. SETOGUCHI[1], H. YUMURA[1], T. MASUDA[1], N. AMEMIYA[2], H. ICHIKAWA[3], N. FUJIWARA[3];* [1]SUMITOMO ELECTRIC INDUSTRIES, LTD., [2]KYOTO UNIVERSITY, [3]INTERNATIONAL SUPERCONDUCTIVITY TECHNOLOGY CENTER. — HIGH TEMPERATURE SUPERCONDUCTING (HTS) CABLES ACHIEVE LARGE POWER CAPACITY AND LOW-LOSS POWER TRANSMISSION IN A

COMPACT SIZE. IN THE NEW JAPANESE NATIONAL PROJECT, SUMITOMO ELECTRIC INDUSTRIES, LTD. (SEI) IS TRYING TO DEVELOP A 66 KV - 5 KARMS HTS CABLE WITH REBCO WIRES. ONE OF THE IMPORTANT TECHNICAL TARGETS IS TO REDUCE AC LOSS UNDER 2 W/M/PH AT 5 KARMS.IN ORDER TO REDUCE THE AC LOSS, SEI HAS DEVELOPED A NEW TYPE OF TEXTURED METAL SUBSTRATE (CLAD-TYPE SUBSTRATE). IT HAS LOWER MAGNETIZATION LOSS AND HIGHER MECHANICAL STRENGTH COMPARED WITH A CONVENTIONAL NIW SUBSTRATE. IN ADDITION, 30MM-WIDE REBCO TAPES WERE DIVIDED INTO 2MM-WIDE STRIPS, AND THESE STRIPS WERE WOUND SPIRALLY ON A FORMER WITH SMALL GAPS. A MANUFACTURED 2-LAYER CABLE CONDUCTOR HAS THE CRITICAL CURRENT VALUE OF 2450 A AT 77.3 K, AND IT HAS GOOD AC LOSS CHARACTERISTICS AS LESS THAN 0.1 W/M AT 1 KARMS AND 50 HZ. AS THE NEXT STEP, A 4-LAYER CABLE CONDUCTOR WAS MANUFACTURED. THE MEASURED CRITICAL CURRENT VALUE OF THE CONDUCTOR WAS 4500 A AT 77.3 K, AND THE MEASURED AC LOSS VALUE WAS ABOUT 0.3 W/M AT 2 KARMS AND 50 HZ. THESE RESULTS SHOW THAT THE NEW REBCO WIRE HAS POTENTIAL TO ACHIEVE THE AC LOSS TARGET.

THIS WORK WAS SUPPORTED BY THE NEW ENERGY AND INDUSTRIAL TECHNOLOGY DEVELOPMENT ORGANIZATION (NEDO).

4LPH-09

A DISCUSSION ON CURRENT DISTRIBUTION IN MULTILAYER AC HTS CABLES - PROXIMITY EFFECT ***W. Z. GONG****, Y. XIN, J. Y. ZHANG;* INNOPOWER SUPERCONDUCTOR CABLE CO., LTD.. — PROXIMITY EFFECT, WHICH IS WIDELY CONCERNED IN CONVENTIONAL TRANSFORMERS AND CABLES, HAS BEEN NEGLECTED IN DESIGNING AN AC HTS CABLE. HOWEVER, IT MAY BECOME THE FUNDAMENTAL FACTOR AFFECTING THE CURRENT DISTRIBUTION IN AC HTS CABLES. EXTENSIVE EXPERIMENTS ON HTS CABLE SAMPLES WITH DIFFERENT NUMBER OF LAYERS, WINDING PITCHES, AND WINDING DIRECTIONS WERE CARRIED OUT. TESTING RESULTS SHOWED A STRONG TENDENCY THAT THE CURRENT CONCENTRATES IN THE OUTMOST LAYER AND THE INNERMOST LAYERS, NO MATTER HOW MUCH THE WINDING PARAMETERS HAD CHANGED. THESE RESULTS WERE DIFFICULT TO BE UNDERSTOOD JUST IN THE CONSIDERATION OF RESISTANCE AND INDUCTANCE, SO PROXIMITY EFFECT WAS PUT FORWARD AS A MORE REASONABLE EXPLANATION. RECOGNITION OF THE CRITICAL INFLUENCE OF THE PROXIMITY EFFECT WOULD BE A GREAT HELP IN OPTIMIZING THE DESIGN OF AN AC MULTILAYER HTS CABLE AND SIMILAR DEVICES.

THIS WORK WAS SUPPORTED IN PART BY THE CHINESE MINISTRY OF SCIENCE AND TECHNOLOGY (GRANT NUMBER 2007AA03Z209)

4LPJ-01

OVER-CURRENT CHARACTERISTICS OF 66 KV RE123 HTS POWER CABLE ***X. WANG****[1], H. UEDA[1], A. ISHIYAMA[1], M. OHYA[2], N. FUJIWARA[3];* [1]WASEDA UNIVERSITY, [2]SUMITOMO ELECTRIC INDUSTRIES, LTD., [3]INTERNATIONAL SUPERCONDUCTIVITY TECHNOLOGY CENTER. — THE NEW JAPANESE NATIONAL PROJECT OF DEVELOPMENT OF A 66 KV/5 KA HIGH-TEMPERATURE SUPERCONDUCTING (HTS) POWER CABLE HAS BEEN STARTED SINCE 2008. IN AN AC POWER SYSTEM, A FAULT CURRENT MAY FLOW IN THE EVENT OF A SHORT CIRCUIT ACCIDENT. THE MAXIMUM FAULT CURRENT CONDITION IS DEFINED TO BE 31.5 KA_{RMS} FOR A DURATION OF 2 S FOR 66 KV CLASS TRANSMISSION LINE IN THIS PROJECT. THEREFORE, ONE OF THE TECHNICAL TARGETS IN THIS PROJECT IS TO DESIGN THE HTS POWER CABLE TO SURVIVE AT THIS FAULT CURRENT CONDITION. IN ORDER TO SECURE STABILITY AND FEASIBILITY OF HTS POWER CABLE AND PROTECT FROM THE FAULT CURRENT, IT IS IMPORTANT TO INVESTIGATE THE THERMAL CHARACTERISTICS AND CURRENT DISTRIBUTION IN THE CABLE UNDER FAULT CONDITIONS. IN THIS STUDY, WE CARRIED OUT OVER-CURRENT EXPERIMENTS ON A 2 M-LONG HTS MODEL CABLE, AND PERFORMED NUMERICAL SIMULATIONS UNDER FAULT CONDITIONS BY USING A COMPUTER PROGRAM WE DEVELOPED ON THE BASIS OF 3D FINITE ELEMENT METHOD (FEM) AND ELECTRICAL CIRCUIT MODEL.

THIS WORK WAS SUPPORTED BY THE NEW ENERGY AND INDUSTRIAL TECHNOLOGY DEVELOPMENT ORGANIZATION (NEDO) AS THE PROJECT FOR DEVELOPMENT OF MATERIALS & POWER APPLICATION OF COATED CONDUCTORS, M-PACC.

4LPJ-02

OVER-CURRENT CHARACTERISTICS OF A 275KV CLASS YBCO POWER CABLE ***T. URYU****[1], X. WANG[1], H. UEDA[1], A. ISHIYAMA[1], M. YAGI[2], N. FUJIWARA[3];* [1]WASEDA UNIVERSITY, [2]FURUKAWA ELECTRIC CO., LTD., [3]ISTEC-SRL. — IN JAPAN, THE PROJECT OF THE DEVELOPMENT OF THE 275 KV CLASS YBCO POWER CABLE STARTED IN 2008. HIGH TEMPERATURE SUPERCONDUCTING (HTS) POWER CABLES TYPICALLY CONSIST OF A COPPER FORMER, HTS CONDUCTOR LAYER, ELECTRICAL INSULATION LAYER, HTS SHIELD LAYER, AND COPPER SHIELD LAYER. IN PRACTICAL USES, 275 KV CLASS TRANSMISSION LINE MIGHT BE SUBJECTED TO SHORT-CIRCUIT FAULT CURRENTS, SUCH AS 63KA_{RMS} FOR A DURATION OF 0.6S. THEREFORE, IN ORDER TO SECURE STABILITY AND FEASIBILITY OF THE CABLE, IT IS IMPORTANT TO ESTIMATE THE CURRENT DISTRIBUTION AND TEMPERATURE INCREASES UNDER THE FAULT CONDITION. WE DESIGNED COPPER REQUIREMENT IN THE CABLE; THE COPPER FORMER, COPPER SHIELD LAYER, COPPER STABILIZER OF YBCO COATED CONDUCTOR. IN THIS STUDY, WE CARRIED OUT OVER-CURRENT EXPERIMENTS ON A 2-M LONG YBCO MODEL CABLE, AND PERFORMED NUMERICAL SIMULATIONS BY USING A COMPUTER PROGRAM WE DEVELOPED ON THE BASIS OF FINITE ELEMENT METHOD (FEM) AND ELECTRIC CIRCUIT MODEL. IN THE EXPERIMENTAL AND SIMULATION RESULTS, WE INVESTIGATED THE ELECTROMAGNETIC AND THERMAL BEHAVIORS OF THE CABLE UNDER FAULT CONDITIONS.

THIS WORK WAS SUPPORTED BY THE NEW ENERGY AND INDUSTRIAL TECHNOLOGY DEVELOPMENT ORGANIZATION (NEDO) AS THE PROJECT FOR DEVELOPMENT OF MATERIALS & POWER APPLICATION OF COATED CONDUCTORS, M-PACC.

4LPJ-04

STABILITY ANALYSIS OF HTS POWER CABLE WITH FAULT CURRENT ***M. FURUSE***[1]*, S. FUCHINO*[1]*, K. AGATSUMA*[1]*, T. MASUDA*[2]*, M. OHYA*[2]*, S. HONJO*[3]*, T. MIMURA*[3]*, Y. NOGUCHI*[3]*;* [1]NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY, [2]SUMITOMO ELECTRIC INDUSTRIES, LTD., [3]TOKYO ELECTRIC POWER COMPANY. — WE HAVE DEVELOPED A NUMERICAL COMPUTATION CODE FOR STABILITY ANALYSIS OF HTS POWER CABLES WITH FAULT CURRENT UNDER FORCED FLOW COOLED CONDITION BY SUB-COOLED NITROGEN. WE ESTIMATED THE THERMAL STABILITY PERFORMANCE OF HTS MODEL POWER CABLES WITH FAULT CURRENT BY THE COMPUTATION CODE. THE CALCULATION RESULTS REVEAL THE SIGNIFICANT INFLUENCE OF SUB-COOLED NITROGEN FLOW UPON THE TIME DEPENDING LONGITUDINAL TEMPERATURE PROFILES OF NOT ONLY CABLE CORES BUT ALSO SUB-COOLED NITROGEN FLUID FLOW. THE FLUID TEMPERATURE AND THE OUTER SURFACE TEMPERATURE OF THE CABLE CORES EXPOSED TO FLUID NITROGEN ARE NOT UNIFORM ALONG THE CABLE AXIS. AFTER THE REMOVAL OF THE FAULT CONDITION, UPSTREAM FLUID TEMPERATURE RESTORES TO INLET TEMPERATURE BY FRESH FLUID FLOW IN A SHORT TIME. BUT DOWNSTREAM FLUID TEMPERATURE INCREASES BECAUSE OF ACCUMULATION OF THE HEAT INPUT THROUGH HEAT TRANSFER FROM THE WALL OF CABLE CORES. THE DETAILED COMPUTATION RESULTS COMPARED WITH EXPERIMENTS WILL BE PRESENTED.

4LPJ-05

NUMERICAL ANALYSIS OF SUPERCONDUCTING POWER CABLE DURING FAULT CONDITION ***S. CHOI***[1]*, S. LEE*[2]*, K. SIM*[3]*, J. CHO*[3]*, T. KO*[1]*;* [1]YONSEI UNIVERSITY, [2]UIDUK UNIVERSITY, [3]KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE. — A SUPERCONDUCTING POWER CABLE CAN CARRY MORE THAN 2 TO 5 TIMES HIGHER ELECTRIC POWER COMPARED WITH CONVENTIONAL ONES. THE SUPERCONDUCTING POWER CABLE IS COMPOSED OF 2 LAYERS FOR TRANSMISSION AND 1 LAYER FOR SHIELD AND CU STABILIZER FOR BYPASS THE FAULT CURRENT. WHEN A FAULT CURRENT FLOWS, SUPERCONDUCTING TAPES CAN BE QUENCHED AND THE FAULT CURRENT WILL BE BYPASSED TO CONDUCTOR'S OTHER NORMAL COMPONENTS AND CU STABILIZER. THE BYPASSED FAULT CURRENT GENERATES ELECTRICAL JOULE HEAT WHICH RAISES THE TEMPERATURE OF CONDUCTORS AND STABILIZER RAPIDLY. THE STRUCTURE AND PROPERTY OF HTS TAPE AND CU STABILIZER WILL AFFECT TO THE TEMPERATURE OF THE SUPERCONDUCTING POWER CABLE.IN THIS PAPER, NUMERICAL ANALYSIS WAS PERFORMED TO ESTIMATE THE TEMPERATURE RISE OF SUPERCONDUCTING POWER CABLE UNDER OVER-CURRENT. WE HAVE MADE SHORT SAMPLES WITH THE SAME CONSTRUCTION OF THE HTS POWER CABLE AND TESTED IN THE LIQUID NITROGEN. THE SHORT-CIRCUIT TEST WAS CARRIED OUT WITH A PEAK VALUE OF 50 KA AND A DURATION OF 1.7S. DURING FAULT CONDITION, THE TEMPERATURE OF THE CONDUCTING LAYER AND THE SHIELDING LAYER WAS MEASURED AND THE TEST RESULTS AGREE WELL WITH THE NUMERICAL ANALYSIS. WE HAVE CONFIRMED THAT HTS CABLE HAS NOT BEEN DAMAGED BY THE FAULT CURRENT.

THIS RESEARCH WAS SUPPORTED BY A GRANT FROM CENTER FOR APPLIED SUPERCONDUCTIVITY TECHNOLOGY OF THE 21ST CENTURY FRONTIER R&D PROGRAM FUNDED BY THE MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY, REPUBLIC OF KOREA.

4LPJ-06

DYNAMIC SIMULATION OF HTSC CABLES WITH CONVENTIONAL SIMULATION PROGRAM *M. J. GELABERT-SERRA*[1]*, A. SUMPER*[2]*,* ***X. GRANADOS***[3]*, A. SUDRIA-ANDREU*[2]*, J. RULL-DURAN*[1]*;* [1]CITCEA-UPC, [2]CITCEA-UPC/IREC, [3]ICMAB. — THE DEVELOPMENT ACHIEVED BY SC DEVICES FOR APPLICATION IN THE GRID, REQUIRES THE SUPPORT OF DESIGNING TOOLS IN ORDER TO ESTABLISH THE EFFECT OF THESE NEW DEVICES IN THE OPERATION OF THE ELECTRICAL SYSTEM. CLASSICALLY, STANDARD SIMULATION CODES ARE EXTENSIVELY USED IN THE DESIGN AND MAINTENANCE OF THE GRID BY THE UTILITIES BUT THE NEW DEVICES REQUIRES SPECIFIC CODE MODELS COMPATIBLE WITH THE GRID SIMULATORS. IN THIS WORK WE DEAL ON A CODE MODEL FOR INTEGRATION OF SUPERCONDUCTING CABLES IN THE GRID, WITH CAPACITY TO SIMULATE DYNAMIC BEHAVIOR. RESULTS OF SIMULATION ARE REPORTED CONCERNING THE PERFORMANCE OF THE SIMULATION PLATFORM.

4LPJ-07

MINIMAL PATH CONNECTION OF SUPERCONDUCTING POWER CABLE USING STEINER TREE ***S. LEE****;* SEOUL NATIONAL UNIVERSITY OF TECHNOLOGY. — THE SUPERCONDUCTING POWER CABLE IS EXPENSIVE AND OCCUPIES A BIG SPACE FOR INSTALLATION. NEEDLESS TO SAY, THE SHORTER THE LENGTH IS, THE LOWER IT COSTS. STEINER TREE PROBLEM IS A TOOL FOR FINDING A MINIMAL PATH THAT CONNECTS ALL NODES BY ADDING SOME EXTRA NODES. THE EXTRA NODES ARE CALLED THE STEINER NODES. WHEN THREE VERTICES OF AN EQUILATERAL TRIANGLE ARE CONNECTED BY STEINER TREE, 42 % OF TOTAL LENGTH IS REDUCED COMPARED TO CONNECTING EACH VERTEX DIRECTLY.IN THIS PAPER, THE STEINER TREE IS APPLIED TO CONNECTION OF THE SUPERCONDUCTING POWER CABLE. WHEN SOME ELECTRICAL NODES ARE CONNECTED BY STEINER TREE, TOTAL LENGTH OF THE SUPERCONDUCTING POWER CABLE BECOMES MINIMAL. VOLTAGE DROP INSIDE THE CABLE AND LAND OCCUPATION FOR INSTALLATION ALSO CAN BE MINIMIZED BY CONNECTING THE ELECTRICAL NODES USING THE STEINER TREE. CONNECTION OF FIVE ELECTRICAL NODES USING STEINER TREE IS DEMONSTRATED AS AN EXAMPLE.

4LPJ-08

THE ANALYSIS OF CURRENT DISTRIBUTION FOR PARALLEL HTS TAPES *X. LI,* ***Y. WANG****, X. CUI;* NORTH CHINA ELECTRIC POWER UNIVERSITY. — BY MODELING THE CURRENT DISTRIBUTION OF PARALLEL HIGH TEMPERATURE SUPERCONDUCTING (HTS) TAPES, THE CURRENT

DISTRIBUTION IN ALL THE SUB-CIRCUIT AT ANY TIME IS MEASURED WHEN THE TRANSPORT CURRENT IS AC OR DC RESPECTIVELY. SIMULTANEOUSLY, THE QUENCH CHARACTER OF EACH TAPE IS DETECTED. FURTHERMORE, BY MEANS OF HEATING ONE OR TWO TAPES THROUGH THE ELECTRIC FUSE, THE INFLUENCE OF THE HEATED TAPES ON THE CURRENT DISTRIBUTION AND QUENCH CHARACTER OF THE WHOLE PARALLEL CIRCUIT CAN BE ANALYZED. THE EXPERIMENT MODEL IS IMPROVED BY ANALYZING THE FACTORS WHICH AFFECT THE CURRENT DISTRIBUTION IN PARALLEL CIRCUIT, AND RESEARCHING THE ERROR SOURCES. BASED ON THE EXPERIMENT AND ANALYSIS, THIS PAPER WILL LAY A THEORETICAL FOUNDATION FOR THE ANALYSIS OF CURRENT DISTRIBUTION AND THE STEADY OPERATION OF THE HTS CABLE.

THANKS FOR THE HELP FROM YINSHUN WANG AND XIANG CUI.

4LPK-01

TEST RESULTS OF A 30M HTS CABLE FOR YOKOHAMA PROJECT ***T. MASUDA***[1], *H. YUMURA*[1], *M. OHYA*[1], *Y. ASHIBE*[1], *H. ITO*[1], *M. WATANABE*[1], *S. HONJO*[2], *T. MIMURA*[2], *Y. KITOU*[2], *Y. NOGUCHI*[2]; [1]SUMITOMO ELECTRIC INDUSTRIES, LTD., [2]TOKYO ELECTRIC POWER COMPANY. — HTS CABLE DEMONSTRATION PROJECT SUPPORTED BY MINISTRY OF ECONOMY, TRADE AND INDUSTRY (METI) AND NEW ENERGY AND INDUSTRIAL TECHNOLOGY DEVELOPMENT ORGANIZATION (NEDO) HAS STARTED IN JAPAN. THE TARGET OF THIS PROJECT IS TO OPERATE A 66 KV, 200 MVA HTS CABLE IN THE LIVE NETWORK OF TOKYO ELECTRIC POWER COMPANY IN ORDER TO DEMONSTRATE ITS RELIABILITY AND STABLE OPERATION. THE DESIGN OF THE HTS CABLE WITH DI-BSCCO HAS BEEN COMPLETED AS WELL AS THOSE OF A TERMINATION AND A JOINT. A 30-METER HTS CABLE SYSTEM WITH TERMINATIONS, A JOINT AND A COOLING SYSTEM WAS INSTALLED IN SEI FACILITY TO CONFIRM THEIR DESIGN AND PERFORMANCE. VARIOUS TESTS AS VOLTAGE TESTS, NOMINAL AND OVER CURRENT TESTS, HEAT CYCLE TESTS, HEAT LOSS MEASUREMENTS AND SO ON WERE CONDUCTED AND IT IS VERIFIED THAT THE CABLE HAS GOOD PERFORMANCES AS DESIGN. THIS PAPER DESCRIBES THE DESIGN AND TEST RESULTS OF A 30-METER HTS CABLE, AND DISCUSSES REQUIRED TEST ITEMS OF HTS CABLES.

4LPK-02

TESTING RESULTS OF 154KV HTS POWER CABLE IN SOUTH KOREA ***B. YANG***[1], *J. KANG*[1], *J. CHO*[2], *S. LEE*[3], *S. KIM*[4]; [1]KEPCO, [2]KERI, [3]LS CABLE, [4]CVE. — UNTIL NOW SOME COUNTRIES INCLUDING SOUTH KOREA HAVE MADE BIG PROGRESS AND MANY EFFORTS IN THE DEVELOPMENT OF HTS POWER EQUIPMENTS, ESPECIALLY HTS CABLE SYSTEM IS THE STRONGEST CANDIDATE AMONG THEM FROM THE VIEWPOINT OF APPLYING TO REAL GRID.IN SOUTH KOREA, TRANSMISSION LEVEL 154KV, THE WORLD TOP VOLTAGE CLASS HTS CABLE SYSTEM HAVE BEEN INSTALLED AND TESTED IN TEST FIELDS SUCCESSFULLY. IN ORDER TO MEET TYPE TEST REQUIREMENTS MADE BY KEPCO GRID COMPANY, TRANSMISSION LEVEL HTS CABLE SYSTEM HAS BEEN INSTALLED AND TESTED IN KEPCO GOCHANG POWER TESTING FIELDS SINCE THE EARLY OF 2010. ALSO KEPCO HAVE A PLAN TO DEMONSTRATE TRANSMISSION LEVEL HTS CABLE SYSTEM IN REAL GRID, IN ORDER TO MEET PRACTICAL REQUIREMENTS AND BE FEASIBLE IN IT.THIS PAPER SAYS THE RESULTS OF TYPE TEST IN 154KV HTS CABLE SYSTEM AND THE WAY HOW TO TEST TRANSMISSION LEVEL HTS CABLE.

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4LPK-03

PROGRESS ON THE PERFORMANCE TEST OF KEPCO HTS POWER CABLE ***Y. CHOI***; KBSI. — THE KOREA ELECTRIC POWER CORPORATION (KEPCO) HTS POWER CABLE HAS BEEN SUCCESSFULLY INSTALLED AND OPERATED FOR FEASIBLE CONFIRMATION SINCE 2006 AT GOCHANG POWER TEST CENTER. THE 3-PHASE 100 M LONG HTS POWER CABLE WITH 22.9 KV/1.25 KA WAS MANUFACTURED AND COOLED BY A CLOSED-LOOP OF SUBCOOLED LIQUID NITROGEN. AT THE BEGINNING STAGE, THE COOLING SYSTEM WAS COMPOSED OF A LIQUID NITROGEN DECOMPRESSION COOLING UNIT. NO MAJOR FAULT HAS BEEN OBSERVED DURING LONG TERM OPERATING TEST. AS A NEXT STEP, COOLING SYSTEM WAS MODIFIED THAT A CRYOCOOLER WAS EMPLOYED, RESULTING IN THE TOTAL COOLING CAPACITY OF 4 KW AT LIQUID NITROGEN TEMPERATURE. IN THIS PAPER, THE PERFORMANCE TEST OF HTS POWER CABLE USING MODIFIED COOLING SYSTEM IS REPORTED. TEMPERATURE AS WELL AS PRESSURE IN THE SYSTEM IS DISCUSSED WITH RESPECT TO THE SUPPLIED CURRENT LEVEL. THE TECHNIQUE TO MINIMIZE HEAT LOAD IS ALSO INVESTIGATED FOR 500 M LONG HTS POWER CABLE APPLICATION.

THIS WORK WAS PARTIALLY SUPPORTED BY THE ELECTRIC POWER INDUSTRY TECHNOLOGY EVALUATION AND PLANNING (ETEP), AN AGENCY OF THE KOREAN GOVERNMENT MINISTRY OF KNOWLEDGE ECONOMY (MKE).

4LPK-04

HARMONIC DEPENDANT LOSS CHARACTERISTIC STUDY OF HTS CABLE USING THYRISTOR CONVERTER ***J. KIM***[1], *A. KIM*[1], *D. KIM*[1], *I. YU*[1], *M. PARK*[1], *J. CHO*[2], *K. SIM*[2], *S. KIM*[2], *J. LEE*[3]; [1]CHANGWON NATIONAL UNIVERSITY, [2]KOREA ELECTROTECHNOLOGY RESEARCH INSITUTE, [3]KYUNGNAM UNIVERSITY. — HIGH VOLTAGE DIRECT CURRENT (HVDC) CABLES ARE NORMALLY USED FOR UNDERGROUND OR SUBMARINE TRANSMISSION. MODERN HVDC SYSTEMS COMBINES THE GOOD EXPERIENCE OF THE OLD INSTALLATIONS WITH RECENTLY DEVELOPED TECHNOLOGIES AND MATERIALS. THE RESULT IS A VERY COMPETITIVE, FLEXIBLE AND EFFICIENT WAY OF TRANSMITTING ELECTRICAL ENERGY WITH A VERY LOW ENVIRONMENTAL IMPACT.AC SYSTEM GENERATES LOSSES EVEN IN THE HIGH TEMPERATURE

SUPERCONDUCTING (HTS) POWER CABLE FOR AC SYSTEM. IN THE CASE OF HTS DC CABLE THERE IS NO LOSS BECAUSE OF THE ZERO RESISTANCE OF HTS MATERIAL IS OBSERVED ONLY IN DC CURRENT, WHILE TRANSMISSION LOSS IS GENERATED IN AC CURRENT. HTS DC CABLE IS A CABLE THAT UTILIZES THE ADVANTAGES OF SUPERCONDUCTIVITY MOST EFFECTIVELY AND SHOWS NO PROBLEM INHERENT TO HTS AC CABLES. THEREFORE, THE DC APPLICATION OF HTS CABLES IS EXPECTED TO EXPAND GREATLY IN THE NEAR FUTURE, WITH THE ADVANCEMENT OF AC/DC CONVERTERS. DC SIDE VOLTAGE AND CURRENT OF HVDC TRANSMISSION SYSTEM, HOWEVER, ARE AFFECTED BY NON-LINEAR SWITCHING DEVICES SUCH AS THYRISTOR VALVE WHICH CAUSES REAL POWER LOSSES EVEN UNDER SUPERCONDUCTING CONDITION.THE AUTHORS MANUFACTURED A THYRISTOR CONVERTER AND A MINIATURIZED HTS MODEL CABLE TO INVESTIGATE THE LOSS CHARACTERISTIC UNDER DC APPLICATION ENVIRONMENT WITH HARMONIC COMPONENTS. BOTH 1^{ST} AND 2^{ND} GENERATION HTS TAPES ARE USED FOR THE EXPERIMENT AND THE RESULTS WILL BE DISCUSSED IN DETAIL.

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4LPK-05

CRITICAL CURRENT AND ITS MAGNETIC FIELD EFFECT MEASUREMENT OF HTS TAPES FORMING DC SUPERCONDUCTING CABLE ***M. HAMABE***[1]*, M. SUGINO*[1]*, H. WATANABE*[1]*, T. KAWAHARA*[1]*, S. YAMAGUCHI*[1]*, Y. ISHIGURO*[2]*, K. KAWAMURA*[3]*;* [1]CHUBU UNIVERSITY, [2]JFE STEEL, [3]MAYEKAWA M.F.G.. — WE CONSTRUCTED A TEST STAND OF 20 M DC SUPERCONDUCTING POWER TRANSMISSION CABLE IN CHUBU UNIVERSITY, IN 2006. THE CABLE CONSISTED OF THE THIRTY-NINE BI-2223 HTS TAPES IN TWO LAYERS; NINETEEN TAPES WERE USED IN THE FIRST LAYER AND TWENTY TAPES WERE USED IN THE SECOND LAYER. ONE OF THE FEATURES OF THE CABLE IS THAT EACH HTS TAPE IN THE FIRST LAYER IS ELECTRICALLY INSULATED SINCE THE NINETEEN HTS TAPES IN THE FIRST LAYER DON'T CONTACT EACH OTHER. THEREFORE, WE CAN APPLY THE CURRENT TO THE INDIVIDUAL HTS TAPES IN THE FIRST LAYER. WE MEASURED CRITICAL CURRENT OF THE ONE HTS TAPE IN THE FIRST LAYER WHEN THE CURRENT WAS APPLIED TO THE OTHER HTS TAPES, AND COMPARED THE RESULT WITH THE MAGNETIC FIELD CALCULATION DUE TO THE APPLIED CURRENT. FOR EXAMPLE, THE CRITICAL CURRENT SLIGHTLY INCREASED WHEN THE CURRENT WAS APPLIED TO ALL OTHER EIGHTEEN HTS TAPES IN THE SAME LAYER. IN THIS CASE, THE SELF MAGNETIC FIELD OF THE MEASURED HTS TAPE WAS ELIMINATED BY THE MAGNETIC FIELD OF THE NEIGHBOR HTS TAPES.

THIS WORK IS PARTLY SUPPORTED BY THE "UNIVERSITY-INDUSTRY JOINT RESEARCH" PROJECT FOR PRIVATE UNIVERSITIES: MATCHING FUND SUBSIDY FROM MINISTRY OF EDUCATION, CULTURE, SPORTS, SCIENCE AND TECHNOLOGY, JAPAN, 2005 - 2009.

4LPK-06

A NOVEL APPROACH FOR DESIGN OF HTS DC CABLE ***Y. WANG****, H. LIU, Y. ZHENG, H. ZHANG;* NORTH CHINA ELECTRIC POWER UNIVERSITY. — HIGH TEMPERATURE SUPERCONDUCTING (HTS) CABLE IS ONE OF IMPORTANT APPARATUS IN FUTURE SMART-GRID. HTS DIRECT CURRENT (DC) CABLE CAN PROVIDE SECURE AND RELIABLE TRANSMISSION OF ELECTRIC POWER AT THE GIGAWATT LEVEL WITH SEVERAL HUNDREDS OF KA AND KV. BESIDE THE MAGNETIC FIELD OF CABLE SERIOUSLY DEGRADES THE CRITICAL CURRENT OF HTS SUPERCONDUCTOR AND THEN THE CURRENT CAPACITY, SINCE SYSTEMS USED TO CONVERT AC TO DC PRODUCE SOME CURRENT VARIATIONS WHICH ARE USUALLY AT FREQUENCIES OF MULTIPLE POWER FREQUENCY; MODERN POWER CONVERTERS OFTEN INTRODUCE CURRENT CURRENTS AT OTHER FREQUENCIES EVEN FILTERS REDUCE THE MAGNITUDE OF THOSE RIPPLE CURRENTS THUS RESULTING INTO AC LOSS. IN ORDER TO REDUCE THIS LOSS , UNLIKE THE CONVENTIONAL UNIFORM CURRENT DESIGN IN AC CABLE, A NOVEL APPROACH IS PRESENTED FOR MINIMIZING THE LOSS AS SMALL AS POSSIBLE BY ADJUSTING THE INDUCTIVE REACTANCE OF EACH LAYER SO THAT THE RATIOS OF AC CURRENT AMPLITUDE TO CRITICAL CURRENT AND AC MAGNETIC FILED AMPLITUDE TO FULLY PENETRATED FILED ARE ALWAYS SAME IN EACH LAYER, . THE MAGNETIC FIELD DISTRIBUTION AND CRITICAL CURRENT ARE SIMULATED BY FINITE ELEMENT METHOD (FEM). THE CALCULATIONS SHOW THAT THE NEW APPROACHES CAN GREATLY REDUCE AC LOSS, IMPROVE EFFICIENCY, WHICH ARE POTENTIAL FOR DC CURRENT TRANSMISSION HTS CABLE APPLICATION.

THIS WORK WAS SUPPORTED IN PART BY SPECIALIZED RESEARCH FUND FOR THE DOCTORAL PROGRAM OF HIGHER EDUCATION AND THE FOUNDATION OF NCEPU UNDER GRANT KH0194.

4LPK-07

DEVELOPMENT OF DC SUPERCONDUCTING CABLE FOR RAILWAY SYSTEM ***M. TOMITA****, Y. FUKUMOTO, K. SUZUKI, M. MURALIDHAR, A. ISHIHARA;* RAAILWAY TECHNICAL RESERCH INSTITUTE. — THE HIGH-T_C SUPERCONDUCTING (HTSC) CABLE IS EXPECTED TO BECOME A PRACTICAL APPLICATION IN THE FUTURE. IT COULD BE USED AS A POWER CABLE BECAUSE ONE CAN REALIZE BULK POWER TRANSMISSION, COMPACTNESS, AND LOW COST. HTSC DC CABLE IS IDEAL FOR FEEDER OF OVERHEAD CONTACT LINE SYSTEM BETWEEN SUBSTATION AND ELECTRIC TRAIN. IF THE SUPERCONDUCTING CABLES ARE USED AS A FEEDER OF THE OVERHEAD CONTACT LINE SYSTEM, THE VOLTAGE DECAY COULD BE SIGNIFICANTLY REDUCED. WE COMPLETED A PROTOTYPE BI-2223 TAPE BASED ON DIRECT CURRENT CABLE FOR TRIAL PURPOSES OF SEVERAL METERS LENGTH. THE CURRENT CIRCULATED THROUGH THE SUPERCONDUCTING CABLE AT LIQUID NITROGEN. WHEN USING ONLY THE INNER SHEET WIRE, THE MAXIMUM CURRENT WAS 1720 A. WHILE, IN THE OUTER SHEET WIRE THE CURRENT REACHED 2430 A. THESE CURRENT CARRYING CAPACITIES ARE SUFFICIENT FOR RAILWAY SYSTEMS IN JAPAN

AND ARE COMPARABLE TO PRESENT CURRENT AMPERAGE GENERATED BY 1500V POWER SUPPLY OF RAILWAY SYSTEM IN JAPAN. THE INFLUENCE OF MAGNETIC SELF-FIELD WAS NEGLIGIBLE. SALIENT DESIGN FEATURES AND TEST RESULTS OF THE HTSC CABLE WILL BE DISCUSSED WITH RESPECT TO USE IN THE RAILWAY SYSTEM AND THIS IS FOR THE FIRST TIME IN THE WORLD.

4LPK-08

IRON STEEL CRYOGENIC PIPE FOR DC SUPERCONDUCTING POWER TRANSMISSION LINE ***S. YAMAGUCHI****, T. FUJII, M. HAMABE, H. WATANABE, T. KAWAHARA;* CHUBU UNIVERSITY. — IRON STEEL IS NOT USED FOR AC POWER TRANSMISSION LINE USUALLY AS THE BASIC MATERIAL BECAUSE ITS HYSTERESIS LOSS OF THE AC MAGNETIC FIELD IS QUITE HIGH AND IT CANNOT BE USED IN LOW TEMPERATURE. BUT IF WE APPLIED THE IRON STEEL PIPE FOR THE CRYOGENIC OUTER PIPE OF DC POWER TRANSMISSION LINE, WE CAN AVOID THESE PROBLEMS. THE COST OF THE IRON STEEL IS CHEAPER THAN THE STAINLESS STEEL BECAUSE THE NICKEL IS NECESSARY TO MAKE THE STAINLESS STEEL, AND THE RESOURCE OF NICKEL IS NOT ENOUGH TO MAKE THE PIPELINE TO REALIZE THE WORLD WIDE GRID (WWG). AND THE COST OF THE IRON STEEL IS CHEAP. MOREOVER, SINCE THE IRON STEEL IS FERROMAGNETISM, IT IS BETTER TO SHIELD THE MAGNETIC FIELD AND CAN INCREASE THE INDUCTANCE OF POWER TRANSMISSION LINE. LARGE INDUCTANCE OF POWER TRANSMISSION LINE CAN REDUCE THE RIPPLE CURRENT OF THE POWER CONVERTER AND ENHANCE THE MAGNETIC FIELD ENERGY OF THE TRANSMISSION LINE. IN ORDER TO CLEAR THIS SUBJECT, THE IRON PIPE IS SET IN THE 20-METER CABLE TEST BENCH, AND THE MAGNETIC FLUX INSIDE THE IRON PIPE IS MEASURED. WE DISCUSS THE POTENTIALITY OF THIS IDEA ALONG THE EXPERIMENTAL DATA, AND DISCUSS THE FUTURE DESIGN OF THE DC POWER TRANSMISSION LINE.

DRS. JIAN SUN, YURY IVANOV, TATSUNORI SUGIMOTO AND PROF. ATSUO IIYOSHI

4LPL-01

RESEARCH ON HYBRID TYPE SUPERCONDUCTING FAULT CURRENT LIMITER WITH YBCO CC ***Z. ZHANG****;* INSTITUTE OF ELECTRICAL ENGINEERING CHINESE ACADEMY OF SCIENCES. — SUPERCONDUCTING FAULT CURRENT LIMITER (SFCL) IS A PROSPECTIVE AND DEVELOPING ELECTRIC DEVICES CONNECTED IN SERIES IN POWER GRID TO LIMIT SHORT-CIRCUIT CURRENT. IN RECENT YEARS, A GREAT DEAL OF RESEARCH HAS BEEN CARRIED OUT BASED ON YBCO CC TAPE. FOR YBCO CC RESISTIVE SFCL, IN THIS PAPER, WE MAINLY FOCUS ON THE PROBLEM OF BOTH AC LOSS AND IMPACT OF OVER-CURRENT AT THE INITIATION OF THE FAULT. A NOVEL TOPOLOGY OF SFCL IS BUILD, IN WHICH YBCO CC TAPE IS USED TO WIND BIFILAR NON-INDUCTIVE COILS TO LIMIT THE SHORT-CIRCUIT CURRENT WHEN THE TAPE IS QUENCHED, WHILE, BI-2223 TAPE IS USED TO WIND DC REACTOR. THEY ARE CONNECTED IN SERIES IN A RECTIFIER TO COMPOSE A UNIT OF SFCL. THERE ARE 2×3 UNITS USED IN A SINGLE PHASE SFCL. ACCORDING TO THE CHARACTERISTIC OF TAPES, THE MODELING OF THE SFCL IS ACCOMPLISHED IN DETAIL, AND THE PARAMETER OF THE SFCL IS OPTIMIZED. A THREE-PHASE 400V/200 SFCL IS DESIGNED AND MANUFACTURED. THE ANALYSIS RESULTS WERE COMPARED WITH THE EXPERIMENTAL ONES, AND BOTH THE RESULTS AGREED.

4LPL-02

A DOUBLE LINE COMMUTATION TYPE SFCL WITH FIRST PEAK LIMITING FUNCTION ***O. HYUN****[1], S. YIM[1], C. PARK[1], S. YOO[1], S. YANG[1], W. KIM[1], H. KIM[1], G. LEE[2], J. SIM[2], K. PARK[2];* [1]KOREA ELECTRIC POWER RESEARCH INSTITUTE, [2]LS INDUSTRIAL SYSTEMS. — WE FABRICATED AND CONDUCTED SHORT CIRCUIT TESTS FOR A DOUBLE LINE COMMUTATION TYPE HYBRID SUPERCONDUCTING FAULT CURRENT LIMITER (SFCL) WHICH HAS THE FIRST PEAK CURRENT LIMITING FUNCTION. THE PRIMARY LINE HAS AN ULTRA FAST SWITCH (UFS), WHICH IS EITHER POWER ELECTRONIC OR MECHANICAL, AND THE FIRST BYPASS LINE HAS SUPERCONDUCTING COMPONENTS AND A RESISTIVE PART IN SERIES. THE RESISTIVE PART INCLUDES RESISTOR OR SUCH SWITCHES AS DIAC CIRCUIT. A FAULT CURRENT TRIGGERS THE UFS TO COMMUTATE THE CURRENT FROM THE PRIMARY LINE TO THE FIRST BYPASS LINE. THE COMMUTATION IS COMPLETED IN LESS THAN A MILLISECOND, WHICH IS SHORT ENOUGH FOR THE SUPERCONDUCTORS CAN HOLD THE FAULT CURRENT WITH NO RESISTANCE. AFTER COMPLETION OF THE FIRST LINE COMMUTATION THE SUPERCONDUCTORS QUENCH TO LIMIT THE FAULT CURRENT WITH MINIMALLY REQUIRED LIMITING RATIO FOR MAXIMUM 1/2 CYCLE BEFORE THE FAULT CURRENT CROSSES THE ZERO POINT. A RECENTLY DEVELOPED FAST SWITCH IS TO PERFORM THE SECOND LINE COMMUTATION. THE FULL CURRENT LIMITATION AFTER THE FIRST 1/2 CYCLE IS CARRIED OUT BY A CONVENTIONAL LIMITER. A PROTOTYPE SFCL FOR THE DESIGN SHOWED FIRST PEAK INTERRUPTION AND IMPLIED USEFULNESS IN THE MEDIUM VOLTAGE. THE GREATEST ADVANTAGE MAY BE SIGNIFICANT REDUCTION OF THE SUPERCONDUCTOR VOLUME AND COOLING LOAD AS WELL AS ENHANCEMENT OF OPERATION RELIABILITY.

THIS WORK WAS SUPPORTED BY A GRANT FROM THE CENTER FOR APPLIED SUPERCONDUCTIVITY TECHNOLOGY OF THE 21ST CENTURY FRONTIER R&D PROGRAM FUNDED BY THE MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY, REPUBLIC OF KOREA.

4LPL-03

EXPERIMENTAL STUDY ON FAULT CURRENT LIMITING AND UNINTERRUPTIBLE POWER SUPPLYING CHARACTERISTICS OF A SFCL USING MAGNETIC COUPLING OF TWO COILS ***S. LIM****, I. YOU, S. WANG, J. KIM;* SOONGSIL UNIVERSITY. — IN THIS PAPER, THE UNINTERRUPTIBLE POWER SUPPLYING OPERATION OF A SFCL USING MAGNETIC COUPLING OF TWO COILS DURING THE FAULT PERIOD WAS SUGGESTED. THE STRUCTURE OF THE SUGGESTED SFCL IS THE SAME AS ONE OF THE CONVENTIONAL SFCLS USING MAGNETIC COUPLING OF TWO COILS EXCEPT FOR THE THIRD WINDING AND TWO POWER SWITCHES. THE THIRD WINDING IS WOUND ON THE

SAME IRON CORE AS TWO COILS OF THE SFCL USING MAGNETIC COUPLING ARE WOUND AND TWO POWER SWITCHES ARE CONNECTED WITH THE THIRD WINDING AND THE LOAD REQUIRED FOR THE UNINTERRUPTIBLE POWER, RESPECTIVELY.TO INVESTIGATE THE FAULT CURRENT LIMITING AND THE UNINTERRUPTIBLE POWER SUPPLYING OPERATIONS OF THE SUGGESTED SFCL USING MAGNETIC COUPLING, THE SHORT-CIRCUIT TESTES WERE CARRIED OUT. THROUGH THE ANALYSIS FOR THE EXPERIMENTAL RESULTS, THE FAULT CURRENT LIMITING AND THE UNINTERRUPTIBLE POWER SUPPLYING OPERATIONS OF THE FLUX-LOCK TYPE SFCL COULD BE CONFIRMED TO BE PERFORMED THROUGH THE PROPER DESIGN OF THE SFCL USING MAGNETIC COUPLING.

4LPL-04

ANALYSIS ON OPERATIONAL CHARACTERISTICS OF HYBRID TYPE SUPERCONDUCTOR FAULT CURRENT LIMITER WITH THE FIRST HALF CYCLE NON-LIMITING OPERATION *I. YOU, S. WANG,* ***S. LIM****, J. KIM;* SOONGSIL UNIVERSITY. — THE HYBRID TYPE SFCL CONSISTS OF A SUPERCONDUCTING TRIGGER PART, A FAST-SPEED SWITCH PART AND A CURRENT LIMITING PART. THE HYBRID TYPE SFCL WITH FIRST HALF CYCLE NON-LIMITING OPERATION PASSES A HALF-CYCLE FAULT CURRENT WITHOUT THE LIMITATION AND STARTS LIMITING THE FAULT CURRENT AFTER A HALF-CYCLE. THIS OPERATION MADE IT POSSIBLE TO COORDINATE WITH CONVENTIONAL RELAYS AND TO REALIZE OPTIMUM CURRENT LIMITING CHARACTERISTICS.HOWEVER, THE OPERATIONAL CHARACTERISTICS OF THE HYBRID TYPE SFCL WITH FIRST HALF CYCLE NON-LIMITING OPERATION DEPEND ON DESIGN PARAMETER. AMONG THEM, THE OPERATIONAL CHARACTERISTIC OF THE HYBRID TYPE SFCL WITH FIRST HALF CYCLE NON-LIMITING OPERATION ARE AFFECTED BY THE DESIGN VALUE OF BOTH THE CURRENT LIMITING PART AND THE SUPERCONDUCTING TRIGGER PART. THEREFORE, THE STUDIES FOR THE OPERATIONAL CHARACTERISTICS OF THE HYBRID TYPE SFCL WITH FIRST HALF CYCLE NON-LIMITING OPERATION CONSIDERING DESIGN PARAMETERS ARE NEEDED.IN THIS PAPER, WE DEVELOPED A PSCAD/EMTDC ANALYSIS MODEL OF THE HYBRID TYPE SFCL WITH FIRST HALF CYCLE NON-LIMITING OPERATION ACCORDING TO DESIGN PARAMETER. THROUGH THE SIMULATION AND AN EXPERIMENT, WE CONFIRMED THAT THE BURDEN OF THE SUPERCONDUCTOR ELEMENT WAS DECREASED SO THAT THE RESISTANCE OF THE CURRENT LIMITING PART INCREASED AND THE FAST-SPEED SWITCH WAS OPERATED MORE QUICKLY AS THE RESISTANCE OF SUPERCONDUCTING TRIGGER PART INCREASED.

THIS WORK HAS BEEN SUPPORTED BY KESRI(R-2008-38), WHICH IS FUNDED BY MKE(MINISTRY OF KNOWLEDGE ECONOMY)

4LPL-05

STUDY ON PEAK CURRENT LIMITING CHARACTERISTICS OF A FLUX-LOCK TYPE SFCL USING ITS THIRD WINDING ***S. LIM****, J. KIM;* SOONGSIL UNIVERSITY. — IN THIS PAPER, THE FLUX-LOCK TYPE SUPERCONDUCTING FAULT CURRENT LIMITER (SFCL) WITH THE PEAK CURRENT LIMITING FUNCTION IN CASE OF THE FAULT OCCURRENCE WAS SUGGESTED. GENERALLY, THE PEAK AMPLITUDE OF THE FAULT CURRENT AFTER THE FAULT OCCURRENCE DEPENDS ON THE TRANSIENT COMPONENT OF THE FAULT CURRENT, WHICH IS DETERMINED BY THE FAULT CONDITION SUCH AS THE FAULT ANGLE. IN THE SUGGESTED FLUX-LOCK TYPE SFCL, THE LOWER PEAK AMPLITUDE OF THE FAULT CURRENT CAUSES THE ONLY HTSC ELEMENT CONNECTED IN SERIES WITH ONE OF TWO COILS COMPRISING THE FLUX-LOCK TYPE SFCL TO BE QUENCHED, WHICH THE FAULT CURRENT CAN BE LIMITED BY THE LIMITING IMPEDANCE OF THE FLUX-LOCK TYPE SFCL. ON THE OTHER HAND, THE FAULT CURRENT WITH THE HIGHER PEAK AMPLITUDE MAKES THE HTSC ELEMENT CONNECTED WITH THE THIRD WINDING TO BE QUENCHED AFTER THE HTSC ELEMENT CONNECTED IN SERIES WITH ONE OF THE SFCL'S TWO COILS IS QUENCHED, WHICH CONTRIBUTES TO THE HIGHER IMPEDANCE OF THE SFCL. THEREFORE, THE EFFECTIVE FAULT CURRENT LIMITING OPERATION OF THE FLUX-LOCK TYPE SFCL CAN BE PERFORMED BY GENERATING THE SFCL'S IMPEDANCE IN PROPORTION TO THE PEAK AMPLITUDE OF THE FAULT CURRENT. TO CONFIRM THE CURRENT LIMITING OPERATION OF THE PROPOSED FLUX-LOCK TYPE SFCL, THE SHORT-CIRCUIT TESTS OF THE FLUX-LOCK TYPE SFCL USING ITS THIRD WINDING ACCORDING TO THE FAULT ANGLE WERE CARRIED OUT AND ITS EFFECTIVE FAULT CURRENT LIMITING OPERATIONS COULD BE DISCUSSED.

THIS WORK HAS BEEN SUPPORTED BY KESRI(R-2008-38), WHICH IS FUNDED BY MKE(MINISTRY OF KNOWLEDGE ECONOMY).

4LPL-06

INCREASE CHARACTERISTICS OF CURRENT LIMITING CAPACITY OF SFCL BY USING MATRIX-TYPE SFCL MODULE ***B. YOO****[1], D. CHUNG[1], Y. CHO[2], B. JUNG[2], H. CHOI[1];* [1]WOOSUK UNIV., [2]CHOSUN UNIV.. — WE REPORT THE INCREASE OF CURRENT LIMITING CAPACITY OF SFCLS BY USING THE BASIC 1 X 3 MATRIX MODULE WITH 3 SUPERCONDUCTING ELEMENTS. TO DO THIS, WE FABRICATE MATRIX-TYPE SFCLS WITH 1 X 3 MODULE CONSISTS OF A TRIGGER PART AND CURRENT LIMITING PARTS. FIRSTLY, WE ANALYZE THE CURRENT LIMITING CHARACTERISTICS OF 1 X 3 MATRIX MFCLS. SECONDLY, WE INVESTIGATE THE INCREASE CHARACTERISTICS OF 2 X 3 MODULES AND 3 X 3 MODULES WHICH ARE PARALLEL CONNECTED WITH BASIC 1 X 3 MODULES. FROM THIS PROCEDURE, WE APPROVE THE EASY INCREASE OF CURRENT LIMITING CAPACITY THROUGHOUT THE SIMPLE CONNECTION OF BASIC 1 X 3 MODULES WITHOUT COMPLEX WIRING. WE USE YBCO SUPERCONDUCTING THIN FILMS AND CONSTRUCT MFCL SYSTEMS BY USING 9 SUPERCONDUCTORS AND 3 REACTORS. EXPERIMENTAL RESULTS ARE REPORTED IN TERMS OF THE INCREASE CHARACTERISTICS OF LIMITING CAPACITY AND QUENCH PROPAGATION.

4LPL-07

CHARACTERIZATION OF FAULT VOLTAGES OF MATRIX-TYPE SFCL WITH 1 X 9 MODULE ***D. CHUNG****[1], B. YOO[1], Y. CHO[2], B. JUNG[2], D. CHEONG[3], H. CHOI[2];* [1]WOOSUK UNIV., [2]CHOSUN

UNIV., [3]KOREA UNIVIERSITY OF EDUCATION. — IN THIS PAPER, WE REPORT THE EASY INCREASE OF THE CAPACITY OF FAULT VOLTAGES BY USING MATRIX-TYPE SFCL (MFCL) MODULE. SUPERCONDUCTORS USED IN THIS WORK ARE YBCO THIN FILMS DEPOSITED ON 2 IN. DIAMETER AL2O3 SUBSTRATES. ALSO, REACTORS WITH A DIAMETER OF 80 MM AND LENGTH OF 230 MM ARE FABRICATED IN ORDER TO INDUCE INTENSE AND EQUAL MAGNETIC FIELD INTO SUPERCONDUCTING ELEMENTS. THEN, WE CONSTRUCT THE INTEGRATED MFCLS WITH 1 X 3 MODULE WHICH CONSIST OF A TRIGGER PART WITH A SINGLE SUPERCONDUCTING ELEMENT AND CURRENT LIMITING PARTS WITH TWO SUPERCONDUCTING ELEMENTS. FINALLY, WE TEST THE INCREASE OF THE CAPACITY OF FAULT VOLTAGES BY USING 1 X 3 MODULE, 1 X 6 MODULE AND 1 X 9 MODULE. EXPERIMENTAL RESULTS ARE REPORTED IN TERMS OF THE CHARACTERISTICS OF FAULT VOLTAGES, FAULT CURRENTS AND SO ON.

4LPL-08

EMERGENCY BLACKOUT OPERATION OF CRYOGENIC SYSTEM FOR HYBRID SFCL ***H. CHANG***[1]*, M. KIM*[1]*, J. SIM*[2]*, S. YIM*[3]*, O. HYUN*[3]*;* [1]HONG IK UNIVERSITY, [2]LS INDUSTRIAL SYSTEMS INC., [3]KOREA ELECTRIC POWER RESEARCH INSTITUTE. — AN OPERATION SCHEME OF CRYOGENIC SYSTEM IS INVESTIGATED IN PREPARATION FOR LOSS OF COOLING POWER IN HYBRID SUPERCONDUCTING FAULT CURRENT LIMITER (SFCL). THIS IS PART OF OUR ONGOING EFFORTS TO DEVELOP THE 22.9KV/630A SFCL IN KOREAN HTS PROGRAM. IN THE CRYOGENIC SYSTEM UNDER NORMAL OPERATION, HTS TRIGGER ELEMENTS ARE COOLED IN LIQUID-NITROGEN POOL AT 77 K BY A GM CRYOCOOLER AND COMPRESSED AT 300 KPA BY HELIUM GAS. A STEP-BY-STEP PROCEDURE IS SCHEDULED AND TESTED TO MAINTAIN THE HTS ELEMENTS AT OR BELOW 77 K DURING BLACKOUT AND RECOVER PERIOD. UPON DETECTION OF POWER OUTAGE, THE FIRST STEP IS TO REDUCE THE RELIEF PRESSURE FROM 300 KPA TO 100 KPA SO THAT LIQUID NITROGEN CAN EVAPORATE IN SATURATED STATE AT 77 K. THE THERMAL LOAD DURING BLACKOUT PERIOD IS COVERED BY THE LATENT HEAT OF LIQUID NITROGEN AT ATMOSPHERIC PRESSURE. WHEN THE POWER IS RESTORED, THE SFCL IS IMMEDIATELY READY TO WORK SINCE THE HTS ELEMENTS REMAIN AT 77 K. HOWEVER, THE LIQUID PRESSURE SHOULD BE GRADUALLY RAISED TO 300 KPA BY COMPRESSED HELIUM, AFTER THE ACTUAL COOLING POWER OF CRYOCOOLER IS RECOVERED TO THE LEVEL OF FULL THERMAL LOAD. THE SUPPLY SCHEDULE OF MAKE-UP LIQUID IS OPTIONAL, DEPENDING ON THE AMOUNT OF BOIL-OFF LOSS. THE INSTRUMENTATION AND CONTROL PARTS FOR THE EMERGENCY PROCEDURE ARE DESIGNED AND INSTALLED ON THE PROTOTYPE OF HYBRID SFCL, AND THE REHEARSED RESULTS WITH A POWER OUTAGE ARE PRESENTED AND DISCUSSED.

THIS STUDY IS SUPPORTED BY GRANTS FROM THE CENTER FOR APPLIED SUPERCONDUCTIVITY TECHNOLOGY (CAST) UNDER THE 21C FRONTIER R&D PROGRAM FUNDED BY THE MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY IN KOREA.

4LPM-01

THEORETICAL AND EXPERIMENTAL STUDY OF SUPERCONDUCTING COILS WOUND USING COATED CONDUCTORS ***W. YUAN****, M. D. AINSLIE, W. XIAN, Z. HONG, Y. YAN, A. M. CAMPBELL, T. A. COOMBS;* UNIVERSITY OF CAMBRIDGE. — A NUMERICAL MODEL IS DEVELOPED TO CALCULATE THE AC LOSSES OF SUPERCONDUCTING PANCAKE COILS WOUND USING SECOND-GENERATION HIGH-TEMPERATURE SUPERCONDUCTING TAPES. THIS MODEL TAKES AS A STARTING POINT THE ORIGINAL MODEL OF AN INFINITE LONG STACK OFTAPES BY YUAN ET AL. THE ASSUMPTION IS THAT THE MAGNETIC FLUX LINES WILL LIE PARALLELTO THE WIDE FACES OF TAPES IN THE UNPENETRATED AREA OF THE COIL. INSTEAD OF USING ANINFINITELY LONG STACK TO APPROXIMATE THE CIRCULAR COIL AS IN MANY PREVIOUS PAPERS, THIS PAPER GIVES AN EXACT CIRCULARCOIL MODEL. THE COMPUTATION RESULTS ARE IN GOOD AGREEMENT WITH THE ASSUMPTIONS.AN EXPERIMENTAL RIG IS SET UP TO VALIDATE THIS MODEL. TWO DIFFERENT METHODS ARE USED TO COMPENSATE THE LARGE INDUCTIVE VOLTAGE OF THE SUPERCONDUCTING COIL - USING A COMPENSATION COIL OR A CAPACITOR. A LOCK-IN AMPLIFIER IS USED TO MEASURE THE RESISTIVE VOLTAGE OF THE SUPERCONDUCTING COIL. THE EXPERIMENTAL RESULTS ARE CONSISTENT WITH THE THEORETICAL PREDICTIONS.

THE AUTHORS WOULD LIKE TO THANK MARK HUSBAND FROM ROLLS ROYCE INC. FOR HIS GREAT SUPPORT AND HELP THROUGH THIS WORK.

4LPM-03

NORMAL ZONE PROPAGATION IN PANCAKE COILS MADE OUT OF YBCO COATED CONDUCTORS. ***G. A. LEVIN***[1]*, K. A. NOVAK*[2]*, W. A. JONES*[1]*, P. N. BARNES*[1]*;* [1]PROPULSION DIRECTORATE, AIR FORCE RESEARCH LABORATORY, WRIGHT-PATTERSON AIR FORCE BASE, OH, USA, [2]DEPARTMENT OF MATHEMATICS, AIR FORCE INSTITUTE OF TECHNOLOGY, WRIGHT-PATTERSON AIR FORCE BASE, OH 45433 USA. — WE WILL PRESENT THE RESULTS OF NUMERICAL ANALYSIS OF A QUENCH IN PANCAKE COILS MADE OUT OF YBCO COATED CONDUCTORS. THE MAIN GOAL OF OUR STUDY IS TO FIND A WAY TO IMPROVE THE QUENCH PROTECTION QUALITY OF SUCH COILS. WE INVESTIGATE THE EFFECT OF SUBSTANTIALLY INCREASED, IN COMPARISON WITH THAT IN THE STATE-OF-THE-ART MANUFACTURED CONDUCTORS, INTERFACIAL RESISTANCE BETWEEN THE SUPERCONDUCTING FILM AND STABILIZER ON NORMAL ZONE PROPAGATION AND STABILITY. IN A PANCAKE COIL ONE NEEDS TO TAKE INTO ACCOUNT THE HEAT PROPAGATION IN TWO DIRECTIONS - TRANSVERSE, BETWEEN THE NEIGHBORING TURNS, AND LATERAL, ALONG THE CONDUCTOR. THE MAIN CRITERION OF USEFULNESS OF INCREASED INTERFACIAL RESISTANCE IS THE PEAK TEMPERATURE T_P INSIDE THE NORMAL ZONE AS A FUNCTION OF VOLTAGE V GENERATED ACROSS THE COIL BY PROPAGATING QUENCH. SUCH VOLTAGE IS CURRENTLY THE MAIN MEANS OF QUENCH DETECTION. THEREFORE, IT IS DESIRABLE THAT THE RATE OF INCREASE DT_P/DV WAS AS SMALL AS POSSIBLE, SO THAT THE QUENCH CAN BE DETECTED

BEFORE THE TEMPERATURE RISES ABOVE THE DAMAGE THRESHOLD.

4LPM-04

AC LOSSES AND TRANSPORT CURRENT IN ROEBEL CABLE MADE OF YBCO COATED CONDUCTOR TAPES ***M. MAJOROS***[1], *M. D. SUMPTION*[1], *D. TURRIONI*[2], *E. BARZI*[2], *A. ZLOBIN*[2], *A. NIJHUIS*[3], *E. W. COLLINGS*[1]; [1]THE OHIO STATE UNIVERSITY, COLUMBUS, OH, USA, [2]FERMI NATIONAL ACCELERATOR LABORATORY, BATAVIA, IL, USA, [3]LOW TEMPERATURE DIVISION, FACULTY OF APPLIED PHYSICS, UNIVERSITY OF TWENTE, ENSCHEDE, NL. — A PROMISING DESIGN OF A LOW AC LOSS CABLE IS BASED ON THE ROEBEL CABLE CONCEPT. THIS CABLE MAY HAVE A NUMBER OF APPLICATIONS, INCLUDING SOME IN HIGH ENERGY PHYSICS MACHINES, WHICH OPERATE AT LOW TEMPERATURES. IN THE ROEBEL CABLE, THE STRANDS ARE MAGNETICALLY DECOUPLED WITHOUT TWISTING. WE HAVE MEASURED MAGNETIZATION AND TRANSPORT AC LOSSES IN A 10 STRAND ROEBEL. THE MAGNETIZATION MEASUREMENTS WERE CARRIED OUT IN PERPENDICULAR ORIENTATION IN FREQUENCY RANGE OF 50-200 HZ. BOTH MAGNETIZATION AND TRANSPORT AC LOSSES HAVE BEEN DONE IN LIQUID NITROGEN BATH AT 77.3 K. LOW RAMP RATE MAGNETIZATION LOSSES WERE ALSO PERFORMED IN A LHE BATH AT 4.2 K AT THE UNIVERSITY OF TWENTE. FINALLY, SELF FIELD TRANSPORT CURRENTS WERE MEASURED AT 4.2 K USING A TRANSFORMER ARRANGEMENT AT FERMILAB. WHILE THE MAGNETIZATION AC LOSS IN THE PERPENDICULAR ORIENTATION IS PREDOMINANTLY HYSTERETIC IN NATURE, WE OBSERVE SOME FREQUENCY DEPENDENCE OF THE LOSS WHEN THE CABLE APPROACHES FULL FLUX PENETRATION AT HIGH FIELD AMPLITUDES. THE MAGNITUDE IS CONSISTENT WITH EDDY CURRENT LOSSES IN THE COPPER STABILIZATION LAYER, RATHER THAN CABLE LEVEL EDDY CURRENTS. FURTHERMORE, THE CABLE AND THE STRAND LOSSES ARE CONVERGING AT HIGH FIELD AMPLITUDES SUGGESTING THAT INTER-STRAND COUPLING LOSS IS NOT SIGNIFICANT IN THIS FREQUENCY RANGE

4LPM-05

HEAT AND QUENCH PROPAGATION IN YBCO COATED CONDUCTOR COILS AT 4.2 K AND SUBJECTED TO APPLIED FIELDS - MODELING AND MEASUREMENT ***M. MAJOROS***[1], *M. D. SUMPTION*[1], *M. A. SUSNER*[1], *V. LOMBARDO*[2], *D. TURRIONI*[2], *E. BARZI*[2], *E. W. COLLINGS*[1]; [1]THE OHIO STATE UNIVERSITY, COLUMBUS, OH, USA, [2]FERMI NATIONAL ACCELERATOR LABORATORY, BATAVIA, IL, USA. — NEW HIGH ENERGY PHYSICS MAGNETS REQUIRE INCREASINGLY HIGH MAGNETIC FIELDS, DEMANDING THE USE OF NEW SUPERCONDUCTING MATERIALS. YBCO IS OF INTEREST IN A NUMBER OF POSSIBLE HEP APPLICATION AREAS, INCLUDING HIGH FIELD SOLENOIDS FOR MUON COLLIDERS. THE THERMAL PROPAGATION, QUENCH PROPAGATION, AND CONDUCTOR PROTECTION ARE HIGHLY IMPORTANT IN THESE APPLICATIONS. IN THE PRESENT WORK WE HAVE MEASURED THE THERMAL CONDUCTIVITY AND HEAT PROPAGATION IN STACKS OF SEVERAL YBCO COATED CONDUCTOR TAPES SIMULATING PARTS OF MAGNET WINDINGS. THE MEASUREMENTS HAVE BEEN PERFORMED IN LIQUID HELIUM BATH. NUMERICAL FEM MODELING OF HEATING AND CURRENT SHARING EFFECTS IN SUCH TAPE STACKS IN LHE WAS ALSO PERFORMED. THE RESULTS ARE USED AS INPUT TO A MODEL FOR QUENCHING IN A SOLENOID MAGNET. A COIL WITH 19 MM ID AND 62 MM OD WAS WOUND USING YBCO TAPE AND WAS INSTRUMENTED FOR VOLTAGE AND TEMPERATURE MEASUREMENTS AT SEVERAL PLACES AROUND THE WINDING, SUCH THAT BOTH RADIAL AND AZIMUTHAL QUENCH PROPAGATION COULD BE MEASURED. A HEATER WAS INCLUDED FOR BOTH QUENCH INITIATION AND THERMAL GRADIENT MEASUREMENT. AFTER THIS THE COIL WAS EPOXY IMPREGNATED. THE COIL WAS THEN PLACED IN AN APPLIED FIELD IN POOL BOILING LIQUID HELIUM. DC CURRENTS WERE APPLIED TO SOME FRACTION OF IC, AFTER WHICH A CURRENT PULSE WAS APPLIED TO THE HEATER, AND NZP VALUES WERE MEASURED IN RADIAL AND AZIMUTHAL DIRECTIONS.

4LPM-06

QUENCH ANALYSIS OF A HIGH-CURRENT FORCED-FLOW HTS CONDUCTOR FOR FUSION MAGNETS ***C. MARINUCCI***[1], *R. WESCHE*[1], *L. BOTTURA*[2]; [1]EPFL, CRPP FUSION TECHNOLGY, [2]CERN. — HIGH TEMPERATURE SUPERCONDUCTORS (HTS) ARE CONSIDERED A SERIOUS ALTERNATIVE TO LOW TEMPERATURE SUPERCONDUCTORS FOR MAGNETS OF FUTURE FUSION DEVICES (E.G. DEMO) BECAUSE OF SEVERAL POTENTIAL ADVANTAGES, E.G. HIGH OPERATION TEMPERATURE, TEMPERATURE MARGIN, HIGH FIELD PROPERTIES AND CRYOGENIC POWER SAVING. FOR THESE APPLICATIONS YBCO COATED CONDUCTORS ARE PREFERRED TO OTHER HTS CONDUCTORS BECAUSE OF THEIR HIGH CRITICAL CURRENT DENSITY IN HIGH MAGNETIC FIELD. IN THE DESIGN AND OPERATION OF MAGNETS USING HTS CONDUCTORS A FUNDAMENTAL UNDERSTANDING OF THE QUENCH PHENOMENON IS PARTICULARLY IMPORTANT BECAUSE THE QUENCH PROPAGATION VELOCITY IS LOW DUE TO HIGH SPECIFIC HEAT AT HIGH TEMPERATURE. WE HAVE INCLUDED THE YBCO PHYSICAL PROPERTIES IN THE CRYOSOFT™ CODE THEA AND THEN PERFORMED THE SIMULATIONS OF A HIGH-CURRENT FORCED-FLOW CONDUCTOR (ROEBEL CABLE) MODEL TO ASSESS THE KEY QUENCH PARAMETERS, E.G. THE TEMPERATURE INCREASE OF THE NORMAL ZONE AND ITS PROPAGATION VELOCITY. THE SENSITIVITY OF THESE RESULTS ON CONDUCTOR DESIGN PARAMETERS, SUPERCONDUCTOR PROPERTIES AND OPERATION PARAMETERS WAS ASSESSED WITH A VARIATIONAL ANALYSIS.

4LPM-07

THERMAL STABILITY PROPERTIES UNDER THE CRYOCOOLING CONDITION FOR $YBA_2CU_3O_7$ COATED CONDUCTOR TAPE ***K. WATANABE***[1], *V. R. ROMANOVSKII*[2], *Y. KAWASE*[1], *G. NISHIJIMA*[1], *S. AWAJI*[1], *I. INOUE*[3], *H. SAKAMOTO*[3], *M. MIMURA*[3], *S. NAGAYA*[4]; [1]INSTITUTE FOR MATERIALS RESEARCH, TOHOKU UNIVERSITY, [2]RUSSIAN RESEARCH CENTER 'KURCHATOV INSTITUTE', [3]FURUKAWA ELECTRIC CO., LTD., [4]CHUBU ELECTRIC POWER CO., INC.. — FROM A VIEWPOINT OF A CRYOGEN-FREE HIGH FIELD SUPERCONDUCTING MAGNET, THE THERMAL STABILITY

PROPERTIES BEFORE THERMAL RUNAWAY FOR $YBA_2CU_3O_7$ (Y123) COATED CONDUCTOR TAPES WERE EXAMINED IN THE CONDUCTION COOLING CONDITION BY A GM-CRYOCOOLER. UP TO NOW, WE HAVE REPORTED THAT AG-SHEATHED $BI_2SR_2CA\ CU_2O_8$ (BI2212) WIRES WITH J_C~10^4 A/CM^2 REVEAL STABLE BEHAVIORS OF 3 TIMES LARGER CRITICAL CURRENTS BEFORE THERMAL RUNAWAY, ALTHOUGH CONVENTIONAL NB_3SN WIRES WITH J_C~10^4 A/CM^2 OCCUR A QUENCH ALMOST AT THEIR CRITICAL CURRENT VALUES IN THE CRYOCOOLING CONDITION. WE ARE NOW INTENDING TO DEVELOP A CRYOGENFREE 23 T SUPERCONDUCTING MAGNET INCORPORATING Y123 COATED CONDUCTOR TAPES. IN ORDER TO DETERMINE THE MAXIMUM CURRENT-CARRYING CAPACITY OF Y123 TAPE IN HIGH FIELDS, WE USE A ZERO-DIMENSIONAL HEAT BALANCE MODEL. THE STUDY WAS DONE AT B=10 T, BATH TEMPERATURE T_0=4.2 K, J_C=8×10^6 A/CM^2, CRYOCOOLING HEAT TRANSFER COEFFICIENT H=10^{-3}W/CM^{2}K, TAPE WIDTH B=0.2 CM, Y123 THICKNESS A_S=1×10^{-4} CM, AG THICKNESS A_{AG}=30×10^{-4}CM, CU THICKNESS A_{CU}=20×10^{-4} CM, AND RESIDUAL RESISTANCE RATIO RRR=100 (FOR AG AND CU). WE FOUND THAT Y123 WITH J_C~8×10^6 A/CM^2 HAS NOT THE OVER-CRITICAL CURRENT BUT THE RATHER SUB-CRITICAL CURRENT BEFORE THE THERMAL RUNAWAY. THE SUB-CRITICAL VALUE OF THE THERMAL RUNAWAY CURRENT WAS IN GOOD AGREEMENT WITH EXPERIMENTAL RESULTS USING Y123 TAPE IN THE CRYOCOOLING CONDITION.

4LPM-08

THERMAL STABILITY OF CONDUCTION-COOLED YBCO PANCAKE COIL ***H. MIYAZAKI,*** *S. IWAI, T. TOSAKA, K. TASAKI, S. HANAI, M. URATA, S. IOKA, Y. ISHII;* TOSHIBA CORPORATION. — WE FABRICATED AND TESTED A CONDUCTION-COOLED HTS COIL WOUND WITH YBCO COATED CONDUCTOR TAPES IN ORDER TO STUDY THE THERMAL STABILITY IN YBCO COIL. THE COIL WAS COMPOSED OF TWO SINGLE-PANCAKE COILS AND IMPREGNATED WITH EPOXY RESIN. THE INNER DIAMETER OF THE COIL IS 100 MM AND THE OUTER DIAMETER IS 164 MM. WE MEASURED THE V-I CHARACTERISTICS OF THE COIL IN A LIQUID NITROGEN ENVIRONMENT (77 K) AND IN A CONDUCTION-COOLED CONFIGURATION AT 30 TO 60 K. IN THE CASE OF 77 K, THE MEASURED CRITICAL CURRENT OF THE COIL WAS 54 A AND N-VALUE WAS 36 IN THE RANGE OF 10^{-9} TO 10^{-7} V/CM. THE MEASURED V-I CURVES WERE CONSISTENT WITH THE CALCULATED ONES USING SHORT SAMPLE IC-B,T,Θ CHARACTERISTICS AT 30 TO 77 K. WE ALSO MEASURED THE THERMAL RUNAWAY CURRENT OF THE COIL AT 30 TO 60 K AND NUMERICALLY SIMULATED THE THERMAL PROPERTIES BY USING A 3-DIMENSIONAL HEAT CONDUCTION EQUATION. THE EXPERIMENTAL RESULTS WERE FOUND TO BE IN GOOD AGREEMENT WITH THE CALCULATED RESULTS.

ALTERNATING CURRENT. IN THIS WORK, AC TRANSPORT LOSSES OF YBCO TAPES WITH NI-W SUBSTRATES WERE MEASURED IN PARALLEL AND PERPENDICULAR DC MAGNETIC FIELDS, RESPECTIVELY. THE EXPERIMENTAL RESULTS WERE COMPARED WITH THEORETICAL MODELS GIVEN BY THE NORRIS EQUATIONS. THE RESULTS SHOW THAT THE AC LOSSES OF YBCO TAPE REDUCE GRADUALLY AS THE BACKGROUND FIELD INCREASED, AND THE MINIMUM VALUES APPEAR AS THE FIELD REACH TO 15MT AND 45MT FOR PARALLEL AND PERPENDICULAR FIELD RESPECTIVELY. IN ADDITION, THE AC LOSSES IN

4LPM-10

BENCHMARK OF TWO QUENCH SIMULATION CODES FOR THE PROTECTION STUDY OF AN HIGH-FIELD HTS INSERT DIPOLE ***A. STENVALL***[1]***,*** *M. SORBI*[2]*, G. VOLPINI*[2]*, R. MIKKONEN*[1]*;* [1]TAMPERE UNIVERSITY OF TECHNOLOGY, [2]ISTITUTO NAZIONALE DI FISICA NUCLEARE. — RESEARCH ON POSSIBILITIES IN LONG-TERM LHC UPGRADE INCLUDE CONSIDERATIONS ON REPLACING THE NBTI DIPOLES WITH NB3SN OUTSERTS AND HTS INSERTS. REGARDING TO THIS TARGET, THE WP7.4 (VERY HIGH FIELD INSERT) IN PROJECT EUCARD IS TO CONSTRUCT ABOUT 1 M LONG HTS DIPOLE PRODUCING 6 T IN BACKGROUND FIELD OF 15 T. SINCE THE QUENCH ANALYSIS OF HTS COILS IS CHALLENGING E.G. DUE TO SLOW PROPAGATION VELOCITIES AND POSSIBLY AMBIGUOUS LIMIT BETWEEN THE NORMAL AND SUPERCONDUCTING STATE, TWO DIFFERENT STRATEGIES ARE DEVELOPED IN PARALLEL TO ANALYZE THE QUENCH OF THE SMALL PROTOTYPE INSERT. THE ONE IS BASED ON PROPAGATION VELOCITIES AND THE OTHER ON SOLVING HEAT DIFFUSION EQUATION WITH FINITE ELEMENT METHOD. THE VERY FIRST STEPS OF THE DEVELOPMENT INCLUDE BENCHMARK CALCULATIONS WITH THE ALREADY EXISTING PROGRAMS FOR SMALL NBTI SOLENOID TO GUARANTEE SIMILAR STARTING POINTS FOR THE PARTNERS. AFTER THIS, A QUENCH ANALYSIS WAS PERFORMED FOR DIFFERENT HTS SOLENOIDS. IN THIS PAPER WE CONSIDER THE RESULTS OF THESE CALCULATIONS.

EUCARD (EUROPEAN COORDINATION FOR ACCELERATOR RESEARCH AND DEVELOPMENT) IS CO-FUNDED BY THE EUROPEAN COMMISSION WITHIN THE FRAMEWORK PROGRAMME 7 CAPACITIES SPECIFIC PROGRAMME, UNDER GRANT AGREEMENT NO. 227579. PROJECT WEBSITE: HTTP://CERN.CH/EUCARD.

4LPN-01

APPLICATION OF IBAD-MGO BUFFERED COATED CONDUCTORS FOR HTS POWER TRANSFORMERS ***Y. GOSHO***[1]***,*** *T. SAITOH*[2]*, H. OKAMOTO*[3]*, H. HAYASHI*[3]*;* [1]SUPERCONDUCTIVITY RESEARCH LABORATORY INTERNATIONAL SUPERCONDUCTIVITY TECHNOLOGY CENTER, [2]FUJIKURA LTD., [3]KYUSHU ELECTRIC POWER CO.. — DEVELOPMENT OF A 66 KV/6 KV 20 MVA CLASS HTS POWER TRANSFORMER IS NOW IN PROGRESS. WE HAVE DEVELOPED THE KEY ELEMENTAL TECHNOLOGIES INCLUDING WIRE SCRIBING, COIL WINDING, COOLING SYSTEM, ETC. IN THIS PAPER, WE MAINLY REFER TO WINDING TECHNOLOGY.WINDING TECHNOLOGIES OF COATED CONDUCTORS TO OBTAIN A COIL WITH LOW AC LOSSES FOR LARGE APPLIED CURRENT AS WELL AS WITH ENDURANCE FOR SHORT CIRCUIT CURRENTS HAVE BEEN DEVELOPED. A MODEL COIL WAS FABRICATED USING 5 MM WIDE IBAD-MGO/PLD-GDBCO COATED CONDUCTORS AND OVER CURRENT TEST CORRESPONDING TO A TYPICAL SHORT CIRCUIT CURRENT FOR THE 20 MVA CLASS TRANSFORMER WAS CONDUCTED USING THIS COIL TO VERIFY ENDURANCE OF THE CRITICAL CURRENT

CHARACTERISTICS. SOUNDNESS AGAINST BENDING STRAIN GENERATED BY COILING/WINDING WAS CLARIFIED BY CONFIRMATION OF NO IC DETERIORATION DUE TO EDGEWISE BENDING.ALTHOUGH WE HAVE USED AN IBAD-GZO LAYER AS A BUFFER LAYER OF COATED CONDUCTORS IN THE EARLY STAGE OF THE R&D, WE DECIDE TO SHIFT THE BUFFER LAYER MATERIAL TO MGO BECAUSE OF ITS HIGH FABRICATION SPEED AND LOW FUTURE TECHNOLOGICAL COST. WE HAVE INVESTIGATED OVER CURRENT CHARACTERISTICS AS WELL AS EFFECT OF THE EDGEWISE BENDING STRAIN ON IC ENDURANCE FOR MGO BUFFERED COATED CONDUCTORS. CONSEQUENTLY, WE OBTAINED THE EQUIVALENT PERFORMANCES TO THE RESULTS OF GZO.

THIS WORK WAS SUPPORTED BY THE "NEDO AS THE PROJECT FOR DEVELOPMENT OF MATERIALS & POWER APPLICATION OF COATED CONDUCTORS, M-PACC".

4LPN-02

FEASIBILITY RESEARCH OF IMPROVING THE SUPERCONDUCTING INDUCTANCE PULSED CURRENT OUTPUT WAVEFORM BY USING HTS AIR-CORE TRANSFORMER ***M. SONG****, Y. TANG, J. LI;* R□D CENTER OF APPLIED SUPERCONDUCTIVITY,HUAZHONG UNIVERSITY OF SCIENCE AND TECHNOLOGY. — THIS PAPER RESEARCHES THE FEASIBILITY OF IMPROVING PULSED CURRENT FORM BY USING A HTS AIR-CORE TRANSFORMER TO REALIZE THE AIM OF SHAPEABLE PULSED POWER OUTPUT WITH HIGH ENERGY DENSITY. BASED ON THE THEORETICAL ANALYSIS, THE DISCHARGING EXPERIMENTS ARE DONE WITH THE EXPERIMENTAL HTS TRANSFORMER AND INDUCTANCE. THE SIMULATIONS AND EXPERIMENTAL RESULTS INDICATE THAT THE HTS AIR-CORE PULSE TRANSFORMER CAN MAGNIFY THE OUTPUT CURRENT AND ACCELERATE THE DISCHARGE SPEED. BUT WHEN A SERIES INDUCTANCE MODULES USE ONE HTS AIR-CORE TRANSFORMER, THE RESIDUAL CURRENT MAY INFLUENCE THE DISCHARGING WAVEFORM. THE RESULTS GIVES SOME REFERENCES FOR THE RESEARCH OF SUPERCONDUCTING INDUCTANCE PULSED CURRENT OUTPUT.

HTS, AIR-CORE TRANSFORMER, RESIDUAL CURRENT

4LPN-03

FAULT CURRENT LIMITATION IN POWER NETWORK BY SUPERCONDUCTING TRANSFORMERS MADE OF 2G HTS ***T. JANOWSKI****[1], B. A. GLOWACKI[2], G. WOJTASIEWICZ[3], S. KOZAK[3], J. KOZAK[3], B. KONDRATOWICZ-KUCEWICZ[3], M. MAJKA[3];* [1]LUBLIN UNIVERSITY OF TECHNOLOGY, POLAND, [2]DEPARTMENT OF MATERIALS SCIENCE AND METALLURGY, UNIVERSITY OF CAMBRIDGE, UK; INSTITUTE OF POWER ENGINEERING, POLAND, [3]ELECTROTECHNICAL INSTITUTE IN WARSAW, POLAND. — THE FAULT CURRENT LIMITING FEATURE OF SUPERCONDUCTING TRANSFORMER WITH HTS 2G WINDINGS PROVIDE PROTECTION AND SIGNIFICANTLY REDUCE WEAR AND TEAR FOR CIRCUIT BREAKERS AND OTHER SUBSTATION POWER EQUIPMENT. SHORT CIRCUIT CURRENT COMPARISON OF 60 MVA CONVENTIONAL TRANSFORMER AND HTS TRANSFORMERS MADE OF BSCCO TAPE AND YBCO 2G HTS TAPE HAS BEEN DESCRIBED IN THIS PAPER. AN ANALYSIS RESULT SHOWS THAT YBCO 2G TAPES ENABLE TO BUILT SUPERCONDUCTING TRANSFORMERS LIMITING THE SHORT CIRCUIT CURRENTS. SUPERCONDUCTING WINDINGS REQUIRE SPECIAL CONSIDERATIONS FOR INDUCED ELECTROMAGNETIC FORCES TO LIMIT TO ALLOWABLE TENSILE STRESSES. 2G ANISOTROPIC YBCO TAPE FORM CONDUCTORS USED FOR THE WINDING OF THE TRANSFORMER WILL BE EXPOSED TO DIFFERENT ORIENTATIONS AND AMPLITUDES OF THE LOCAL MAGNETIC FIELD VECTOR. IF THE TRANSFORMER IS GOING TO ACT ALSO AS A FAULT CURRENT LIMITING DEVICE, UNIFORMITY OF THE TRANSITION TRANSFORMER WINDING AS A WHOLE IS CRUCIAL TO AVOID SECTIONAL RESPONSES OF THE TRANSFORMER. THEREFORE IT WAS ESSENTIAL FOR US TO CONDUCT A SYSTEMATIC GONIOMETRIC CURRENT-MAGNETIC FIELD ANGULAR MEASUREMENTS TO DEFINE 'CONSTANT CURRENT DOMAIN' FOR THE CONDUCTOR AT GIVEN OPERATING TEMPERATURE.

THE MINISTRY OF SCIENCE, PROJECT NO. NN510 526439

4LPN-04

DEVELOPMENT OF ELEMENTAL TECHNOLOGY FOR HTS POWER TRANSFORMER ***H. HAYASHI****[1], H. OKAMOTO[1], M. IWAKUMA[2], A. TOMIOKA[2], Y. GOSHO[3], Y. SHIOHARA[3];* [1]KYUSHU ELECTRIC POWER CO.,INC., [2]KYUSHU UNIVERSITY, [3]ISTEC-SRL. — IT IS HIGHLY EXPECTED THAT SUPERCONDUCTING TRANSFORMERS, WHICH ARE CHARACTERIZED BY INCOMBUSTIBILITY, LIGHT WEIGHT, AND COMPACTNESS, WILL BE USED PRACTICALLY FOR EQUIPMENT IN SUBSTATIONS AND OFFICE BUILDINGS SITED IN URBAN AREAS. IN RECENT YEARS, REMARKABLE IMPROVEMENTS IN THE PERFORMANCE OF YBACUO (YBCO) TAPE WIRE HAVE BEEN SEEN. THIS KIND OF TAPE WIRE HAS THE PROPERTY THAT ITS CRITICAL CURRENT IS LARGE IN A HIGHLY MAGNETIC FIELD; AND, ITS USE IS EXPECTED TO REDUCE AC LOSS BY APPLYING SLIT PROCESSING ON THE TAPE WIRE, CONTRIBUTING TO FUTURE COST REDUCTIONS. IN ADDITION, THE DEVELOPMENT OF EFFICIENT, ECONOMICAL CRYOGENIC UNITS IS ALSO EXPECTED.THE AUTHORS HAVE MANUFACTURED A SHORT CIRCUITS TEST COIL OF 400KVA AND A TRANSPOSE TEST COIL OF 400KVA USING YBCO TAPE WIRES. SHORT CIRCUITS TEST AND EQUILIBRANT CURRENT TEST WERE ENFORCED. AS A RESULT, STABLE COIL CHARACTERISTIC AND EQUILIBRANT CURRENT WERE ACHIEVED. AS A RESULT, WE CONFIRMED THAT TEST RESULTS DEVISED TRANSFORMER CAN MADE TO BE BOTH COMPACT AND HIGHLY EFFICIENT.

THIS WORK WAS SUPPORTED BY THE NEW ENERGY AND INDUSTRIAL TECHNOLOGY DEVELOPMENT ORGANIZATION (NEDO).

4LPN-05

DESIGN AND LOSS ANALYSIS OF AN HTS TRANSFORMER WITH A LARGE CURRENT CAPACITY ***W. S. KIM****[1], S. LEE[2], S. H. PARK[2], J. LEE[3], C. PARK[4], S. HAHN[5], K. CHOI[2];* [1]KOREA ELECTRIC POWER RESEARCH INSTITUTE, [2]KOREA POLYTECHNIC UNIVERSITY, [3]WOOSUK UNIVERSITY, [4]SEOUL NATIONAL UNIVERSITY,

[5]ELECTRICAL ENGINEERING AND SCIENCE RESEARCH INSTITUTE. — 154 KV/ 22.9 KV, 100 MVA, 3 PHASE HTS TRANSFORMERS ARE PROMISING CANDIDATES FOR THE POWER TRANSMISSION GRID IN KOREA. HOWEVER AC LOSS REDUCTION TECHNOLOGIES SHOULD PRECEDE THE COMMERCIALIZATION OF HTS TRANSFORMERS. LOW AC LOSS AND CRYOGENIC INSULATION TECHNOLOGIES FOR THE HTS TRANSFORMERS ARE SEPARATELY UNDER DEVELOPMENT IN ONE OF NATIONAL PROJECTS. THE 100 MVA CLASS HTS TRANSFORMER SHOULD CONDUCT THE SECONDARY CURRENT OVER 2,500 A AND THE PRIMARY ONE OVER 400 A. IN THIS PAPER, WE DESIGNED AN HTS TRANSFORMER WHICH HAS THE SAME CURRENT CAPACITY AND WINDING STRUCTURE WITH 100 MVA CLASS ONE. THE RATED VOLTAGES ARE SCALED DOWN TO 1/100 FOR THE TESTS IN LABORATORY. THE SUPERCONDUCTING WINDINGS UNDERGO ALMOST SAME PERPENDICULAR MAGNETIC FIELD WITH THE 100 MVA ONE.

THIS RESEARCH WAS SUPPORTED BY A GRANT FROM CENTER FOR APPLIED SUPERCONDUCTIVITY TECHNOLOGY OF THE 21ST CENTURY FRONTIER R&D PROGRAM FUNDED BY THE MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY, REPUBLIC OF KOREA.

4LPN-06

NOVEL SELF-LIMITING TRANSFORMER WITH ACTIVE MAGNETIC SHORT CIRCUIT USING PERFECT YBCO WIRE LOOPS ***J. KOSA****;* KECSKEMET COLLEGE FACULTY OF MECHANICAL ENGINEERING AND AUTOMATION. — WITH THE NEW ARRANGEMENT TO BE PRESENTED WE CAN REALIZE A NOVEL SELF-LIMITING TRANSFORMER. WE HAVE DEVELOPED A 1-PHASE MODEL. WE USED 3-COLUMNED TRANSFORMER FOR ONE PHASE AND WE SURROUNDED 2 COLUMNS OF THREE, THE PRIMARY AND THE SECONDARY COILS, WITH A COMMON PERFECT CLOSED YBCO LOOP. THIS WAY WE COULD REALIZE THE ACTIVE MAGNETIC SHORT CIRCUIT WHICH GIVES A NEW POSSIBILITY FOR NOVEL APPLICATIONS. THE OPERATION IS BASED ON THE PRINCIPLE OF THE MAGNETIC FLUX CONSERVATION IN A CLOSED LOOP. THIS IS A WELL-KNOWN PHYSICAL LAW BUT SO FAR NOT APPLIED YET IN THIS MANNER. WE USED PERFECT CLOSED YBCO WIRE LOOPS WITH PARALLEL AND SERIAL TURNS. THE PAPER PRESENTS THE RESULTS OF OUR EXPERIMENTS AND OPENS NEW ADVANCED APPLICATIONS OF PERFECT YBCO LOOPS MADE OF HTS WIRE. WE CONSIDERED THE EFFICIENCY AND SIGNIFICANCE OF THE PERFECT CLOSED LOOP MADE FROM YBCO WIRE.

THE AUTHOR THANKS SUPERPOWER, INC. IN NEW YORK FOR THE GOOD QUALITY YBCO WIRE AND THE DATA PROVIDED.

4LPN-07

ANALYSIS OF CURRENT LIMITING AND RECOVERY CHARACTERISTICS OF SUPERCONDUCTING FAULT CURRENT LIMITING TRANSFORMER (SFCLT) WITH YBCO COATED CONDUCTORS ***T. KITO****, M. KOTARI, H. KOJIMA, N. HAYAKAWA, F. ENDO, H. OKUBO;* NAGOYA UNIVERSITY. — SUPERCONDUCTING FAULT CURRENT LIMITING TRANSFORMER (SFCLT) IS EXPECTED TO FUNCTION AS SUPERCONDUCTING TRANSFORMER IN NORMAL OPERATING CONDITION AND SUPERCONDUCTING FAULT CURRENT LIMITER IN FAULT CONDITION. WE HAVE DESIGNED, FABRICATED AND TESTED SFCLT WITH YBCO COATED CONDUCTORS TO BE OPERATED AT 77K. EXPERIMENTAL RESULTS OF CURRENT LIMITATION AND RECOVERY TESTS REVEALED THAT SFCLT EFFECTIVELY REDUCED THE LARGE FAULT CURRENT AND SUCCESSFULLY RECOVERED INTO THE SUPERCONDUCTING STATE IMMEDIATELY AFTER THE FAULT CLEARANCE. IN THIS PAPER, FOR THE FUNCTIONAL OPTIMIZATION OF SFCLT WITH CURRENT LIMITING AND RECOVERY CHARACTERISTICS, WE DEVELOPED A SIMULATION MODEL TO ANALYZE THE ELECTRICAL AND THERMAL BEHAVIORS OF SFCLT BY SOLVING THE CIRCUIT EQUATION AND THE HEAT CONDUCTION EQUATION. CURRENT LIMITING AND RECOVERY CHARACTERISTICS ACQUIRED FROM THE SIMULATION MODEL COULD REPRODUCE THE EXPERIMENTAL RESULTS. BY THE USE OF THIS SIMULATION MODEL, WE COULD EVALUATE THE TRANSITION OF RESISTANCE AND TEMPERATURE OF THE YBCO COATED CONDUCTORS DURING THE FAULT CURRENT LIMITATION AS WELL AS AFTER THE FAULT CLEARANCE, AND VERIFIED THE RECOVERY CRITERIA OF SFCLT FOR DIFFERENT LOAD AND FAULT CURRENT CONDITIONS.

THIS WORK WAS SUPPORTED BY GRANT-IN-AID FOR SCIENTIFIC RESEARCH (S) OF THE MINISTRY OF EDUCATION, CULTURE, SPORTS, AND TECHNOLOGY, JAPAN.

4LX-01

CONSOLIDATION OF THE 13 KA INTERCONNECTS IN THE LHC FOR OPERATION AT 7 TEV ***A. VERWEIJ****, F. BERTINELLI, N. CATALAN LASHERAS, Z. CHARIFOULLINE, R. DENZ, P. FESSIA, C. GARION, H. TEN KATE, M. KORATZINOS, S. MATHOT, A. PERIN, C. SCHEUERLEIN, S. SGOBBA, J. STECKERT, J. TOCK;* CERN. — THE INCIDENT IN THE LHC IN SEPT. 2008 WAS CAUSED BY A BURN-THROUGH OF ONE OF THE MAGNET INTERCONNECTIONS IN THE MAIN DIPOLE CIRCUIT. SUCCESSIVE MEASUREMENTS OF THE RESISTANCE OF THE OTHER INTERCONNECTS REVEALED MANY OTHER DEFECTIVE JOINTS, EVEN THOUGH THE SC CABLES WERE PROPERLY CONNECTED. THESE DEFECTIVE JOINTS ARE CHARACTERIZED BY A POOR BONDING BETWEEN THE SC CABLE AND THE COPPER STABILIZER IN COMBINATION WITH AN ELECTRICAL DISCONTINUITY IN THE COPPER STABILIZER. A QUENCH AT 7-13 KA LEVEL IN SUCH A JOINT CAN LEAD TO A FAST AND UNPROTECTED THERMAL RUN-AWAY AND HENCE OPENING OF THE CIRCUIT. IT HAS THEREFORE BEEN DECIDED TO OPERATE THE LHC AT A REDUCED AND SAFE CURRENT OF 6 KA CORRESPONDING TO 3.5 TEV COLLISION ENERGY UNTIL ALL DEFECTIVE JOINTS ARE REPAIRED. A TASK FORCE IS REVIEWING THE STATUS OF ALL ELECTRICAL JOINTS IN THE MAGNET CIRCUITS AND PREPARING THE NECESSARY REPAIR. THE PRINCIPLE SOLUTION IS TO RESOLDER THE WORST DEFECTIVE JOINTS AND, IN ADDITION, TO APPLY AN ELECTRICAL SHUNT MADE OF COPPER ACROSS ALL JOINTS WITH SUFFICIENT CROSS-SECTION TO GUARANTEE SAFE 13 KA OPERATION AT 7 TEV. IN THIS PAPER THE REQUIREMENTS OF THE SHUNTS BASED ON ELECTRO-THERMAL CALCULATIONS

ARE PRESENTED, AS WELL AS THE VARIOUS CONSTRAINTS IMPOSED BY THE IMPLEMENTATION IN THE LHC TUNNEL. FINALLY, THE QUALITY ASSURANCE MEASUREMENTS NEEDED TO GUARANTEE SAFE OPERATION OF THE JOINTS DURING THE LIFETIME OF THE LHC ARE PRESENTED.

4LX-02

STABILITY OF HIGH-JC NB3SN WIRES IN THE ADIABATIC LIMIT* ***A. K. GHOSH***[1]*, E. GREGORY*[2]*, X. PENG*[3]*;* [1]BROOKHAVEN NATIONAL LABORATORY, [2]SUPERGENICS I, [3]HYPER TECH RESEARCH INC.. — HIGH-JC NB3SN STRANDS OFTEN EXHIBIT INSTABILITIES IN 4.2 K LIQUID HELIUM AT LOW FIELDS ~ 0.5 TO 3 T WHICH ARE ASSOCIATED WITH MAGNETIZATION FLUX-JUMPS. HOWEVER AT 1.9 K IN SUPERFLUID HELIUM, A MINIMUM IN PREMATURE QUENCH CURRENTS AT INTERMEDIATE FIELDS OF 5 TO 7 T HAS BEEN OBSERVED IN VOLTAGE-CURRENT MEASUREMENTS. THESE MEASUREMENTS ARE TYPICALLY USED FOR CRITICAL CURRENT DETERMINATIONS, AND THE PREMATURE QUENCHING IS DRIVEN BY CURRENT REDISTRIBUTION WITHIN THE STRAND AS THE CURRENT IS INCREASED AND IS TERMED "SELF-FIELD" INSTABILITY. IN THIS PAPER, THE MAGNETIZATION AND SELF-FIELD STABILITY OF NB3SN STRANDS WITH JC ~ 2000 A/MM2 AT 12T ARE DESCRIBED FOR A SERIES OF WIRES MADE USING THE SN-TUBE APPROACH WITH FILAMENT DIAMETERS RANGING FROM 13 TO 65 MICRONS. THE COPPER STABILIZER OF THESE WIRES AFTER REACTION HAS RESIDUAL RESISTIVITY RATIO, RRR, OF ~ 5, WHICH IN EFFECT MEANS THAT ANY DYNAMIC STABILIZATION FROM THERMAL CONDUCTION EFFECTS IS NEGLIGIBLE. IN THIS REGIME OF RRR, WE FIND THAT THE MAGNETIZATION STABILITY WITH TRANSPORT CURRENT INCREASES WITH DECREASING FILAMENT DIAMETER AS PREDICTED BY SIMPLE ADIABATIC THEORY. WE ALSO OBSERVED THAT AT 4.2 K THE SELF-FIELD STABILITY IMPROVED WITH DECREASING FILAMENT SIZE, BUT BECAME WORSE WITH DECREASING TEMPERATURE AS EVIDENCED BY MEASUREMENTS AT 2 K.

* SUPPORTED BY THE U.S. DEPARTMENT OF ENERGY UNDER CONTRACT NO. DE-AC02-98CH10886

4LX-03

STABILITY IN NB_3SN CONDUCTORS; MAGNETIC AND SELF FIELD INSTABILITY CONSIDERATIONS AT 4 K AND 2 K, INFLUENCE OF MAGNET CONDITIONS ***M. D. SUMPTION****, E. W. COLLINGS;* THE OHIO STATE UNIVERSITY. — THE ROLE OF SELF FIELD AND MAGNETIZATION INSTABILITY ARE DESCRIBED WITH A SIMPLE MODEL WHICH INCLUDES WHICH INCLUDES MAGNETIZATION INSTABILITY, SELF FIELD INSTABILITY AND MAGNETIZATION COMPONENTS DUE TO SELF FIELD EFFECTS WHICH DRIVE D_{EFF} SENSITIVE COMPONENTS DURING CURRENT PROFILE TYPE MEASUREMENTS. THE INFLUENCE OF RRR, D_{EFF}, AND STRAND DIAMETER WILL BE COMPARED EXPLICITLY (GRAPHICALLY) AND REGIMES OF BOTH MAGNETIC AND SELF-FIELD INSTABILITIES AT 4 K AS WELL AS 2 K WILL BE DESCRIBED. THE INFLUENCE OF THE SIMULTANEOUS CHANGING OF EXTERNAL FIELD AND STRAND TRANSPORT (AS WOULD BE PRESENT IN A MAGNET) ON THE RELATIVE STRENGTHS OF THE SELF-FIELD AND THE MAGNETIZATION BASED CURRENT DISTRIBUTIONS IS THEN DISCUSSED. THE INFLUENCE OF THE POSITION OF THE STRAND WITHIN THE CABLE AND THE CABLE WITHIN THE MAGNET IS ALSO ADDRESSED. STABILITY MEASUREMENTS FOR A NUMBER OF RIT AND TUBE TYPE SAMPLES IS THEN PRESENTED, AND STABILITY RESULTS ON COMPARABLE STRANDS WITH FILAMENT DIAMETERS RANGING FROM 217 TO 1500 ARE PRESENTED. RESULTS ARE PRESENTED FOR SOME STRANDS (WITH LOW D_{EFF} AND 12 T J_C OF 2000 A/MM^2) WITH STABILITY CURRENTS ABOVE 15 KA/MM^2.

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4LX-04

CONVERGENCE STUDIES OF THERMAL AND ELECTROMAGNETIC TRANSIENT QUENCH ANALYSIS OF 11 GEV SUPER HIGH MOMENTUM SPECTROMETER SUPERCONDUCTING MAGNETS IN JEFFERSON LAB ***E. SUN***[1]*, P. BRINDZA*[1]*, S. LASSITER*[1]*, M. FOWLER*[1]*, E. XU*[2]*;* [1]JEFFERSON LAB, [2]VECTOR FIELDS SOFTWARE, COBHAM TECHNICAL SERVICES. — THIS PAPER PRESENTS RESULTS OF CONVERGENCE STUDIES OF TRANSIENT THERMAL AND ELECTROMAGNETIC QUENCH ANALYSIS OF SUPER HIGH MOMENTUM SPECTROMETER (SHMS) SUPERCONDUCTING MAGNETS: HB, Q1, Q2, Q3, AND DIPOLE, USING VECTOR FIELDS® QUENCH ANALYSIS CODES. THE CONVERGENCE OF THE HOTSPOT TEMPERATURE AND SOLUTION SOLVE TIMES WERE USED TO INVESTIGATE THE EFFECTS OF ELEMENT TYPES, MESH DENSITY, AND SOLUTION TOLERANCE CRITERIA. THE Q2, Q3 AND DIPOLE MAGNETS USE A COPPER STABILIZED, SUPERCONDUCTING RUTHERFORD CABLE, WHERE AS THE HB AND Q1 MAGNETS USE JUST THE SURPLUS SSC RUTHERFORD CABLE. THE COMPARISONS BETWEEN TETRAHEDRAL ELEMENTS AND HEXAHEDRAL ELEMENTS WAS STUDIED, AND THEIR ADVANTAGES AND DISADVANTAGES ARE DISCUSSED. MULTIPLE ANALYSES WERE CONDUCTED WITH VARIOUS MESH DENSITIES FOR BOTH ELEMENT TYPES. THE EFFECTS OF MESH DENSITY TO EACH TYPE OF ELEMENTS AND A MESH GUIDELINE ARE PRESENTED. THE IMPACT OF SOLUTION TOLERANCE TO THE HOTSPOT TEMPERATURE WAS ALSO EXPLORED, AND IT IS FOUND THAT TIGHT TOLERANCE CAUSES AN EXTREMELY LONG SOLVE TIME WITH ONLY MARGINALLY IMPROVED FINAL RESULTS. THE QUENCH METHOD IS USED TO CONDUCT CONVERGENCE STUDIES BECAUSE THE QUENCH METHOD IS SIGNIFICANTLY FASTER AS IT ONLY MODELS THE COIL AND IGNORES THE EFFECT OF THE EDDY CURRENTS, THE FORCE COLLAR, AND THE IRON.

4LX-05

THE ROLE OF QUENCH-BACK IN THE PASSIVE QUENCH PROTECTION OF UNCOUPLED SOLENOIDS IN SERIES WITH AND WITHOUT COIL SUB-DIVISION *X. GUO[1], **M. A. GREEN**[2], L. WANG[3], H. WU[1], H. PAN[1];* [1]INSTITUTE OF CRYOGENICS AND SUPERCONDUCTIVE TECHNOLOGY, HIT, HARBIN, CHINA, [2]LAWRENCE BERKELEY NATIONAL LABORATORY, [3]SHANGHAI INSTITUTE OF APPLIED PHYSICS, SHANGHAI, CHINA.. — THIS PAPER IS THE FINAL PAPER IN A SERIES OF PAPERS THAT DISCUSSES PASSIVE QUENCH PROTECTION FOR HIGH INDUCTANCE SOLENOID MAGNETS. THIS REPORT DESCRIBES HOW PASSIVE QUENCH PROTECTION SYSTEM MAY BE APPLIED TO SUPERCONDUCTING MAGNETS THAT ARE CONNECTED IN SERIES BUT ARE NOT COUPLED TO EACH OTHER INDUCTIVELY. PREVIOUS PAPERS HAVE DISCUSSED THE ROLE OF MAGNET SUB-DIVISION AND QUENCH BACK FROM A CONDUCTIVE MANDREL IN REDUCING THE HOT-SPOT TEMPERATURE AND THE PEAK COIL VOLTAGES TO GROUND. WHEN A MAGNET IS CONNECTED IN SERIES WITH ANOTHER MAGNET, QUENCH-BACK CAN CAUSE THE SECOND MAGNET TO QUENCH EVEN IF THE TWO MAGNETS ARE NOT INDUCTIVELY COUPLED. QUENCH-BACK FROM A CONDUCTIVE (LOW RESISTIVITY) MANDREL APPEARS TO BE ESSENTIAL FOR SPREADING THE QUENCH FROM ONE MAGNET TO THE OTHER MAGNETS IN THE STRING WHEN THEY ARE CONNECTED IN SERIES. THE MAGNET MANDREL MUST HAVE GOOD INDUCTIVE COUPLING TO THE MAGNET CIRCUIT THAT IS BEING QUENCHED. MAGNET CIRCUIT SUB-DIVISION IS EMPLOYED TO REDUCE THE VOLTAGES TO GROUND WITHIN THE MAGNETS THAT ARE CONNECTED IN SERIES.

THIS WORK IS SUPPORTED BY FUNDS OF THE CRYOGENICS AND SUPERCONDUCTING TECHNOLOGY INNOVATION PROJECT UNDER THE “985-2” PLAN OF THE HIT. THIS WORK IS ALSO SUPPORTED BY THE OFFICE OF SCIENCE, US-DOE UNDER DOE CONTRACT DE-AC02-05CH11231.

4LX-07

PROTECTION SYSTEM FOR THE SUPERCONDUCTING OUTSERT COILS OF THE 45 T HYBRID MAGNET AT HFML ***A. DEN OUDEN**, S. A. J. WIEGERS, J. A. A. J. PERENBOOM, J. MAAN;* RADBOUD UNIVERSITY NIJMEGEN. — TO EXTEND ITS USER’S FACILITY THE HIGH FIELD MAGNET LABORATORY OF THE RADBOUD UNIVERSITY NIJMEGEN DEVELOPS A 45 T HYBRID MAGNET CONSISTING OF A 33 T RESISTIVE INSERT MAGNET AND A 12 T, ALL NB_3SN/CU CABLE-IN-CONDUIT CONDUCTOR (CICC) BASED SUPERCONDUCTING OUTSERT MAGNET. STANDARD QUENCH PROTECTION OF THE OUTSERT COILS IS ACHIEVED BY A PERMANENTLY CONNECTED EXTERNAL DUMP RESISTOR PARALLEL TO THE COILS, RESULTING IN A DECAY TIME CONSTANT OF 2.4 S AT A MAXIMUM TERMINAL VOLTAGE OF 3 KV. AVOIDING A FACILITY OFF-TIME OF SEVERAL DAYS AFTER A QUENCH, A MAJOR CHALLENGE IS TO PREVENT A QUENCH OF THE OUTSERT MAGNET DURING SPURIOUS TRIPS OF THE INSERT CIRCUIT THAT MAY OCCUR. SUCH AN EVENT IS CHARACTERIZED BY A TYPICAL 0.3 S DECAY OF THE INSERT CURRENT GENERATING FIELD CHANGES AT THE WINDINGS OF THE OUTSERT COILS OF A FEW T/S. WITHOUT PRECAUTIONS, THE RESULTING AC LOSSES IN THE SUPERCONDUCTING STRANDS WOULD QUENCH THE INNER WINDINGS. SWITCHING A LOW RESISTANCE PARALLEL TO THE DUMP RESISTOR DURING THE TRIP EFFECTIVELY LIMITS THE INITIALLY FAST CURRENT AND FIELD DECAY IN THE OUTSERT COILS AND RESULTS IN A REDUCED TEMPERATURE RISE WITHOUT CAUSING A QUENCH. IN THIS PAPER WE DESCRIBE THIS PROTECTION SCHEME IN DETAIL AND DISCUSS THE EFFECTIVENESS OF THIS METHOD IN TERMS OF SYSTEM AND COMPONENT CHARACTERISTICS AND THE REQUIRED AC LOSS PROPERTIES OF THE PROPOSED CICC DESIGN.

4LY-01

AC LOSS MEASUREMENT IN A THREE-PHASE TRI-AXIAL CABLE: THEORETICAL BACKGROUND AND PRACTICAL MEASUREMENT ***D. N. NGUYEN**, S. P. ASHWORTH;* LOS ALAMOS NATIONAL LABORATORY. — WE DEVELOPED THEORETICAL BACKGROUND TO SHOW THAT ELECTROMAGNETIC MEASUREMENTS FOR AC LOSS IN A THREE-PHASE TRI-AXIAL CABLE ARE, IN PRINCIPLE, POSSIBLE. WE THEN IMPLEMENTED THIS THEORY IN PRACTICAL MEASUREMENTS ON A 3 M LONG, TRI-AXIAL CABLE FABRICATED FROM RABIST COATED CONDUCTOR. INITIALLY, THE PROPOSED MEASUREMENT TECHNIQUE WAS IMPLEMENTED IN THE SIMPLER CASES WHEN THE THREE CABLE PHASES ARE 180 DEGREE OUT OF PHASE I.E. (0^O, 180^O, 360^O) OR (0^O, 360^O, 180^O) RATHER THAN (0^O, 120^O, 240^O) AS IN A TRADITIONAL THREE-PHASE SYSTEM. WHEN THE INNERMOST AND THE OUTERMOST PHASES ARE IN-PHASE BUT ANTI-PHASE TO THE MIDDLE PHASE (0^O, 180^O, 360^O), THE CIRCUMFERENTIAL FIELDS GENERATED BY THE TWO INNERMOST PHASES TEND TO CANCEL OUT EACH OTHER. THEREFORE, AC LOSS GENERATED BY THE CABLE IN THIS CASE WOULD BE THE LOWER LIMIT. FOR THE SECOND CASE WHEN THE INNERMOST AND MIDDLE PHASES ARE IN-PHASE BUT ANTI-PHASE TO THE OUTERMOST ONE (0^O, 360^O, 180^O), THE CIRCUMFERENTIAL FIELDS GENERATED BY THE TWO INNERMOST PHASES ARE IN-PHASE AND SUM OF THESE FIELDS WILL BE THE HIGHEST POSSIBLE. THE AC LOSS GENERATED BY THE CABLE IN THIS CASE SHOULD BE THE UPPER LIMIT. AS EXPECTED, THE MEASURED AC LOSS WHEN CABLE OPERATING IN THE REAL THREE-PHASE MODE LIES WITHIN THE ENVELOPE BORDERED BY THE LIMITS DESCRIBED ABOVE. WE BELIEVE THIS DATA REPRESENTS THE FIRST ELECTROMAGNETIC THREE PHASE AC LOSS MEASUREMENT.

4LY-02

EFFECTS OF LATERAL-TAILORING OF COATED CONDUCTOR FOR AC LOSS REDUCTION OF SUPERCONDUCTING POWER TRANSMISSION CABLES ***N. AMEMIYA**[1], K. TAKEUCHI[1], Q. LI[2], T. NAKAMURA[1], M. YAGI[3], S. MUKOYAMA[3], N. FUJIWARA[4];* [1]KYOTO UNIVERSITY, [2]UNIVERSITY OF CAMBRIDGE, [3]FURUKAWA ELECTRIC CO., LTD., [4]SUPERCONDUCTIVITY RESEARCH LABORATORY. — SINCE SUPERCONDUCTOR LAYER OF COATED CONDUCTOR IS EXTREMELY THIN, ITS AC LOSS IS DOMINATED BY THE MAGNETIC FIELD COMPONENT NORMAL TO ITS SUPERCONDUCTOR LAYER. IN CASE OF SUPERCONDUCTING POWER TRANSMISSION CABLES COMPRISING COATED CONDUCTORS, THIS NORMAL

MAGNETIC FIELD COMPONENT IS GENERATED BY THE POLYGONAL CROSS-SECTION OF A LAYER AND GAPS BETWEEN COATED CONDUCTORS. IN THIS PAPER, EFFECTS OF TAILORING COATED CONDUCTOR LATERALLY FOR AC LOSS REDUCTION OF SUPERCONDUCTING POWER CABLES ARE DISCUSSED: EFFECT OF CUTTING A COATED CONDUCTOR INTO NARROWER STRIPS; EFFECT OF REMOVING EDGES WITH LOW CRITICAL CURRENT DENSITY. IF WE CUT A COATED CONDUCTOR INTO NARROWER STRIPS AND ASSEMBLE SUCH STRIPS TO FORM A LAYER IN A CABLE, THE POLYGONAL CROSS-SECTION OF THE LAYER APPROACHES TO CIRCLE TO REDUCE THE NORMAL MAGNETIC FIELD COMPONENT. IF THE CRITICAL CURRENT DENSITY IS LOW AT THE EDGES OF COATED CONDUCTORS, AC LOSS CAN BE REDUCED BY REMOVING THE EDGES WITH LOW CRITICAL CURRENT DENSITY WHERE LARGE AC LOSSES ARE GENERATED. WE DESIGNED SUPERCONDUCTING POWER TRANSMISSION CABLES COMPRISING TWO LAYERS OF TAILORED COATED CONDUCTORS, AND THEIR AC LOSSES WERE CALCULATED NUMERICALLY. THE CALCULATED AC LOSSES WERE COMPARED WITH THE MEASURED AC LOSSES OF SHORT MODEL CABLES TO CONFIRM THE EFFECT OF LATERAL-TAILORING OF COATED CONDUCTOR FOR AC LOSS REDUCTION.

THIS WORK WAS SUPPORTED BY THE NEDO IN M-PACC PROJECT.

4LY-03

THERMAL MODELING OF HIGH-TEMPERATURE SUPERCONDUCTING DC TRANSMISSION CABLE *J. A. SOUZA,* ***J. C. ORDONEZ****, R. HOVSAPIAN, J. V. C. VARGAS;* FLORIDA STATE UNIVERSITY - FSU. — THE RECENT INCREASE IN THE DISTRIBUTED POWER GENERATION IS HIGHLIGHTING THE DEMAND TO INVESTIGATE AND IMPLEMENT BETTER AND MORE EFFICIENT POWER DISTRIBUTION GRIDS. A HIGH-TEMPERATURE SUPERCONDUCTING (HTS) DC TRANSMISSION CABLE HAS THE POTENTIAL TO ADDRESS THE NEED AND ITS USAGE IS EXPECTED TO INCREASE IN THE FUTURE. THERMAL MODELING OF THE HTS DC CABLE IS A CRITICAL TOOL TO HAVE IN ORDER TO BETTER UNDERSTAND AND CHARACTERIZE THE OPERATION OF SUCH TRANSMISSION LINES. THIS PAPER INTRODUCES A GENERAL COMPUTATIONAL MODEL FOR A HTS DC CABLE. A PHYSICAL MODEL, BASED ON FUNDAMENTAL CORRELATIONS, AND PRINCIPLES OF CLASSICAL THERMODYNAMICS, MASS AND HEAT TRANSFER, WAS DEVELOPED AND THE RESULTING THREE-DIMENSIONAL DIFFERENTIAL EQUATIONS WERE DISCRETIZED IN SPACE. THEREFORE, THE COMBINATION OF THE PHYSICAL MODEL WITH THE FINITE VOLUME SCHEME FOR THE DISCRETIZATION OF THE DIFFERENTIAL EQUATIONS IS THE SO CALLED VOLUME ELEMENT MODEL, VEM. THE MODEL ACCOUNTS FOR HEAT TRANSFER BY CONDUCTION, CONVECTION AND RADIATION, OBTAINING NUMERICALLY THE TEMPERATURE DISTRIBUTION OF STRAIGHT AND SINUOUS SUPERCONDUCTIVE CABLES OPERATING UNDER DIFFERENT ENVIRONMENTAL, OPERATIONAL AND DESIGN CONDITIONS. A COARSE CONVERGED MESH COMBINES NUMERICAL ACCURACY WITH LOW COMPUTATIONAL TIME. AS A RESULT, THE MODEL IS EXPECTED TO BE A USEFUL TOOL FOR SIMULATION, DESIGN, AND OPTIMIZATION OF HTS DC TRANSMISSION CABLES.

THE OFFICE OF NAVAL RESEARCH

4LY-04

ASSESSMENT OF OVERLAPPING THE TAPES FOR REDUCING AC LOSSES IN HTS POWER TRANSMISSION CABLES MADE OF HELICALLY WOUND COATED CONDUCTORS ***M. SIAHRANG****[1], F. SIROIS[1], D. N. NGUYEN[2];* [1]ECOLE POLYTECHNIQUE DE MONTREAL, [2]LOS ALAMOS NATIONAL LABORATORY. — IN THE CONVENTIONAL DESIGN OF HIGH TEMPERATURE SUPERCONDUCTING (HTS) POWER TRANSMISSION CABLES, AC LOSSES ARE KNOWN TO INCREASE AS THE GAP SIZE BETWEEN THE TAPES INCREASES. HOWEVER DUE TO MECHANICAL LIMITATIONS THIS GAP CANNOT BE ENTIRELY CLOSED, IT SEEMS CONCEIVABLE TO ALLOW THE ADJACENT TAPES TO PERIODICALLY OVERLAP EACH OTHER OVER A SMALL DISTANCE (TYPICALLY 1 MM). IN THIS PAPER, USING NUMERICAL TOOLS THAT WE PREVIOUSLY DEVELOPED FOR ANALYZING HTS POWER CABLES MADE OF TWISTED TAPES, WE PRESENT A PARAMETRIC NUMERICAL STUDY ON THE AC LOSS BEHAVIOR OF THE OVERLAPPED DESIGN. THROUGH THE SIMULATION RESULTS, WE SHOW THAT WE CAN ACHIEVE A SUBSTANTIAL REDUCTION OF AC LOSSES OVER THE CONVENTIONAL DESIGN. IN PARTICULAR WHEN THE NON-UNIFORM CRITICAL CURRENT DENSITY DISTRIBUTION NEAR THE EDGES OF THE TAPES IS CONSIDERED, THIS REDUCTION IS APPROXIMATELY OF 1 ORDER OF MAGNITUDE. IN ORDER TO UNDERSTAND THE MECHANISM THROUGH WHICH THE AC LOSSES DECREASE, THE EFFECT OF OVERLAPPING ON THE FIELD AND CURRENT DISTRIBUTION INSIDE THE TAPES IS ALSO DISCUSSED. THE VALIDITY OF THE NUMERICAL MODEL USED TO PERFORM THE SIMULATIONS WAS VERIFIED AGAINST EXPERIMENTAL MEASUREMENTS IN A SIMPLE SOLENOIDAL-TYPE CABLE.

THIS WORK IS SPONSORED BY NSERC AND LOS ALAMOS NATIONAL LABORATORY

4LY-05

AC LOSS DISTRIBUTION AMONG COATED CONDUCTORS IN SUPERCONDUCTING POWER TRANSMISSION CABLES ***Q. LI****[1], N. AMEMIYA[2], K. TAKEUCHI[2], T. NAKAMURA[2], N. FUJIWARA[3];* [1]UNIVERSITY OF CAMBRIDGE, [2]KYOTO UNIVERSITY, [3]SUPERCONDUCTIVITY RESEARCH LABORATORY. — SUPERCONDUCTING POWER TRANSMISSION CABLE COMPRISING COATED CONDUCTORS HAS ATTRACTED BROAD ATTENTION AS ONE OF THE MOST VALUABLE AND FEASIBLE APPLICATIONS OF HIGH TC SUPERCONDUCTORS. AC LOSS REDUCTION IS ONE OF THE CRITICAL ISSUES FOR THEIR INTRODUCTION TO POWER GRIDS, AND MANY RESEARCHERS HAVE REPORTED THEIR NUMERICAL ANALYSES OF AC LOSS CHARACTERISTICS. IN MOST OF THESE PREVIOUS STUDIES, EVEN CRITICAL CURRENTS HAVE BEEN ASSUMED IN ALL COATED CONDUCTORS IN A CABLE. THE UNEVEN CRITICAL CURRENTS IN A REAL CABLE CAN CAUSE A DISTRIBUTED AC LOSS AND MAY INCREASE THE ENTIRE AC LOSS OF THE CABLE. IT HAS BEEN POINTED OUT THAT THE GAP BETWEEN COATED CONDUCTORS SUBSTANTIALLY INFLUENCES THE AC LOSS

CHARACTERISTICS, AND THE GAPS IN ONE CABLE ARE NOT ALWAYS EVEN. AN IRREGULAR GAP CAN ALSO RESULT IN A DISTRIBUTED AC LOSS. IN THIS PAPER, FIRSTLY, DISTRIBUTED AC LOSSES GENERATED IN MONOLAYER AND MULTI-LAYER SUPERCONDUCTING CABLES CONSISTING OF COATED CONDUCTORS WITH ASSORTED PRE-DESIGNED CRITICAL CURRENTS ARE NUMERICALLY CALCULATED. THE INFLUENCE OF THE EXISTENCE OF A DAMAGED COATED CONDUCTOR IS ALSO STUDIED. SECONDLY, AC LOSSES OF THE CABLES WITH AN IRREGULAR GAP BETWEEN COATED CONDUCTORS ARE CALCULATED. THE MAGNETIC FLUX AS WELL AS CURRENT DISTRIBUTIONS ARE ILLUSTRATED TO ANALYZE THE AC LOSS CHARACTERISTIC OF EACH COATED CONDUCTOR. NUMERICAL RESULTS ARE COMPARED TO AND SUPPORTED BY EXPERIMENTAL RESULTS.

THIS WORK WAS SUPPORTED BY THE NEDO IN M-PACC PROJECT.

4LY-06

THERMAL MANAGEMENT OF LONG-LENGTH HTS CABLE SYSTEMS ***J. A. DEMKO***[1]*, W. V. HASSENZAHL*[2]*;* [1]ORNL, [2]ADVANCED ENERGY ANALYSIS. — DIRECT CURRENT (DC), HIGH TEMPERATURE SUPERCONDUCTING (HTS) CABLE SYSTEMS HAVE BEEN SUGGESTED AS AN EFFECTIVE METHOD OF TRANSMITTING MASSIVE QUANTITIES OF ELECTRIC POWER (UP TO 10 GW) OVER VERY LONG DISTANCES (THOUSANDS OF KILOMETERS). THIS IS MADE POSSIBLE PARTLY BECAUSE OF THE LOW-LOSS HIGH-CURRENT-CARRYING CAPABILITY OF THE HTS WIRE WHEN OPERATED AT TEMPERATURES BELOW THE CRITICAL CURRENT OF THE WIRE. FOR RELIABLE, ENERGY-EFFICIENT OPERATION OF A DC HTS CABLE THE THERMAL MANAGEMENT OF THE CABLE SYSTEM MUST BE CAREFULLY DESIGNED. ONE DC CABLE DESIGN CONCEPT PROPOSED BY THE ELECTRIC POWER RESEARCH INSTITUTE (EPRI) HAS THE CABLE COOLED WITH LIQUID NITROGEN, WHICH FLOWS IN A CRYOGENIC ENCLOSURE THAT INCLUDES THE CABLE AND A SEPARATE RETURN TUBE, AND REFRIGERATION STATIONS POSITIONED EVERY 10 TO 20 KM. BOTH GO AND RETURN LINES ARE CONTAINED IN A SINGLE VACUUM/CRYOGENIC ENVELOPE. IN ADDITION, LONG LENGTH AC CABLES MAY BE EFFECTIVE FOR INCREASING POWER FLOW ALONG EXISTING CORRIDORS WITH NO CHANGE IN RIGHT-OF-WAY DIMENSIONS. OTHER COOLANTS, SUCH AS GASEOUS HELIUM OR GASEOUS HYDROGEN, COULD PROVIDE POTENTIAL ADVANTAGES AS WELL AS TECHNICAL CHALLENGES TO THE OPERATION OF LONG-LENGTH DC HTS CABLE SYSTEMS. A DISCUSSION OF THE HEAT PRODUCED IN SUPERCONDUCTING CABLES AND AN ANALYSIS OF THE USE OF VARIOUS CRYOGENIC FLUIDS IN LONG-DISTANCE HTS POWER CABLES WILL BE DISCUSSED IN THIS PAPER.

RESEARCH SPONSORED BY THE U.S. DEPARTMENT OF ENERGY, OFFICE OF ELECTRICITY DELIVERY AND ENERGY RELIABILITY, SUPERCONDUCTIVITY PROGRAM FOR ELECTRIC POWER SYSTEMS, UNDER CONTRACT NO. DE-AC05-00OR22725 WITH UT-BATTELLE, LLC.

4LY-07

FEASIBILITY STUDY ON HIGH TEMPERATURE SUPERCONDUCTING FAULT CURRENT LIMITING CABLE (HTS-FCL CABLE) USING FLUX FLOW RESISTANCE ***F. KATO****, H. KOJIMA, N. HAYAKAWA, F. ENDO, H. OKUBO;* NAGOYA UNIVERSITY. — WE PROPOSE A HIGH TEMPERATURE SUPERCONDUCTING FAULT CURRENT LIMITING CABLE (HTS-FCL CABLE), WHICH IS A HTS CABLE WITH FAULT CURRENT LIMITING FUNCTION. WHEN A FAULT OCCURS IN A POWER SYSTEM, THE HTS-FCL CABLE BEHAVES AS A FAULT CURRENT LIMITER, WHICH IMPROVES THE TRANSIENT STABILITY OF THE POWER SYSTEM. THE HTS-FCL CABLE IS EXPECTED TO GENERATE FLUX FLOW RESISTANCE WITHOUT QUENCHING IN THE FAULT CONDITION UNDER THE CONTROL OF CABLE LENGTH WITH CURRENT LIMITING FUNCTION. IN THIS PAPER, WE PROPOSE A CONCEPT OF THE HTS-FCL CABLE USING FLUX FLOW RESISTANCE, INCLUDING A POSSIBILITY OF INTRODUCTION OF THE HTS-FCL CABLE INTO A POWER SYSTEM. ONE OF THE MOST IMPORTANT ISSUES FOR THE DEVELOPMENT OF THE HTS-FCL CABLE IS THE DETAILED *E-I* CHARACTERISTICS AT FLUX FLOW REGION. THEREFORE, WE ACQUIRED THE *E-I* CHARACTERISTICS OF A YBCO COATED CONDUCTOR AND EVALUATED THE TEMPERATURE RISE AT THE FLUX FLOW REGION BY THE CIRCUIT AND HEAT EQUATIONS. USING THE OBTAINED *E-I* CHARACTERISTICS AT THE FLUX FLOW REGION, WE DEVELOPED A NUMERICAL MODEL OF GENERATED RESISTANCE AND TEMPERATURE RISE IN THE HTS-FCL CABLE, AND INVESTIGATED THE CURRENT LIMITING BEHAVIOR OF THE HTS-FCL CABLE FOR DIFFERENT CABLE LENGTHS AND FAULT CONDITIONS IN A MODEL POWER SYSTEM.

4LY-08

RESEARCH OF QUENCH PROTECTION METHOD FOR HIGH-TEMPERATURE SUPERCONDUCTING CABLES ***Y. NIU****, H. ZHANG, Y. WANG, H. LIU;* NORTH CHINA ELECTRIC POWER UNIVERSITY. — THERE ARE GREAT DIFFERENCES BETWEEN HIGH-TEMPERATURE SUPERCONDUCTING CABLES AND CONVENTIONAL CABLES IN OPERATING CHARACTERISTICS AND ELECTROMAGNETIC PROPERTIES .IN THIS PAPER, WE CONDUCTED A THEORETICAL ANALYSIS OF THE IMPEDANCE CHARACTERISTICS AND QUENCH CHARACTERISTICS OF HIGH-TEMPERATURE SUPERCONDUCTING CABLE, AND PROPOSED A NEW METHOD BASED ON PHASE MEASUREMENT OF OPERATING VOLTAGE AND CURRENT THROUGH ANALYSIS AND COMPARISON OF EXISTING QUENCH DETECTION METHOD. THE LOGIC CRITERION OF QUENCH DETECTION WAS PUT FORWARD BY ANALYZING THE PHASE DISCRIMINATION BETWEEN CURRENT AND VOLTAGE WHEN QUENCH TAKES PLACE AT DIFFERENT POSITIONS AND AT DIFFERENT SYSTEM CONDITIONS. THIS QUENCH DETECTION COULD EFFECTIVELY RESTRAIN THE EFFECT OF NOISE AND HARMONIC. SIMULATION RESULTS SHOW THE USEFULNESS OF SUCH A QUENCH DETECTION METHOD AND PROVIDE A BASIS FOR FURTHER RESEARCH IN QUENCH PROTECTION, THE CO-ORDINATION STRATEGY FOR RELAY PROTECTION AND RECLOSING.

HIGH-TEMPERATURE SUPERCONDUCTING CABLES IMPEDANCE CHARACTERISTICS QUENCH DETECTION PHASE MEASUREMENT

4LZ-01

DEVELOPMENT AND TEST OF HTS-UNDULATOR COMPONENTS FOR FEL APPLICATIONS ***S. PRESTEMON****, D. ARBELAEZ, R. D. SCHLUETER, D. R. DIETDERICH;* LBNL. — A HIGH-PERFORMANCE SUPERCONDUCTING UNDULATOR CONCEPT, INCORPORATING STACKED YBA2CU3O7-Δ TAPES OPERATING AT 4.2K, IS CURRENTLY UNDER INVESTIGATION AT LBNL. THE CONCEPT IS PARTICULARLY PROMISING FOR NARROW-GAP, SHORT PERIOD (<10MM) APPLICATIONS, WHERE TRADITIONAL SUPERCONDUCTING AND PERMANENT MAGNET TECHNOLOGIES ARE ILL-SUITED. THE CURRENT PATH IS DICTATED BY ETCHING OF THE YBCO LAYER USING LITHOGRAPHY TECHNIQUES, RESULTING IN A HIGH DEGREE OF UNIFORMITY FROM TAPE TO TAPE AS WELL AS A STRAIGHTFORWARD AND HIGHLY COST-EFFECTIVE MEANS OF PRODUCTION. WE COMPARE ANALYTIC PREDICTIONS OF PERFORMANCE WITH MEASURED TRANSPORT CURRENT FOR SINGLE AND STACKED TAPES. THE PATTERNED CURRENT PATHS ARE STUDIED USING SEM, AND AN ANALYSIS IS PROVIDED FOR ALLOWABLE DEFECTS IN TERMS OF FIELD ERRORS FOR FEL APPLICATION.

THIS WORK IS SUPPORTED BY THE DIRECTOR, OFFICE OF SCIENCE, OF THE U.S. DEPARTMENT OF ENERGY UNDER CONTRACT NO. DE-AC02-05CH11231.

4LZ-02

DESIGN AND TEST OF AN HTS PLANAR UNDULATOR PROTOTYPE ***C. BOFFO****[1], W. WALTER[1], S. CASALBUONI[2], A. GRAU[2];* [1]BABCOCK NOELL GMBH, [2]INSTITUTE FOR SYNCHROTRON RADIATION, KARLSRUHE INSTITUTE OF TECHNOLOGY. — THE ENGINEERING CURRENT DENSITY OF COMMERCIAL HTS MATERIALS IS RAPIDLY INCREASING IN PERFORMANCE MAKING THEM MORE AND MORE ATTRACTIVE IN PARTICULAR WHEN ADOPTED IN CONJUNCTION WITH CONDUCTION COOLED SYSTEMS.IN ORDER TO QUALIFY THE PRACTICAL APPLICATION OF HTS CONDUCTORS IN INSERTION DEVICES, AT BABCOCK NOELL GMBH (BNG) WE COMPLETED THE DESIGN AND FABRICATED A SHORT PROTOTYPE PLANAR UNDULATOR BASED ON COMMERCIAL YBCO. THE PROTOTYPE HAS BEEN TESTED AT KIT IN LIQUID HELIUM TO ASSES THE PERFORMANCE. THIS PAPER DESCRIBES THE OVERALL DESIGN AND THE ACHIEVED TEST RESULTS.

4LZ-03

HIGH FIELD HTS R&D SOLENOID FOR MUON COLLIDER ***R. GUPTA****[1], M. ANERELLA[1], A. GHOSH[1], H. KIRK[1], R. PALMER[1], S. PLATE[1], W. SAMPSON[1], Y. SHIROYANAGI[1], P. WANDERER[1], D. CLINE[2], B. BRANDT[3], A. GARREN[3], J. KOLONKO[3], R. SCANLAN[3], R. WEGGEL[3];* [1]BROOKHAVEN NATIONAL LABORATORY, [2]UNIVERSITY OF CALIFORNIA, LOS ANGELES, [3]PARTICLE BEAM LASERS, INC.. — THIS PAPER DESCRIBES A HIGH FIELD HIGH TEMPERATURE SUPERCONDUCTOR (HTS) SOLENOID PROGRAM WITH A GOAL TO GENERATE OVER 20 T FIELD BY ITSELF AND APPROACH 40 T IN A BACKGROUND FIELD OF ~20 T. THE HTS SOLENOIDAL MAGNET IS BEING BUILT AS A PART OF AN R&D PROGRAM TO DEVELOP TECHNOLOGIES FOR A MUON COOLING SYSTEM AND TO TEST THE LIMIT OF HIGH FIELD MAGNET TECHNOLOGY. IT IS FUNDED UNDER A SERIES OF SBIR (SMALL BUSINESS INNOVATIVE RESEARCH) AWARDS TO PARTICLE BEAM LASERS, INC. (PBL), WITH BROOKHAVEN NATIONAL LABORATORY (BNL) BEING A RESEARCH PARTNER TO BUILD AND TEST THE MAGNET. THE MAGNET CONSISTS OF TWO CONCENTRIC SOLENOIDS, EACH MADE WITH THE SECOND GENERATION (2G) HIGH ENGINEERING CURRENT DENSITY HTS TAPE FROM SUPERPOWER. THE FIRST ~10 T SOLENOID HAS AN INNER DIAMETER OF ~100 MM AND OUTER DIAMETER OF ~165 MM; THE SECOND ~12 T SOLENOID WILL HAVE AN INNER DIAMETER OF 25 MM AND OUTER DIAMETER OF 95 MM. SEVERAL DOUBLE PANCAKE COILS OF THE FIRST SOLENOID HAVE ALREADY BEEN BUILT AND TESTED IN THE TEMPERATURE RANGE BETWEEN ~4 K AND ~80 K. THE TWO SOLENOIDS WILL BE NESTED TO GENERATE OVER 20 T AND WILL BE TESTED AT BNL AND THEN IN THE BACKGROUND FIELD OF THE ~20 T LARGE-BORE MAGNET AT THE NATIONAL HIGH FIELD MAGNET LAB (NHFML) IN FLORIDA. QUENCH PROTECTION, HIGH STRESSES AND MINIMIZATION OF DEGRADATION ARE SOME OF THE MAJOR CHALLENGES ASSOCIATED WITH THIS PROGRAM. WE WILL REVIEW THE STATUS OF THIS PROGRAM AND DISCUSS THE OVERALL PLAN.

THIS WORK IS SUPPORTED BY THE U.S. DEPARTMENT OF ENERGY UNDER CONTRACT NO. DE-AC02-98CH10886 AND SBIR AWARDS TO PBL UNDER GRANT NUMBERS DE-FG02-07ER84855 AND DE-FG02-08ER85037.

4LZ-04

CRITICAL CURRENT GRADIENTS IN BI-2212 INSERT COILS FOR ACCELERATOR MAGNETS ***A. GODEKE****, D. ARBELAEZ, D. W. CHENG, D. R. DIETDERICH, H. FELICE, S. O. PRESTEMON, G. SABBI, X. WANG;* LAWRENCE BERKELEY NATIONAL LABORATORY. — RECENT WORK ON WIND-AND-REACT (W&R) BI2SR2CACU2OX (BI-2212) INSERT COILS DEMONSTRATED THEIR FEASIBILITY FOR ACCELERATOR MAGNETS. A KEY ISSUE THAT STILL REQUIRES CLARIFICATION IS THE OBSERVABLE DIFFERENCE OF THE CRITICAL CURRENT (IC) IN THE INNER AND OUTER TURNS OF SUCH COILS, AND WITNESS SAMPLES. AN EXEMPLARY RESULT THAT THE OUTER TURN IN ONE OF THE COILS CARRIES A CURRENT THAT IS ABOUT 30% HIGHER THAN ITS WITNESS CABLE DICTATES FURTHER ANALYSIS. POSSIBLE ORIGINS ARE MAGNETIC FIELD AND/OR STRAIN GRADIENTS ACROSS THE WINDINGS, OR INHOMOGENEOUS OXYGEN CONTENT AND/OR TEMPERATURE DURING THE PARTIAL MELT REACTION. WE PRESENT AN IN-DEPTH ANALYSIS OF MAGNETIC FIELD AND STRAIN GRADIENTS IN COILS THROUGH A COMBINATION OF FINITE ELEMENT MODELING AND DEDICATED EXPERIMENTS ON COILS, WIRES AND CABLES. THIS WILL GENERATE MORE INSIGHT IN THE ORIGINS OF THE IC DIFFERENCES, AND SUGGEST WAYS TO ADDRESS THEM. THE APPLICATION OF W&R BI-2212 IN ACCELERATOR-TYPE MAGNETS, PENDING IMPROVEMENTS IN ENGINEERING CURRENT DENSITY AND THE MATERIAL'S ABILITY TO HANDLE

LARGE LORENTZ LOADS, WILL ENABLE FUTURE HYBRID SYSTEMS THAT CAN SUBSTANTIALLY SURPASS THE INTRINSIC LIMITATIONS OF NB-BASED MAGNETS.

THIS WORK WAS SUPPORTED BY THE DIRECTOR, OFFICE OF SCIENCE, HIGH ENERGY PHYSICS, U.S. DEPARTMENT OF ENERGY UNDER CONTRACT NO. DE-AC02-05CH11231, AND BY ARRA FUNDS THROUGH THE U.S. VERY HIGH FIELD SUPERCONDUCTING MAGNET COLLABORATION (VHFSMC)

4LZ-05**SECOND GENERATION HTS QUADRUPOLE FOR FRIB** ***R. GUPTA***[1]*, M. ANERELLA*[1]*, J. COZZOLINO*[1]*, A. GHOSH*[1]*, H. HOCKER*[1]*, W. SAMPSON*[1]*, J. SCHMALZLE*[1]*, Y. SHIROYANAGI*[1]*, P. WANDERER*[1]*, A. ZELLER*[2]*;* [1]BROOKHAVEN NATIONAL LABORATORY, [2]NATIONAL SUPERCONDUCTING CYCLOTRON LABORATORY. — THIS PAPER WILL DESCRIBE THE DESIGN AND R&D PLAN OF A HIGH TEMPERATURE SUPERCONDUCTOR (HTS) QUADRUPOLE FOR THE ESTABLISHMENT OF THE FACILITY FOR RARE ISOTOPE BEAMS (FRIB). QUADRUPOLES IN THE FRAGMENT SEPARATOR REGION OF THIS FACILITY WILL BE SUBJECTED TO INTENSE LEVEL OF RADIATION (>106 GY PER YEAR) AND HEAT LOADS (OVER 200 WATTS IN THE COILS OF FIRST 0.6 METER LONG MAGNET ITSELF). THE USE OF HTS IS ATTRACTIVE AS IT CAN REMOVE THESE HIGH HEAT LOADS AT ELEVATED 30-50 K RATHER THAN AT 4-10 K, NEEDED FOR CONVENTIONAL LOW TEMPERATURE SUPERCONDUCTORS. EARLIER, IN THE FIRST PHASE OF HTS MAGNET R&D FOR RARE ISOTOPE ACCELERATOR (RIA), WE HAD SUCCESSFULLY DESIGNED, BUILT AND TESTED A 10 T/M, 290 MM APERTURE QUADRUPOLE WITH ~ 4 MM WIDE FIRST GENERATION BSCCO2223 TAPE OPERATED AT 30 K. THE SECOND GENERATION MAGNET DESIGN REQUIRES A HIGHER GRADIENT (15 T/M) AND IS BEING DESIGNED WITH ~12 MM WIDE SECOND GENERATION YBCO TAPE TO OPERATE AT EVEN HIGHER TEMPERATURE, ~50 K. HIGHER OPERATING TEMPERATURE MAKES THE REMOVAL OF LARGE AMOUNTS OF ENERGY EVEN MORE EFFICIENT. WE ARE DEVELOPING A WARM IRON MAGNET DESIGN WHERE THE HTS COILS ARE CONDUCTION-COOLED WITH HELIUM GAS FLOWING THROUGH A SUPPORT STRUCTURE. THE GOAL OF THIS THREE YEAR R&D PROGRAM IS TO EVALUATE THE VIABILITY OF HTS MAGNETS IN A REAL MACHINE WITH MAGNETS IN A CHALLENGING ENVIRONMENT WHERE HTS OFFERS A UNIQUE ADVANTAGE.

THIS WORK IS SUPPORTED BY THE U.S. DEPARTMENT OF ENERGY UNDER CONTRACT NO. DE-AC02-98CH10886 AND UNDER COOPERATIVE AGREEMENT DE-SC0000661 FROM DOE-SC THAT PROVIDES FINANCIAL ASSISTANCE TO MSU TO DESIGN AND ESTABLISH FRIB.

4LZ-06

IMPLEMENTATION OF A FULL HTS DIPOLE SYNCHROTRON STORAGE RING ***M. FEE****, V. CHAMRITSKI, M. CHRISTIAN, S. GIBSON, T. ROBINSON, D. POOKE;* HTS-110 LTD. — BUILDING ON TWO DEMONSTRATION DIPOLES MANUFACTURED BY HTS-110, WE PRESENT AN OVERVIEW OF A FULL HTS DIPOLE STORAGE RING CONCEPT, INCLUDING SUPPORTING INFRASTRUCTURE FOR A COMPLETE INSTALLATION. A CASE IS PRESENTED FOR THE LOWER TOTAL COST OF OWNERSHIP FOR HTS VERSUS COPPER MAGNETS IN INSTALLATIONS WHERE ELECTRICITY COSTS ARE HIGH OR DELIVERY IS CONSTRAINED. ADDITIONAL FACILITY ADVANTAGE ARISES FROM REDUCED WATER-COOLING REQUIREMENTS AND, FROM A TECHNICAL PERPECTIVE, THE USER GAINS IMPROVED EXPERIMENTAL ACCESS TO THE FIELD DUE TO THE SMALLER CROSS-SECTION OF THE SUPERCONDUCTING COILS COMPARED TO THEIR COPPER EQUIVALENTS. SPECIFIC DISCUSSION IS MADE AROUND THE POTENTIAL ADVANTAGES OF RUNNING HIGHER FIELD MAGNETS. A DESCRIPTION OF PROPOSED CENTRALISED COOLING SYSTEM WILL ALSO BE PRESENTED.

4LZ-07

A NEW PROJECT FOR RESEARCH AND DEVELOPMENT OF FUNDAMENTAL TECHNOLOGIES FOR APPLICATIONS OF HIGH TC SUPERCONDUCTOR TAPES TO ACCELERATOR MAGNETS ***N. AMEMIYA***[1]*, K. TAKAHASHI*[1]*, N. OKADA*[1]*, T. NAKAMURA*[1]*, Y. MORI*[1]*, T. OGITSU*[2]*, T. TOSAKA*[3]*, T. KURUSU*[3]*, T. YOSHIYUKI*[3]*, K. NODA*[4]*, M. YOSHIMOTO*[5]*;* [1]KYOTO UNIVERSITY, [2]HIGH ENERGY ACCELERATOR RESEARCH ORGANIZATION, [3]TOSHIBA CORPORATION, [4]NATIONAL INSTITUTE OF RADIOLOGICAL SCIENCES, [5]JAPAN ATOMIC ENERGY AGENCY. — APPLICATIONS OF HIGH TC SUPERCONDUCTORS TO ACCELERATOR MAGNETS ARE ATTRACTIVE FROM THE VIEW POINT OF COOLING EFFICIENCY AS WELL AS THERMAL STABILITY IF THEY CAN BE OPERATED IN A RELATIVELY HIGH TEMPERATURE REGION. THE AUTHORS' GROUP LAUNCHED A PROJECT FOR RESEARCH AND DEVELOPMENT OF THE FUNDAMENTAL TECHNOLOGIES FOR ACCELERATOR MAGNETS USING HIGH TC SUPERCONDUCTOR TAPES. THE EXPECTED FUTURE APPLICATIONS OF THE MAGNETS INCLUDE FFAG ACCELERATOR AND/OR SYNCHROTRON AS WELL AS ROTATING GANTRY FOR CARBON CANCER THERAPY AND ACCELERATOR DRIVEN SUB-CRITICAL REACTOR. A PROTOTYPE MAGNET WILL BE MADE AT THE FINAL STAGE OF THE PROJECT TO DEMONSTRATE THE ESTABLISHED FUNDAMENTAL TECHNOLOGIES. THE OVERVIEW OF THE PROJECT AS WELL AS SOME RESULTS IN THE FIRST STAGE OF THE PROJECT IS PRESENTED. WE HAVE BEEN DEVELOPING A TECHNOLOGY TO DESIGN MAGNETS CONSIDERING THE CURRENT TRANSPORT CHARACTERISTICS OF HIGH TC SUPERCONDUCTOR TAPES WITH ANISOTROPIC MAGNETIC FIELD DEPENDENCE. THE FEASIBILITY OF THREE-DIMENSIONAL WINDING AT THE COIL ENDS OF COSINE-THETA COIL IS DISCUSSED. THE INFLUENCE OF THE SHIELDING CURRENT IN HIGH TC SUPERCONDUCTOR TAPES ON FIELD QUALITY IS STUDIED BASED ON THE NUMERICAL ELECTROMAGNETIC FIELD ANALYSES OF SUPERCONDUCTORS AS WELL AS EXPERIMENTS USING A SMALL DIPOLE MAGNET.

THIS WORK WAS SUPPORTED BY JAPAN SCIENCE AND TECHNOLOGY AGENCY.

4MA-01

(INVITED) **EFFECT OF STRAIN, BZO CONTENT AND THE INCORPORATION OF DOUBLE-PEROVSKITE-BASED TA- AND NB- OXIDE NANOSTRUCTURES ON FLUX-PINNING IN COATED CONDUCTORS** ***A. GOYAL****, S. WEE, E. D. SPECHT, C. CANTONI,*

Y. ZUEV, Y. GAO; OAK RIDGE NATIONAL LABORATORY. — THE EFFECT OF STRAIN ON T_C, AND J_C AS A FUNCTION OF BZO CONTENT IN RBECO BASED COATED CONDUCTORS WILL BE PRESENTED. DATA WILL BE PRESENTED FOR FILMS MADE USING DIFFERENT TECHNIQUES SUCH AS PULSED LASER ABLATION, MOCVD AND MOD. THE EFFECT OF LATTICE-MISMATCH ON SELF-ASSEMBLY OF COLUMNAR DEFECTS WITHIN YBCO FILMS WILL ALSO BE PRESENTED. USING $BAMO_3$-TYPE ADDITIONS, THE LATTICE-MISMATCH WAS VARIED OVER A BROAD RANGE OF VALUES BY USING DIFFERENT COMPONENTS FOR M SUCH AS ZR, SN, CE, ETC. IT IS FOUND THAT ONLY A CERTAIN RANGE OF LATTICE MISMATCH IS MOST AMENABLE TO SELF-ASSEMBLY OF COLUMNAR DEFECTS. LASTLY, A NEW MATERIAL OR COMPOUND WHICH IS FOUND TO BE VERY EFFECTIVE IN FORMING SELF-ASSEMBLED, COLUMNAR DEFECTS HAS BEEN IDENTIFIED. THESE ARE DOUBLE-PEROVSKITE BASED, BA_2RETAO_6 AND BA_2RENBO_6 MATERIALS, WHERE RE IS A RARE-EARTH. THE LATTICE-MISMATCH OF TA AND NB-BASED, DOUBLE PEROVSKITES IS SHOWN TO BE HIGHLY AMENABLE TO FORMATION OF SUCH COLUMNAR DEFECTS. MASSIVE IMPROVEMENT IN FLUX-PINNING IS OBTAINED VIA INCORPORATION OF SUCH DOUBLE PEROVSKITE-BASED, SELF-ASSEMBLED COLUMNAR DEFECTS IN REBCO FILMS ON COATED CONDUCTORS. THIS RESEARCH WAS SPONSORED BY THE U.S. DOE OFFICE OF ELECTRICITY DELIVERY AND ENERGY RELIABILITY - SUPERCONDUCTIVITY PROGRAM FOR ELECTRIC POWER SYSTEMS ADVANCED CABLES AND CONDUCTORS.

4MA-02

LOW-TEMPERATURE PHASE TRANSFORMATION AS A NEW WAY TO ENHANCE PINNING OF YBCO FILMS ***V. SOLOVYOV***[1]*, W. SI*[1]*, J. ZHOU*[1]*, L. WU*[1]*, J. QING*[1]*, K. DEVELOS-BAGARINAO*[2]*, Q. LI*[1]*;* [1]BROOKHAVEN NATIONAL LABORATORY, [2]2NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY. — IN THIS WORK WE EXPLORE A POSSIBILITY OF USING LOW-TEMPERATURE PHASE TRANSFORMATIONS AS A NEW WAY TO ENHANCE CRITICAL CURRENT DENSITY OF THICK EPITAXIAL YBCO LAYERS. THE ADVANTAGE OF THIS APPROACH IS THAT IT CAN POTENTIALLY PRODUCE HIGH-CURRENT YBCO LAYER BY A SIMPLE SEQUENCE OF LOW-TEMPERATURE HEAT-TREATMENTS, OFFERING A BETTER ALTERNATIVE TO ARTIFICIAL INTRODUCTION OF PINNING CENTERS. SINCE THE FLUX PINNING IS BASED ON STRAIN PRODUCED BY THE TRANSFORMATION OF ONE SUPERCONDUCTING PHASE TO ANOTHER, THERE IS NO CROSS-SECTION REDUCTION DUE TO DISPLACEMENT OF THE SUPERCONDUCTING MATRIX BY NON-SUPERCONDUCTING INCLUSIONS. WE IDENTIFY TWO METASTABLE LONG-PERIOD CUPRATE PHASES THAT CAN BE USED FOR THE PURPOSE. THE MOST PROMISING ONE IS A LONG-PERIOD (C = 3.5 NM) PHASE WHICH FORMS AFTER 400^{O}C ANNEALING OF METAL-ORGANIC YBCO FILMS SYNTHESIZED IN THE PROXIMITY OF THE HAMMOND-BORMANN STABILITY LINE. BECAUSE THE PHASE IS SUPERCONDUCTOR WITH T_C = 90K, THE TRANSFORMATION DOES NOT DEGRADE T_C OF THE WHOLE FILM. WE SHOW THAT THE TRANSFORMATION RESULTS IN ALMOST TWO-FOLD INCREASE OF THE CRITICAL CURRENT DENSITY AND IRREVERSIBILITY FIELD OF 0.8 MM THICK FILMS, REACHING THE MAXIMUM OF 4.2 MA/CM^2 AT 77 K.

THIS WORK HAS BEEN PERFORMED UNDER CONTRACT NO. DE-AC02-98CHI-886 WITH THE U. S. DEPARTMENT OF ENERGY, OFFICE OF ELECTRICITY DELIVERY AND ENERGY RELIABILITY.

4MA-03

FLUX-PINNING MECHANISMS IN STOICHIOMETRIC YBCO FILMS PREPARED BY A FLUORINE-FREE MOD METHOD ***H. YAMASAKI***[1]*, K. OHKI*[2]*, I. YAMAGUCHI*[1]*, M. SOHMA*[1]*, W. KONDO*[1]*, H. MATSUI*[1]*, T. MANABE*[1]*, T. KUMAGAI*[1]*;* [1]NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY (AIST), [2]NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY (AIST), NOW IN SUMITOMO ELECTRIC INDUSTRIES. — WE HAVE BEEN STUDYING THE FLUX PINNING MECHANISMS IN HIGH CRITICAL CURRENT DENSITY JC EPITAXIAL YBCO FILMS [1-4]. BY MAGNETIC-FIELD ANGLE DEPENDENT JC MEASUREMENTS AND TEM OBSERVATIONS WE IDENTIFIED SEVERAL PINNING CENTERS CORRELATED ALONG THE C-AXIS OF YBCO: PLANAR DEFECTS AND DISLOCATIONS [1, 2]. RECENTLY WE REVEALED THAT THE RANDOM PINNING IS CAUSED BY HIGH-DENSITY OF NANOMETER-SIZED PRECIPITATES IN Y-RICH CO-EVAPORATED THIN FILMS [4]. IT WAS SHOWN BOTH EXPERIMENTALLY AND THEORETICALLY THAT THE NANO-PRECIPITATES RESULT IN MT.-FUJI-LIKE JC(Θ) PEAKS AROUND H // AB WHEN THE SIZE IS VERY SMALL (< 2Ξ = 7-10 NM AT 77.3 K), OR BROAD JC(Θ) PEAKS CENTERED AT H // C WHEN THE SIZE IS LARGER (> 2Ξ).IN THIS STUDY WE INVESTIGATE THE FLUX PINNING MECHANISMS IN STOICHIOMETRIC YBCO FILMS PREPARED BY A FLUORINE-FREE-MOD METHOD. WE OBSERVED SHARP MOUNTAIN-LIKE JC(Θ) PEAKS AROUND H // AB, BUT NANO-PRECIPITATES HAVE NOT BEEN OBSERVED IN HIGH DENSITY. INSTEAD, HIGH-DENSITY OF STACKING FAULTS PARALLEL TO THE AB-PLANE WERE OBSERVED IN SOME AREAS IN HIGH-RESOLUTION CROSS-SECTIONAL TEM. THE FLUX PINNING DUE TO DISLOCATIONS FORMED AT THE END OF STACKING FAULTS CAN EXPLAIN THE OBSERVED JC(H, Θ).REFERENCES: 1) H. YAMADA ET AL., SUST 17, 58 (2004), 2) K. DEVELOS-BAGARINAO ET AL., SUST 18, 667 (2005), 3) K. DEVELOS-BAGARINAO, H. YAMASAKI AND K. OHKI, JAP 106, 063907 (2008), 4) H. YAMASAKI ET AL., SUST 21, 125011 (2008)

4MA-04

COMPOSITION EFFECTS ON THE CRITICAL CURRENT OF MOCVD-PROCESSED ZR:GDYBCO COATED CONDUCTORS IN AN APPLIED MAGNETIC FIELD ***Y. CHEN***[1]*, T. SHI*[2]*, A. P. GUEVARA*[2]*, Y. ZHANG*[2]*, I. KESGIN*[2]*, Y. YAO*[2]*, A. RAR*[1]*, G. MAJKIC*[2]*, V. SELVAMANICKAM*[2]*;* [1]SUPERPOWER INC, [2]UNIVERSITY OF HOUSTON. — ZR:GDYBCO FILMS WERE GROWN BY REEL-TO-REEL METAL ORGANIC CHEMICAL VAPOR DEPOSITION (MOCVD) ON HASTELLOY TAPES WITH IBAD-BASED BUFFER. THE COMPOSITION WAS VARIED SYSTEMATICALLY TO INVESTIGATE THE EFFECTS OF CHANGES IN (GD+Y)/BA, (GD+Y)/CU AND GD/Y RATIOS AND ZR-DOPING CONCENTRATION ON THE CRITICAL CURRENT DENSITY (JC) OF THE FILMS IN AN APPLIED MAGNETIC FIELD (B). THE

MAGNETIC-FIELD-ANGLE DEPENDENCE OF JC MEASURED AT 77K AND 1T SHOWED THAT (1) INCREASING GD+Y COULD SUPPRESS OR REMOVE THE JC PEAK AT B//C WHICH WAS ASSOCIATED WITH THE PINNING FROM $BAZRO_3$ NANO-COLUMNS; (2) EXCESS AMOUNT OF GD+Y COULD ENHANCE THE JC PEAK AT B//AB AND INCREASE THE MINIMUM JC FOR ALL ANGLE (JC_MIN); (3) THE ZR-DOPING WITH MOL CONCENTRATION IN THE RANGE OF 0.025 - 0.075 COULD INCREASE JC_MIN AS WELL AS SIGNIFICANTLY ENHANCE THE JC PEAK AT B//C, BUT SUPPRESS JC PEAK AT B//AB; (4) INCREASING GD/Y RATIO INCREASED JC_MIN(1T,77K). IN SELF-FIELD OR LOW FIELD, HOWEVER, THE OPTIMIZED GD/Y RATIO WAS ABOUT 1.

4MA-05

STRATEGIC RESEARCH ON PERFORMANCE OPTIMIZATION OF YBCO COATED CONDUCTORS ***T. AYTUG***[1]*, M. PARANTHAMAN*[1]*, E. SPECHT*[1]*, S. COOK*[1]*, C. CANTONI*[1]*, F. LIST*[1]*, K. KIM*[1]*, Y. ZHANG*[1]*, A. GOYAL*[1]*, D. CHRISTEN*[1]*, Y. CHEN*[2]*, V. SELVAMANICKAM*[2]*, V. MARONI*[3]*, D. MILLER*[3]*, Z. CHEN*[3]*, A. KROPF*[3]*, N. ZALUZEC*[3]*;* [1]OAK RIDGE NATIONAL LABORATORY, [2]SUPERPOWER, INC., [3]ARGONNE NATIONAL LABORATORY. — A RESEARCH-SCALE METAL-ORGANIC CHEMICAL VAPOR DEPOSITION (MOCVD) SYSTEM HAS BEEN USED TO INVESTIGATE AND UNDERSTAND THE EFFECTS OF RARE EARTH (CE AND HO) AND TRANSITION METAL (NB) ADDITION/SUBSTITUTION ON THE MICRO-STRUCTURAL PROPERTIES AND FLUX PINNING PERFORMANCE OF THESE FILMS. SYSTEMATIC VARIATIONS IN DOPING HAVE REVEALED TRENDS IN THE RESULTING PERFORMANCE/PROPERTY CORRELATIONS, AS CHARACTERIZED BY COORDINATED ANALYSES OF ELECTRICAL TRANSPORT, X-RAY DIFFRACTION, SCANNING ELECTRON MICROSCOPY, AND TRANSMISSION ELECTRON MICROSCOPY. IN PARTICULAR, THE MICROSTRUCTURAL ANALYSES CORRELATE WELL WITH THE FLUX PINNING BEHAVIOR AND RELATE TO DIFFERENCES IN DEFECT STRUCTURES AND THE NATURE OF THE SECONDARY PHASES THAT ARE GENERATED WITH THE SELECTIVE METAL ELEMENT DOPING. FROM THE COMBINATION OF THESE CHARACTERIZATION TECHNIQUES, AN IMPROVED UNDERSTANDING OF THE GROWTH CHARACTERISTICS AND TRENDS IN PINNING PERFORMANCE OF MOCVD REBCO FILMS WAS ESTABLISHED AND WILL BE DISCUSSED.

THIS WORK WAS SUPPORTED BY THE U.S. DEPARTMENT OF ENERGY, OFFICE OF ELECTRICITY DELIVERY AND ENERGY RELIABILITY, ADVANCED CABLES AND CONDUCTORS.

4MA-06

ALL-MOCVD TECHNOLOGY FOR COATED CONDUCTOR FABRICATION ***A. MOLODYK****, M. NOVOZHILOV, S. STREET, L. CASTELLANI, A. IGNATIEV;* METAL OXIDE TECHNOLOGIES INC.. — METAL OXIDE TECHNOLOGIES INC. IS ACTIVELY DEVELOPING A UNIQUE ALL-MOCVD TECHNOLOGY TO DEPOSIT ONTO A CONTINUOUSLY MOVING METAL TAPE BOTH BUFFER AND YBCO LAYERS FOR COATED CONDUCTORS. AN OVERVIEW OF THE CURRENT STATE OF METOX TECHNOLOGY WILL BE GIVEN. MODULAR DESIGN OF THE PROTOTYPE PRODUCTION MOCVD SYSTEM ALLOWS FOR EITHER IN-LINE OR PARALLEL FABRICATION OF ANY NUMBER OF BUFFER LAYERS AND YBCO LAYERS. THE SYSTEM IS OPERATED IN AIR-TO-AIR, REEL-TO-REEL MODE, AND REPRESENTS ONE OF THE LOWEST POSSIBLE CAPITAL AND OPERATIONAL COST APPROACHES TO COATED CONDUCTOR MANUFACTURING. WORLD CLASS RESULTS OF JC = 3.34 MA/CM2, IC = 480 A/CM ON SHORT SAMPLES, AND IC > 300 A/CM ON 1+ M LONG TAPES HAVE BEEN ACHIEVED IN MOCVD YBCO ON ESTABLISHED BUFFER LAYER ARCHITECTURES. IN ADDITION, IC > 200 A/CM HAS BEEN REPRODUCIBLY DEMONSTRATED ON A PROPRIETARY ALL-METOX ALL-MOCVD ARCHITECTURE.

METOX GRATEFULLY ACKNOWLEDGES THE SUPPORT OF AND COLLABORATION WITH THE FOLLOWING ORGANISATIONS AND PROGRAMMES: CRADA WITH LANL AND ORNL, SBIR WITH DOE, ONR, AND UNIVERSITY OF HOUSTON.

4MA-07

SUPERCONDUCTING YBCO THIN FILMS, MULTILAYERS AND HETEROSTRUCTURES ***A. V. PAN****, S. V. PYSARENKO, O. V. SHCHERBAKOVA, S. A. FEDOSEEV, S. DOU;* UNIVERSITY OF WOLLONGONG. — DEVELOPMENT, FUNDAMENTALS AND PROPERTIES OF YBCO HIGH TEMPERATURE SUPERCONDUCTING FILMS, MUTLILAYERS, COATED CONDUCTORS AND HETEROSTRUCTURES OBTAINED BY PULSED LASER DEPOSITION TECHNIQUE WILL BE PRESENTED. THE PROPERTIES OF THE FILMS AND LAYER INTERFACES ARE OPTIMIZED TO SUIT BOTH HIGH CURRENT APPLICATIONS AND JOSEPHSON JUNCTION FABRICATION. CURRENT-CARRYING LIMITATIONS AND VORTEX PINNING MECHANISM HAVE BEEN ESTABLISHED AND QUANTITATIVELY DEVELOPED TO DESCRIBE THE BEHAVIOR OF THE CRITICAL CURRENT DENSITY AND THE PARAMETERS OF FILM MICROSTRUCTURE. THE PROPERTY VARIATION OF HYBRID HETEROSTRUCTURES SENSITIVE TO THE INTERLAYERING AND MAGNETIC ANISOTROPY IS DEMONSTRATED.

THIS WORK IS SUPPORTED BY THE AUSTRALIAN RESEARCH COUNCIL, AS WELL AS BY HYPRES INC AND MESAPLEXX PTY LTD.

4MA-08

ENHANCED FLUX-PINNING IN LONG LENGTH COATED CONDUCTORS MANUFACTURED VIA HR-PLD AND ABAD ***A. HALLBAUER****, A. RUTT, L. KIRCHHOFF, K. SCHLENGA, A. USOSKIN;* BRUKER HTS GMBH. — IN DIFFERENT APPLICATIONS, INCLUDING HTS BASED MAGNETS, MOTORS, TRANSFORMERS ETC., LONG LENGTH HTS TAPES OF 2^{ND} GENERATION WHICH ARE CAPABLE OF HIGH CURRENTS WITHIN A WIDE RANGE OF MAGNETIC FIELD ARE REQUIRED.OUR LONG LENGTH HTS TAPES ARE BASED ON STAINLESS STEEL COATED WITH YTTRIA STABILIZED ZIRCONIA VIA AN ALTERNATING BEAM ASSISTED DEPOSITION (ABAD) AND FURTHER WITH CEO_2 BUFFER CAP LAYER VIA A HIGH-RATE PULSED LASER DEPOSITION (HR-PLD). THE YBCO- AS WELL AS NANO-DOPED YBCO-FILMS ARE DEPOSITED ALSO BY HR-PLD.THESE COATED CONDUCTORS (CC'S) WITH DOPED AND NON-DOPED YBCO-FILMS ARE

COMPARED REGARDING THEIR CRITICAL CURRENTS IN MAGNETIC FIELDS FROM 0 TO 18T DEPENDING ON FIELD ANGLE AT TEMPERATURES FROM 4.2 K TO 77K. VERY HIGH CRITICAL CURRENTS, I_C-S OF 1100A/CM-WIDTH WAS OBSERVED AT 18 T AND 4.2 K IN OPTIMIZED CC'S IN PERPENDICULAR FIELD. SUCH CURRENT CORRESPONDS TO THE CRITICAL CURRENT DENSITY OF J_C=6.3MA/CM^2. THIS SEEMS TO BE THE HIGHEST CRITICAL CURRENTS AND J_C-S EVER OBSERVED IN SUCH HIGH FIELDS. FURTHER MEASUREMENTS OF THINNER HTS FILMS YIELDED SIMILAR CURRENT DENSITIES. IN PARALLEL FIELD THE I_C-S AND J_C-S ARE MORE THAN 3 TIMES HIGHER COMPARED TO THE PERPENDICULAR FIELD.

THIS WORK IS SUPPORTED IN PART BY GERMAN MINISTRY OF ECONOMY AND TECHNOLOGY (BMWI), PROJECT NO. 0327456A.

4MB-01

INVESTIGATION OF THREE-DIMENSIONAL CURRENT DISTRIBUTION AT SILVER DIFFUSION JOINT OF RE-123 COATED CONDUCTORS BASED ON MAGNETIC MICROSCOPY COMBINED WITH FINITE ELEMENT METHOD ***K. HIGASHIKAWA***[1]*, Y. HONDA*[1]*, M. INOUE*[1]*, T. KISS*[1]*, N. CHIKUMOTO*[2]*, N. SAKAI*[2]*, T. IZUMI*[2]*;* [1]KYUSHU UNIVERSITY, [2]SUPERCONDUCTIVITY RESEARCH LABORATORY, ISTEC. — COMBINING SCANNING HALL-PROBE MICROSCOPY (SHPM) WITH FINITE ELEMENT METHOD (FEM) ANALYSIS, WE HAVE INVESTIGATED THREE-DIMENSIONAL CURRENT DISTRIBUTION AT SILVER DIFFUSION JOINT OF RE-123 COATED CONDUCTORS (CCS). THIS RESEARCH AIMS AT A DETAILED INVESTIGATION OF ELECTROMAGNETIC BEHAVIOUR IN SPLICED AND JOINTED CCS FOR THE IMPROVEMENT OF THE CORRESPONDING PROCESSES. TWO-DIMENSIONAL DISTRIBUTION OF SHEET CURRENT DENSITY IN A SAMPLE WAS VISUALIZED BY A SHPM MEASUREMENT WITH A SPATIAL RESOLUTION OF A FEW HUNDRED MICROMETERS. THEN, SUCH A DISTRIBUTION WAS SUCCESSFULLY RECONSTRUCTED AS A RESULT OF A THREE-DIMENSIONAL FEM ANALYSIS WHEN A REASONABLE CONTACT RESISTANCE AND LOCAL INHOMOGENEITY WERE TAKEN INTO ACCOUNT. THIS MEANS THAT WE CAN DISCUSS THE DETAILED ELECTROMAGNETIC BEHAVIOUR IN THE SAMPLE, SUCH AS CURRENT TRANSFER AND LOSS DENSITY DISTRIBUTION, FROM THE EXPERIMENTAL DATA WITH THE AID OF THE NUMERICAL ANALYSIS. WE BELIEVE THAT THESE FINDINGS WILL BE VERY IMPORTANT INFORMATION FOR THE ESTABLISHMENT OF SPLICING AND JOINTING PROCESSES ON CCS.

THIS WORK WAS SUPPORTED BY THE "NEDO AS THE PROJECT FOR DEVELOPMENT OF MATERIALS & POWER APPLICATION OF COATED CONDUCTORS, M-PACC", "JSPS: KAKENHI (20360143)" AND "JSPS: KAKENHI (20.01945)".

4MB-02

COMPUTATION OF CURRENT DISTRIBUTION IN YBCO TAPES WITH DEFECTS OBTAINED FROM HALL MAGNETIC MAPPING BY INVERSE PROBLEM SOLUTION ***M. CARRERA***[1]*, J. AMORÓS*[2]*, X. GRANADOS*[3]*, R. MAYNOU*[2]*, T. PUIG*[3]*, X. OBRADORS*[3]*;* [1]UNIVERSITAT DE LLEIDA, [2]UNIVERSITAT POLITÈCNICA DE CATALUNYA, [3]INSTITUT DE CIÈNCIA DE MATERIALS DE BARCELONA (ICMAB-CSIC). — THE DEVELOPMENT OF SUPERCONDUCTING DEVICES BASED ON LONG-LENGTH HTS TAPES OFTEN REQUIRES OF THESE TAPES HIGH HOMOGENEITY ALONG ITS LENGTH AS WELL AS ACROSS ITS WIDTH. THIS IMPLIES THE ABSENCE OF SIGNIFICANT LOCAL DEFECTS.NON-DESTRUCTIVE CHARACTERIZATION TECHNIQUES TO EXAMINE CRITICAL CURRENT DISTRIBUTION FOR DEFECT DETECTION ARE OF GREAT INTEREST, SPECIALLY IF THEY COULD BE APPLIED IN SITU FOR REAL-TIME TESTING OF LARGE LENGTHS OF TAPE.IN THIS WORK, WE CONTINUE THE ADAPTATION OF OUR METHOD FOR THE COMPUTATION OF CURRENT MAPS FROM HALL MEASUREMENTS OF THE MAGNETIC FIELD OVER THE TAPE. WE COMPUTE THE CURRENT DENSITY DISTRIBUTION IN A STRETCH OF A COMMERCIAL YBCO TAPE WHICH CONTAINS DEFECTS BY USING AN FAST INVERSE PROBLEM SOLVER SPECIFICALLY DESIGNED. THE 2-DIMENSIONAL CURRENT MAP MESHES WITH THE CURRENT DISTRIBUTIONS IN A CROSS-SECTION OF THE TAPE THAT WE PREVIOUSLY COMPUTED IN REAL TIME, SO THAT A MAP OF THE CURRENT CIRCULATING ON THE ENTIRE SURFACE OF A TAPE WITH ISOLATED DEFECTS MAY BE OBTAINED, REGARDLESS OF ITS LENGTH, BY RUNNING A HALL PROBE OVER IT.THIS METHOD IS APPLIED TO A SERIES OF HALL MAPPINGS CORRESPONDING TO SEVERAL MAGNETIZATION REGIMES, PRODUCED BY APPLYING DIFFERENT CURRENT INTENSITIES TO THE TAPE. DETAILS OF THE EXPERIMENTS AND THE CALCULATION METHOD ARE REPORTED AND THE APPLICABILITY TO DETECT THE IMPACT OF THE DEFECTS IN THE TAPE OVER THE CURRENT DISTRIBUTION IS DISCUSSED.

4MB-03

METHOD AND APPARATUS FOR CONTACTLESS IC MEASUREMENT USING MAGNETIC CIRCUIT ***C. GU****, T. QU, S. ZOU, Z. HAN;* APPLIED SUPERCONDUCTIVITY RESEARCH CENTER, TSINGHUA UNIVERSITY. — A NEW METHOD BASED ON THE PRINCIPLE OF MAGNETIC CIRCUIT IS PROPOSED AND REALIZED FOR CONTACTLESS IC MEASUREMENT OF HTS TAPE. THE MOST ADVANTAGE OF THE NEW METHOD IS THAT IT CAN ELIMINATE NOISES CAUSING BY THE MECHANICAL VIBRATION, WHICH IS EVEN IN THE ORDER OF MILLIMETER MAGNITUDE, AND THUS MAKES HIGH SPEED AND HIGH STABILITY MEASUREMENT POSSIBLE. THEORETICAL ANALYSIS OF METHOD ALONG WITH THE FINITE ELEMENTS SIMULATE ARE GIVEN. AN APPARATUS FOR LONG TAPE MEASUREMENT HAS BEEN CONSTRUCTED, BY WHICH THE EXPERIMENT RESULTS FOR A 150 M LONG BI2223/AG MULTI-FILAMENTARY TAPE ARE REPORTED.

4MB-04

TEMPERATURE DEPENDENCE OF THE MAGNETIC SHIELDING EFFICIENCY MEASURED ON BI-2212 HOLLOW CYLINDERS SUBJECTED TO AXIAL MAGNETIC FIELDS *J. F. FAGNARD*[1]*, S. ELSCHNER*[2]*, J. BOCK*[3]*, M. DIRICKX*[1]*, B. VANDERHEYDEN*[4]*,* ***P. VANDERBEMDEN***[4]*;* [1]SUPRATECS, CISS DEPARTMENT, ROYAL MILITARY ACADEMY, B-1000 BRUSSELS, BELGIUM, [2]UNIVERSITY OF APPLIED SCIENCE MANNHEIM, D-68163 MANNHEIM, GERMANY, [3]NEXANS SUPERCONDUCTORS GMBH,

D-50351 HÜRTH, GERMANY, [4]SUPRATECS, DEPARTMENT OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE, UNIVERSITY OF LIEGE, B-4000 LIEGE, BELGIUM. — IN THIS WORK, WE SHOW THAT BULK BI-2212 CYLINDRICAL TUBES, USED NAMELY AS CURRENT LEADS FOR LTS MAGNETS, EXHIBIT ALSO REMARKABLE SHIELDING PROPERTIES. THE MAGNETIC SCREENING PROPERTIES UNDER AN AXIAL DC MAGNETIC ARE MEASURED AT SEVERAL TEMPERATURES BELOW THE LIQUID NITROGEN TEMPERATURE (77 K). THE SHIELDING FACTOR (SF), DEFINED AS THE RATIO BETWEEN THE APPLIED MAGNETIC FLUX DENSITY AND THE INDUCTION INSIDE THE CYLINDER, IS USED AS A CRITERION FOR THE DETERMINATION OF THE MAXIMUM MAGNETIC FLUX DENSITY THAT CAN BE SHIELDED (BLIM). AT T = 20 K, BLIM IS FOUND TO REACH THE RECORD VALUE OF 0.8 T FOR A CYLINDER WITH A WALL THICKNESS EQUAL TO 5 MM. THE VALUE OF BLIM, DETERMINED AT SEVERAL SWEEP RATES OF THE APPLIED MAGNETIC FIELD, EXHIBITS A POWER LAW WHICH CAN BE RELATED TO THE E = EC(J/JC)^N DEPENDENCE. IN ADDITION, THE DECAY OF PERSISTENT CURRENTS IN THE SUPERCONDUCTOR IS DETERMINED OVER A PERIOD OF 15 DAYS. THE RESULTS OF MAGNETIC SHIELDING DATA ARE SHOWN TO BE IN EXCELLENT AGREEMENT WITH TRANSPORT MEASUREMENTS ON THE SAME MATERIAL, ENABLING THE E(J) CURVE OF THE MATERIAL TO BE DETERMINED OVER 8 ORDERS OF MAGNITUDE OF ELECTRIC FIELD. FINALLY, THE SHIELDING PROPERTIES ARE COMPARED TO THOSE OBTAINED BI-2223 HOLLOW CYLINDERS, SHOWING THAT THE MAGNETIC SHIELDING CAPABILITIES OF BI-2212 BELOW T = 70K CAN EXCEED THOSE OF BI-2223.

4MB-05

REAL TIME XRD CONTROL FOR MOCVD (RE)BCO DEPOSITION BY XRD FOR LONG LENGTH 2G HTS WIRE PRODUCTION ***A. RAR***[1]*, G. CAROTA*[1]*, J. DACKOW*[1]*, K. LENSETH*[1]*, R. DRAKE*[2]*, V. SELVAMANICKAM*[3]*;* [1]SUPERPOWER, INC., [2]PROTO MANUFACTURING LTD., [3]UNIVERSITY OF HOUSTON. — IN THE PAST SEVERAL YEARS SUPERPOWER, INC. HAS INCREASED CRITICAL CURRENT, LENGTH, AND THROUGHPUT OF PRODUCTION-SCALE SECOND-GENERATION (2G) HIGH-TEMPERATURE SUPERCONDUCTOR (HTS) WIRES. THIS PROGRESS WAS MOSTLY DUE TO IMPROVEMENT IN THE MOST CRITICAL PROCESS STEP, MOCVD OF THE (RE)BCO LAYER. FOR FUTURE DEVELOPMENT OF THE STABILITY OF THIS PROCESS WE DEVELOPED AND INSTALLED ON THE MOCVD SYSTEM A REAL TIME ON-LINE XRD SYSTEM WHICH ALLOWS MEASUREMENT OF CRITICAL STRUCTURE PARAMETERS OF DEPOSITED (RE)BCO JUST AFTER IT EXITS THE DEPOSITION CHAMBER AND PROVIDES FEEDBACK ON THE EXPECTED CRITICAL CURRENT OF THE TAPE TO THE OPERATORS. IN THIS PRESENTATION WE WILL DISCUSS THE BASIC CONSTRUCTION, PARAMETERS AND EXPERIMENTAL ROUTINES OF THE ON-LINE XRD SYSTEM, THE CURRENT STATUS OF CHARACTERIZATION OF MOCVD TAPES WITH THIS SYSTEM, AND NUMERICAL RELATIONSHIPS BETWEEN XRD MEASUREMENTS AND THE CRITICAL CURRENT OF THE TAPE. WE WILL ALSO DISCUSS BASIC MODELS SUPPORTING THIS RELATIONSHIP, LIMITATIONS AND POSSIBLE FUTURE DEVELOPMENT OF THIS APPROACH.

4MB-06

INVESTIGATION OF POWER DISSIPATION MECHANISMS IN COATED CONDUCTORS AT HIGH CURRENT DENSITIES BASED ON ULTRA FAST PULSED CURRENT MEASUREMENTS ***P. BERNSTEIN***[1]*, C. MCLOUGHLIN*[1]*, Y. THIMONT*[1]*, F. SIROIS*[2]*, J. COULOMBE*[2]*;* [1]CNRS-CRISMAT ENSICAEN, [2]ECOLE POLYTECHNIQUE DE MONTRÉAL. — CURRENT-VOLTAGE (I-V) CHARACTERISTICS OF TWO FULL-SIZE COMMERCIAL SAMPLES OF COATED CONDUCTORS PROVIDED BY *SUPERPOWER* WERE CHARACTERIZED OVER A WIDE RANGE OF ELECTRIC FIELDS. THE SAMPLES INCLUDED METAL SHUNTS WITH DIFFERENT THICKNESSES DEPOSITED OVER THE YBCO FILM. THE MEASUREMENTS WERE CARRIED OUT WITH A HOME-MADE, HIGH CURRENT PULSED SOURCE CAPABLE OF DELIVERING FLAT CURRENT PULSES OF 1000 A FOR DURATIONS AS SHORT AS 15 *M*S. THE VOLTAGE MEASURED DURING A CURRENT PULSE WAS EXTRAPOLATED TO A TIME CORRESPONDING ROUGHLY TO ZERO ENERGY INJECTED IN THE SAMPLE. THE RESULTING I-V CURVES SHOW THAT, AS THE CURRENT INCREASES ABOVE ITS CRITICAL VALUE, THE SAMPLES GO FROM THE FLUX CREEP TO THE FLUX FLOW REGIME BEFORE TRANSITING TO AN OHMIC REGIME DIFFERENT FROM THE NORMAL STATE. A LARGE VOLTAGE IS MEASURED IN THE FLUX FLOW AND THE OHMIC REGIMES. ASSUMING THAT, WHEN OHMIC, THE SAMPLES ARE IN A VORTEX STATE, WE COULD REPRODUCE THE MEASURED VOLTAGES IN BOTH REGIMES. OUR ANALYSIS SHOWS THAT THE DISSIPATED POWER DEPENDS ON THE VORTEX VELOCITY AND THE VORTEX DENSITY. IN TURN, THE VORTEX VELOCITY DEPENDS MOSTLY ON THE SHUNT RESISTIVITY, AND THE VORTEX DENSITY DEPENDS ON THE MEAN CURRENT DENSITY IN THE COATED CONDUCTOR, I.E. ON THE THICKNESS OF THE SHUNT LAYER. FOR THE SAMPLES INVESTIGATED, THE OBSERVED POWER DISSIPATED DIFFERED BY A FACTOR OF MORE THAN 10, WHICH CAN BE ATTRIBUTED TO THE DIFFERENT SHUNT THICKNESSES.

4MB-07

CURRENT LIMITING PHENOMENA IN $SMBA_2CU_3O_{7-\Delta}$ COATED CONDUCTORS OBSERVED BY LASER-INDUCED THERMOELECTRIC IMAGING AND LOW-TEMPERATURE LASER SCANNING MICROSCOPY ***G. KIM***[1]*, A. MATSEKH*[2]*, M. INOUE*[2]*, T. KISS*[2]*, W. JO*[1]*, H. S. HA*[3]*, S. S. OH*[3]*;* [1]EWHA WOMANS UNIVERSITY, [2]KYUSHU UNIVERSITY, [3]KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE (KERI). — WE REPORT CURRENT-LIMITING BEHAVIORS IN $SMBA_2CU_3O_{7-\Delta}$ (SMBCO) COATED CONDUCTORS STUDIED BY LASER-INDUCED THERMOELECTRIC (LITE) IMAGING AND LOW-TEMPERATURE LASER SCANNING MICROSCOPY (LTLSM). COMBINING WITH THESE TWO TECHNIQUES, WE OBTAINED CLEAR CORRELATION BETWEEN LOCAL DISORDER AND SPATIALLY DISTRIBUTED FLUX FLOW DISSIPATION IN MICROMETER SCALE. THE CONDUCTORS WERE GROWN ON ION-BEAM ASSISTED DEPOSITION (IBAD) TEMPLATES WITH A DRUM-IN-DUAL-CHAMBER (EDDC) DEPOSITION SYSTEM. THE CONDUCTORS SHOWED CRITICAL TEMPERATURE OF 94 K AND CRITICAL CURRENT OF 120 ~ 200 A/CM-WIDTH AT 77K AND SELF-FIELD.

WE FABRICATED THE 100 MM WIDE AND 1MM LONG MICRO-METER BRIDGE ON THE SURFACE BEFORE THE EXPERIMENT USING PHOTOLITHOGRAPHIC TECHNIQUE AND CHEMICAL ETCHING PROCESS. IN LITE, WE HAVE VISUALIZED DIFFERENT PHASE AND THERMAL VOLTAGE RESPONSE AS INHOMOGENEOUS STRUCTURE AND GRAIN BOUNDARY AT ROOM TEMPERATURE. WE ALSO INVESTIGATED LOCAL FLUX FLOW DISSIPATION USING LTLSM BELOW CRITICAL TEMPERATURE. COMBINATION OF BOTH METHODS ALLOWS US TO IMAGING OF SPATIALLY RESOLVED TRANSPORT PROPERTIES IN SMBCO COATED CONDUCTORS, INDICATING THAT THE CURRENT FLOW IS AFFECTED BY DISTRIBUTION OF DEFECTS IN A UNIFORM MATRIX. IT HAS BEEN FOUND THAT LOCAL J_C IN THE UNIFORM AREA IS 25 % HIGHER THAN THE GLOBAL J_C THAT IS LIMITED BY THE LOCAL OBSTACLES.

THIS WORK WAS SUPPORTED BY THE "JAPAN-EAST ASIA NETWORK OF EXCHANGE FOR STUDENTS AND YOUTHS (JENESYS) PROGRAMME SCHOLARSHIP" AND "JSPS: KAKENHI (20360143)".

4MB-08

NON-DESTRUCTIVE MEASUREMENT OF CRITICAL CURRENTS AND E-J CHARACTERISTICS IN CYLINDRICAL (RE)BCO BULK SUPERCONDUCTORS ***Z. XU**, A. M. CAMPBELL, D. A. CARDWELL;* UNIVERSITY OF CAMBRIDGE. — THE CRITICAL CURRENT DENSITY J_C IS AN IMPORTANT PARAMETER FOR APPLICATIONS OF BULK HIGH TEMPERATURE SUPERCONDUCTORS (HTS), SUCH AS RE-BA-CU-O [(RE)BCO], IN HIGH FIELD, PERMANENT MAGNET-LIKE DEVICES. IT IS VERY DESIRABLE TO MEASURE J_C BY A NON-DESTRUCTIVE METHOD, SINCE IT CANNOT BE DEDUCED ACCURATELY FROM THE MAPPING OF TRAPPED FIELD GIVEN THAT A PARTICULAR DISTRIBUTION OF FIELD IN A BULK HTS MAY BE GENERATED BY MANY DIFFERENT DISTRIBUTIONS OF J_C. MOST METHODS TO-DATE, HOWEVER, INVOLVE CUTTING A SAMPLE INTO SMALL PIECES BEFORE MEASUREMENT IN A SQUID OR OTHER APPARATUS. THIS PAPER DESCRIBES A NON-DESTRUCTIVE METHOD OF DETERMINING THE MAGNITUDE OF J_C IN A CYLINDRICAL (RE)BCO BULK SUPERCONDUCTOR BY MEASURING THE INDUCED VOLTAGE USING A PICK-UP COIL UNDER THE APPLICATION OF MAGNETIC PULSES ON TOP OF A BACKGROUND FIELD. THE MAGNETIC FIELD DEPENDENCE OF J_C IS OBTAINED BY VARYING THE BACKGROUND FIELD WHILE THE *E-J* CHARACTERISTIC CAN BE DERIVED FROM THE FREQUENCY VARIATION OF THE APPLIED PULSES. IN ADDITION, SIMULATIONS ARE CONDUCTED USING A THEORETICAL MODEL, AND THE RESULTS ARE IN GOOD AGREEMENT WITH THOSE OBSERVED EXPERIMENTALLY. THIS METHOD, ALONG WITH THE EXPERIMENTAL RESULTS, PROVIDES INSIGHT INTO THE PROCESS OF MAGNETIZATION IN BULK HTS OF CYLINDRICAL AND OTHER GEOMETRIES AND ENABLES OPTIMIZATION OF THE PROFILE OF MULTI-PULSE MAGNETIZATION IN ORDER TO ACHIEVE THE MAXIMUM TRAPPED FIELD.

THE AUTHORS ACKNOWLEDGE MR TONY DENNIS FOR HIS KIND HELP DURING THE SET-UP OF THE EXPERIMENTAL DEVICES.

4MB-09

PROBING LOCALIZED DAMAGE IN QUENCHED YBA2CU3OX COATED CONDUCTORS USING FORENSIC METHODS ***H. SONG**[1], Y. XIN[2], F. HUNTE[3], J. SCHWARTZ[3];* [1]ASC/NHMFL/FSU, [2]NHMFL/FSU, [3]MSE, NCSU. — TO UNDERSTAND THE FAILURE MECHANISMS DURING QUENCHING, YBA2CU3OX (YBCO) COATED CONDUCTORS FROM SUPERPOWER INC ARE QUENCHED SUCH THAT THE CRITICAL CURRENT IS DEGRADED BY VARYING AMOUNTS AND THE MICROSTRUCTURE IS LOCALLY EVALUATED IN THE DEGRADED ZONES. TO EVALUATE THE MICROSTRUCTURES, THE CU AND AG LAYERS ARE ETCHED FROM BOTH UNQUENCHED WITNESS SAMPLES AND QUENCHED. IN THE WITNESS SAMPLES, THE YBCO LAYER IS FOUND TO HAVE SOME POROSITY AND A FEW DISTRIBUTED PARTICLES IN AND ABOVE THE YBCO SURFACE. TWO TYPES OF QUENCHED SAMPLES ARE PREPARED. ONE QUENCHED SAMPLE IS ONLY SLIGHTLY DEGRADED (NEARLY 2% REDUCTION IN LOCAL SECTION IC) AND THE OTHER WAS SIGNIFICANTLY DAMAGED. IN THE SLIGHTLY DEGRADED SAMPLE, LOCAL DAMAGE AREAS ARE FOUND WITH A SIGNIFICANT IN TERMS OF MICROSTRUCTURAL APPEARANCE WHICH IS LIKELY DUE TO INHOMOGENEOUS HEAT DEPOSIT FROM THE QUENCH HEATER. IN THE SIGNIFICANTLY DEGRADED SAMPLE THREE TYPES OF LOCALIZED DAMAGE ARE OBSERVED. FIRST, DAMAGE INDUCED BY NORMAL ZONE PROPAGATION FROM THE CENTRAL HEATER IS OBSERVED USING INLENSE IN SEM ANALYSIS. THE OTHER TWO TYPES OF LOCAL DAMAGE ARE BELIEVED TO ORIGINATE FROM PRE-EXISTING DEFECTS IN THE YBCO STRUCTURE AND FROM LINEAR DEFECTS EXISTING AT THE SAMPLE EDGE. THUS, PRE-EXISTING DEFECTS MAY PLAY AN IMPORTANT ROLE IN QUENCH-INDUCED DEGRADATION AND THUS THE REQUIRED QUENCH PROTECTION LIMITS.

THIS WORK PARTIALLY SUPPORTED BY THE AIR FORCE RESEARCH LABORATORY. THE AUTHORS ARE GRATEFUL TO SUPPORT FROM ULF P. TROCIEWITZ AND DAVID C. LARBALESTIER, AND DISCUSSIONS WITH MANY PEOPLE IN ASC/NHMFL.

4MC-01

CALORIMETRIC INVESTIGATION OF NB_3SN AND NB_3AL WIRES FOR THE NEXT GENERATION OF ACCELERATOR MAGNETS ***C. SENATORE**[1], R. FLÜKIGER[1], T. BOUTBOUL[2], L. OBERLI[3], K. TSUCHIYA[4], T. TAKEUCHI[5];* [1]DEPARTMENT OF CONDENSED MATTER PHYSICS AND MANEP/NCCR, UNIVERSITY OF GENEVA, [2]FUSION FOR ENERGY, [3]CERN, [4]HIGH ENERGY ACCELERATOR RESEARCH ORGANIZATION, KEK, [5]NATIONAL INSTITUTE FOR MATERIALS SCIENCE, NIMS. — POWDER IN TUBE (PIT) NB_3SN AND RAPID HEATING, QUENCHING AND TRANSFORMATION (RHQT) PROCESSED NB_3AL WIRES ARE CURRENTLY BEING DEVELOPED AS CANDIDATES FOR FUTURE USE IN HIGH FIELD (≥ 15T) ACCELERATOR MAGNETS.FOR PIT NB_3SN WIRES, HEAT TREATMENT OPTIMIZATION STUDIES WERE PERFORMED AND THE HIGHEST CRITICAL CURRENT WAS ACHIEVED FOR A LOW TEMPERATURE/LONG DURATION HEAT TREATMENT (625°C/320H). IN THE PRESENT WORK, THE INFLUENCE OF THE

HEAT TREATMENT CONDITIONS ON THE SUPERCONDUCTING PROPERTIES IS INVESTIGATED BY HIGH FIELD SPECIFIC HEAT MEASUREMENTS. IN PARTICULAR WE DETERMINED THE FIELD DEPENDENCE OF THE CALORIMETRIC T_C DISTRIBUTION IN THE A15 LAYER FOR THE STANDARD REACTION SCHEDULE (675°C/84H) AND FOR THE OPTIMIZED HEAT TREATMENT (625°C/320H). FOR THE LATTER WE WERE ABLE TO DISTINGUISH TWO SEPARATE CONTRIBUTIONS IN THE T_C DISTRIBUTION: A NARROW PEAK DETERMINED BY THE COARSE GRAINS AND A BROAD PEAK DUE TO THE FINE GRAINS.FOR RHQT NB_3AL WIRES, TA MATRIX WAS INTRODUCED IN REPLACEMENT OF THE NB MATRIX IN ORDER TO IMPROVE THE MECHANICAL PROPERTIES AND MAGNETIC STABILITIES. WE PRESENT FOR THE FIRST TIME THE T_C DISTRIBUTION AND ITS FIELD DEPENDENCE FOR NB_3AL WIRES WITH BOTH TA AND NB MATRIX. THE OBSERVED DIFFERENCES IN THE TRANSPORT PROPERTIES ARE INTERPRETED ON THE BASIS OF THE PRESENT CALORIMETRIC DATA.

4MC-02

STRUCTURE AND PERFORMANCE OF NB_3SN SUPERCONDUCTING WIRES PREPARED FROM SN-BASED ALLOY SHEETS ***K. TACHIKAWA***[1]*, T. ANDO*[1]*, H. SASAKI*[1]*, M. YAMAGUCHI*[1]*, T. TAKEUCHI*[2]*;* [1]TOKAI UNIVERSITY, [2]NATIONAL INSTITUTE FOR MATERIALS SCIENCE. — SN-TA, SN-B AND SN-NB BASED ALLOY BUTTONS HAVE BEEN PREPARED BY THE REACTION AMONG CONSTITUENT METAL POWDERS AT 650°-775°C. THE BUTTONS WERE PRESSED TO PLATES AND THEN ROLLED TO THIN SHEETS. THESE SHEETS EXHIBIT SIMILAR MICROSTRUCTURES, IN WHICH A SMALL AMOUNT OF TI ADDITION IMPROVES THE BONDING OF TA, B AND NB PARTICLES AGAINST SN MATRIX. THE SHEET WAS LAMINATED WITH A NB SHEET AND WOUND INTO A JELLY ROLL COMPOSITE. THE COMPOSITE WAS FABRICATED INTO A WIRE AND THEN HEAT TREATED. THICK NB_3SN LAYERS WITH NEARLY STOICHIOMETRIC A15 COMPOSITION ARE SYNTHESIZED BY THE MUTUAL DIFFUSION BETWEEN NB AND SN-BASED ALLOY SHEETS, WHICH PROVIDES SUFFICIENT SN. IN THE RESULTING WIRES, AN OFFSET T_C OF ~18.1K AND AN OFFSET B_{C2} (4.2K) OF ~ 26.5T HAVE BEEN OBTAINED. A NON-CU J_C OF ~125A/MM^2 HAS BEEN ACHIEVED AT 22T AND 4.2K. SWIFT WIRE FABRICATION IS POSSIBLE WITH NO INTERMEDIATE ANNEALING, WHICH IS ANOTHER ADVANTAGE OF THE PRESENT PROCESS. IN THIS REPORT MICROSTRUCTURE AND HIGH-FIELD PERFORMANCE OF NB_3SN WIRES USING SN-TA, SN-B AND SN-NB SHEETS ARE EVALUATED AND COMPARED.

4MC-03

LONGITUDINAL AND TRANSVERSE CROSS-SECTIONAL MICROSTRUCTURE AND CRITICAL CURRENT DENSITY IN NB3SN SUPERCONDUCTORS ***I. PONG***[1]*, C. SCHEUERLEIN*[1]*, L. OBERLI*[1]*, C. SENATORE*[2]*, L. BOTTURA*[1]*;* [1]CERN, [2]UNIVERSITY OF GENEVA. — THE LONGITUDINAL AND TRANSVERSE CROSS-SECTIONAL MICROSTRUCTURE AND COMPOSITION OF SEVERAL TYPES OF NB3SN STRANDS HAVE BEEN SYSTEMATICALLY INVESTIGATED USING FEGSEM FRACTOGRAPHY AND EDS, AND THEIR CRITICAL CURRENT DENSITIES AS A FUNCTION OF MAGNETIC FIELD HAVE BEEN COMPARED. WE WILL REPORT OUR OBSERVATION THAT CERTAIN COARSE GRAINED STRUCTURE SEEMS TO BE RELATED TO THE LOCATION OF THE FILAMENTS WITH RESPECT TO THE SUBELEMENTS AND TO THE STRAND. IT IS ALSO OBSERVED THAT THE CONVENTIONAL TRANSVERSE CROSS-SECTIONAL MICROSTRUCTURE IS NOT ALWAYS REPRESENTATIVE OF THE STRAND, AS SOME NB3SN GRAINS HAVE HIGH ASPECT RATIOS AND THE MICROSTRUCTURE MAY CHANGE ALONG THE LONGITUDINAL DIRECTION. VARIOUS TERNARY PHASES HAVE BEEN OBSERVED AND WILL BE REPORTED. IT APPEARS THAT IN HIGH-SN CONTENT NB3SN CONDUCTORS INVESTIGATED IN THIS PAPER, THE STRAND'S GLOBAL COMPOSITION HAS RELATIVELY WEAK INFLUENCE ON THE CRITICAL CURRENT DENSITY, ALTHOUGH THE LOCAL STOICHIOMETRY MAY HAVE STRONGER INFLUENCE DUE TO ITS EFFECT ON, AMONG OTHER FACTORS, MICROSTRUCTURE. THE INTER-FILAMENTARY MICROSTRUCTURE AND TERNARY PHASE DEVELOPMENT, IN ADDITION TO THE NB3SN FILAMENTARY MICROSTRUCTURE, APPEAR TO HAVE A SIGNIFICANT INFLUENCE ON THE CRITICAL CURRENT DENSITY.

4MC-04

ELECTRON BACKSCATTER DIFFRACTION ANALYSIS ON NB_3AL AND NB_3SN MULTIFILAMENTS ***T. TAKEUCHI***[1]*, K. TSUCHIYA*[2]*, N. BANNO*[1]*, A. KIKUCHI*[1]*, Y. IIJIMA*[1]*;* [1]NATIONAL INSTITUTE FOR MATERIALS SCIENCE, [2]HIGH ENERGY ACCELERATOR RESEARCH ORGANIZATION. — THE FRACTURED CROSS-SECTION TECHNIQUE (FRACTOGRAPHY) USED TO DETERMINE GRAIN SIZE IN NB_3SN FILAMENTS IS NOT APPLICABLE TO THE RHQT (RAPID HEATING, QUENCHING AND TRANSFORMATION) NB_3AL FILAMENTS, SINCE TRANSGRANULAR FRACTURE IS DOMINANT. THE ELECTRON BACKSCATTER DIFFRACTION (EBSD) IS A TECHNIQUE FOR OBTAINING CRYSTALLOGRAPHIC INFORMATION INCLUDING GRAINS FROM SAMPLES IN THE FESEM AND HAS ADVANTAGES OVER TEM IN EASE OF SPECIMEN PREPARATION AND THAT LARGE AREAS CAN BE SELECTIVELY EXAMINED. THUS, WE HAVE ESTIMATED THE GRAIN SIZE OF NB_3AL USING EBSD TO BE CORRELATED WITH CRITICAL CURRENT DENSITIES. THE PLASTIC DEFORMATION OF BCC SUPERSATURATED-SOLID SOLUTION $NB(AL)_{SS}$ WAS FOUND TO REFINE THE GRAIN SIZE OF $NB(AL)_{SS}$ AND THE RESULTANT NB_3AL; THE GRAIN SIZE DISTRIBUTION BECAME NARROW AND SHIFTED TO THE FINER. THE BRONZE-ROUTE NB_3SN FILAMENTS WERE ALSO EXAMINED USING FRACTOGRAPHY AND THE EBSD TECHNIQUE, AND THE GRAIN SIZE DISTRIBUTIONS, TEXTURES, AND MISORIENTATION MAPS WERE COMPARED WITH THOSE OF NB_3AL.

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4MC-05

NEW DEVELOPMENTS IN NB_3SN PIT STRAND, THE EFFECT OF SECOND PHASE ADDITIONS ON THE SUPERCONDUCTING PROPERTIES ***L. R. MOTOWIDLO****;* SUPRAMAGNETICS, INC.. — A NEW KIND OF DESIGN FOR NB_3SN STRAND IS STUDIED. THE STRAND HAS A SINGLE STACK DESIGN WITH 120 OCTAGONAL

PIT SUBELEMENTS. THIS DESIGN ALLOWS THE INCORPORATION OF HIGH STRENGTH COMPONENTS UNIFORMLY DISPERSED AMONG THE PIT SUBELEMENTS. IN THIS WORK, THE EFFECT OF SECOND PHASE ADDITIONS OF YTTRIUM AND GADOLINIUM ON THE MICROSTRUCTURE, THE CRITICAL CURRENT DENSITY, AND STRAIN ARE REPORTED FOR PIT NB_3SN STRAND WITH 120 SUBELEMENTS. IN THIS PAPER, WE COMPARE THE CRITICAL CURRENT AND STRAIN PROPERTIES OF THE NEW PIT CONDUCTOR DESIGN WITH CONVENTIONAL PIT CONDUCTOR DESIGNS.

THIS WORK WAS FUNDED BY A DOE HEP SBIR

4MC-06

STOICHIOMETRY AND MORPHOLOGY STUDIES OF THE MICROSTRUCTURES OF TUBE TYPE NB_3SN STRANDS ***D. PUTNAM***[1]*, M. SUMPTION*[1]*, X. PENG*[2]*, M. TOMSIC*[2]*, T. COLLINGS*[1]*;* [1]THE OHIO STATE UNIVERSITY, [2]HYPER TECH RESEARCH, INC.. — A MODEL HAS BEEN DEVELOPED FOR THE PHASE FORMATION PROGRESSION IN TUBE TYPE NB_3SN CONDUCTORS. THIS MODEL PREDICTS THE COARSE GRAIN AND FINE GRAIN AREAS AND THUS THE RELATIONSHIP BETWEEN NON-CU AND LAYER J_C FOR THESE CONDUCTORS. IN THIS WORK THE MODEL IS COMPARED TO EXPERIMENTAL OBSERVATIONS MADE FOR REACTIONS OF TUBE TYPE STRANDS AT SEVERAL REACTION TEMPERATURES, AND FOR VARIOUS STARTING CU/SN RATIOS. THE STRANDS CHOSEN HAD VARYING CU/SN STATING RATIOS, AND WERE REACTED AT TEMPERATURES FROM 615C-750C FOR VARIOUS TIMES. THE RATIO OF COARSE GRAIN TO FINE GRAIN WAS COMPARED AS A FUNCTION OF TEMPERATURE AS WELL AS A FUNCTION OF THE RATIO OF CU/SN, AND THIS WAS COMPARED TO THE EXPECTED LIMITS FROM THE BINARY PHASE DIAGRAMS. EDS WAS USED TO DETERMINE THE LOCAL SN CONTENT IN THE CU-SN LAYER AT TIMES APPROACHING THE COMPLETION OF THE 6:5 AND THEN A15 REACTIONS, IN ORDER TO INFORM THE MODEL. THE NATURE OF THE 6:5 GROWTH AT THE CU-SN/6:5 INTERFACE WAS CLOSELY INVESTIGATED TO DEVELOP A LOCAL MODEL FOR THE FORMATION PROCESS AT THIS BOUNDARY. CROSS-SECTIONAL AND LONGITUDINAL SEM IMAGES WERE TAKEN AT THE POINT WHERE NB_6SN_5 HAD REACHED ITS MAXIMAL EXTENT AND AT THE COMPLETION OF A15 FORMATION IN ORDER TO OBSERVE THE 3-D MORPHOLOGY OF THE 6:5 AND THE COARSE GRAIN A15.

4MC-07

THE EFFECTS OF VARIABLE SN CONTENT ON THE PROPERTIES OF A15 SUPERCONDUCTING NB_3SN ***J. ZHOU****, Y. JO, Z. SUNG, P. LEE, D. LARBALESTIER;* NHMFL-ASC, FSU. — NB_3SN STRAND IS CLOSE TO THE LIMITS DEFINED BY ITS UPPER CRITICAL FIELD AND THE COMPOSITION GRADIENTS (THE A15 PHASE EXISTS OVER THE RANGE 18-25AT% SN) THAT OCCUR IN ALL PRACTICAL CONDUCTORS. THUS IT IS IMPORTANT TO KNOW THE VARIATION OF M_0H_{C2} WITH COMPOSITION. PREVIOUSLY, NO SINGLE SET OF SAMPLES, FROM WHICH M_0H_{C2} COULD BE UNAMBIGUOUSLY DEDUCED, EXISTED. TO ADDRESS THIS ISSUE AND SOME RECENT UNCERTAINTIES ABOUT THE BREADTH OF THE A15 PHASE FIELD, WE HAVE CAREFULLY FABRICATED BULK SAMPLES FROM ELEMENTAL POWDERS USING A HOT ISOSTATIC PRESS. THE MICROSTRUCTURAL AND MICROCHEMICAL PROPERTIES WERE EVALUATED BY XRD, SEM AND EDS. TRANSPORT, SPECIFIC HEAT AND MAGNETIZATION MEASUREMENTS ENABLED US TO COMPARE AVERAGE PROPERTIES TO THE MORE OFTEN APPLIED PERCOLATIVE RESULTS OBTAINED FROM TRANSPORT MEASUREMENTS OF M_0H_{C2}. THESE MEASUREMENTS INDICATE THAT THESE ARE THE MOST HOMOGENEOUS SAMPLES YET PRODUCED. AN UNEXPECTED AND IMPORTANT DISCOVERY WAS THAT HIGHER SN CONTENT SAMPLES (≥24.5%SN), WHILE UNDERGOING THE CUBIC TO TETRAGONAL PHASE TRANSITION AT ~44 K, DO NOT SUFFER ANY $M_0H_{C2}(0)$ DEGRADATION BELOW 30 T, AS IS GENERALLY ACCEPTED IN LITERATURE DATA COMPILATIONS (WHICH GENERALLY REPORT THAT $M_0H_{C2}(0)$ FALLS TO ~ 25 T AS THE COMPOSITION APPROACHES STOICHIOMETRY).

THE WORK IS SUPPORTED BY THE U.S. DEPARTMENT OF ENERGY UNDER CONTRACT NO. DE-FG02-06ER54881 AND DE-FG02-07ER41451. HIGH FIELD MAGNET MEASUREMENTS WERE SUPPORTED BY NSF/DMR-0084173 AND BY THE STATE OF FLORIDA. A. POLYANSKII, W. STARCH, V. GRIFFIN, M.

4MC-08

ANALYSIS OF THE STRAIN SENSITIVITY OF NB3SN BULK AND THIN FILM MODEL SAMPLES ***M. G. T. MENTINK***[1]*, A. ANDERS*[1]*, M. M. J. DHALLE*[2]*, D. R. DIETDERICH*[1]*, A. GODEKE*[1]*, W. GOLDACKER*[3]*, D. PUTNAM*[4]*, J. L. SLACK*[1]*, M. D. SUMPTION*[4]*, H. H. J. TEN KATE*[2]*;* [1]LAWRENCE BERKELEY NATIONAL LABORATORY, BERKELEY, CA, [2]FACULTY OF SCIENCE AND TECHNOLOGY, UNIVERSITY OF TWENTE, THE NETHERLANDS, [3]KARLSRUHE INSTITUTE OF TECHNOLOGY, KARLSRUHE, GERMANY, [4]CENTER FOR SUPERCONDUCTING AND MAGNETIC MATERIALS, OHIO STATE UNIVERSITY, OH. — STRAIN HAS A PRONOUNCED EFFECT ON THE SUPERCONDUCTING TRANSPORT PROPERTIES OF NB_3SN, BUT DISTINGUISHING EXPERIMENTS TO INVESTIGATE THE FUNDAMENTAL BASIS ARE LACKING. THE MAIN REASON FOR THE DEFICIT IS THE INEVITABLE PRESENCE OF INHOMOGENEITIES IN THE A15 PHASE COMPOSITION AND MORPHOLOGY IN TECHNOLOGICAL CONDUCTORS. THE PROBLEM CAN BE MITIGATED THROUGH STUDIES OF WELL-DEFINED MODEL SAMPLES. WE THEREFORE INITIATED THE FABRICATION OF PURE BULK AND THIN FILM SAMPLES WITH SYSTEMATIC VARIATION OF THE COMPOSITION. THE FIRST RESULTS AND ANALYSIS OF STRAIN EXPERIMENTS ON BULK AND THIN FILM SAMPLES ARE PRESENTED AND COMPARED TO TYPICAL WIRE BASED BEHAVIOR. DETAILED INVESTIGATION OF THE STRAIN SENSITIVITY OF MODEL SAMPLES CAN HELP TO UNRAVEL STRAIN SENSITIVITY DIFFERENCES IN WIRES AND SUGGEST WAYS TO REDUCE THE STRAIN SENSITIVITY OF NB_3SN SUPERCONDUCTORS IN GENERAL.

THIS WORK WAS PARTLY SUPPORTED BY THE DIRECTOR, OFFICE OF SCIENCE, HIGH ENERGY PHYSICS, U.S. DEPARTMENT OF ENERGY UNDER CONTRACT NO. DE-AC02-05CH11231

4MPA-02

AC TRANSPORT LOSS OF COATED CONDUCTORS IN ANTI-PARALLEL ARRANGEMENT ***F. GÖMÖRY****, J. SOUC, M. VOJENCIAK;* SLOVAK ACADEMY OF SCIENCES. — AC LOSS IN TWO STACKED COATED CONDUCTORS (CC) CARRYING OPPOSITE CURRENTS WAS INVESTIGATED BY EXPERIMENTS AND NUMERICAL SIMULATIONS. THIS ARRANGEMENT IS A PROMISING OPTION IN THE DESIGN OF FAULT CURRENT LIMITER (FCL) BECAUSE THE TRANSPORT CURRENT LOSS COULD BE SIGNIFICANTLY LOWER THAN IN THE SELF-FIELD CONFIGURATION OF ONE SINGLE TAPE.THE REQUIREMENTS OF NORMAL-STATE RESISTANCE INDICATE THAT IN THE PARTICULAR CC TAPE DEVELOPED FOR FCL APPLICATION THE METALLIC STABILISING LAYER SHOULD BE LESS THAN ~10 MM. CONSIDERING THE ELECTRIC STRENGTH OF UP-TO-DATE INSULATIONS THIS LEADS TO ~ 100 MM DISTANCE BETWEEN SUPERCONDUCTING LAYERS. OUR STUDY SHOWS HOW SENSITIVELY DEPENDS THE LOSS ON THIS QUANTITY. EVEN IN THE CASE OF COATED CONDUCTORS PREPARED ON FERROMAGNETIC SUBSTRATE A SUBSTANTIAL REDUCTION OF THE SUBSTRATE LOSS CAN BE ACHIEVED BY PUTTING THE TAPES IN CLOSE PROXIMITY WITH SUPERCONDUCTING LAYERS FACING EACH OTHER FROM MINIMUM DISTANCE.ANOTHER FACTOR INFLUENCING THE AC LOSS IS THE VARIATION OF CRITICAL CURRENT DENSITY ACROSS THE TAPE WIDTH. THEN THE COMPARISON OF CALCULATED AND MEASURED LOSS DATA ALLOWS TO ASSESS THE TAPE QUALITY IN A NON-DESTRUCTIVE WAY.

4MPA-03

MAGNETIC AND TRANSPORT AC LOSSES IN HTS ROEBEL CABLE ***N. J. LONG***[1]*, L. S. LAKSHMI*[1]*, M. P. STAINES*[1]*, Z. JIANG*[1]*, R. A. BADCOCK*[1]*, K. P. THAKUR*[1]*, J. EMHOFER*[2]*;* [1]INDUSTRIAL RESEARCH LTD, [2]VIENNA UNIVERSITY OF TECHNOLOGY. — WE PRESENT RESULTS FOR MAGNETIC AND TRANSPORT AC LOSSES IN HTS ROEBEL CABLE MANUFACTURED FROM COATED CONDUCTOR TAPE. WE DISCUSS THE PROBLEM OF DISTINGUISHING COUPLING LOSSES FROM HYSTERETIC LOSSES FOR CABLES OF COATED CONDUCTORS WHERE INTRINSIC FREQUENCY DEPENDENT LOSSES IN THE SUPERCONDUCTOR CAN BE OBSERVED. PRELIMINARY RESULTS FOR CABLE SAMPLES COUPLED BY SOLDER CONTACTS ARE PRESENTED. RESULTS FOR THE DEPENDENCE OF MAGNETIC LOSS WITH THE ANGLE OF AN EXTERNAL FIELD SCALE SIMPLY WITH THE FIELD ANGLE WHEN NO MAGNETIC COMPONENTS ARE PRESENT. WE SHOW THAT TRANSPORT LOSSES CAN BE AFFECTED BY ARCHITECTURE CHANGES AND PRESENT MODELLING RESULTS TO SUPPORT THIS CONCLUSION.

4MPA-04

STUDIES OF IC AND AC TRANSPORT LOSS FOR THE MULTI-LAYERED 2G HTS TAPES USED IN AN ELECTRIC MACHINE ***R. PEI;*** CAMBRIDGE UNIVERSITY. — THIS PAPER PRESENTS METHODS FOR CALCULATION AND EXPERIMENTAL STUDY OF CRITICAL CURRENT AND AC LOSS ANALYSIS FOR SINGLE AND MULTI-LAYERED TAPES. THE DATA HAS BEEN COLLECTED USING 2G YBCO TAPES FROM AMSC AND SUPERPOWER, INC.WE INTRODUCE A NEW SYNCHRONOUS MOTOR DESIGNED AND FABRICATED FROM TWO HTS PANCAKE-COILS WOUND FROM 2G HTS TAPES AND 4 COPPER COILS ON THE STATOR, WHILE THE ROTOR CONTAINS 75 BULK HTS ELEMENTS. ALL SUPERCONDUCTING MATERIALS ARE COOLED BY LIQUID NITROGEN (77K). THE 3-PHASE HTS AND COPPER ARMATURE IS MOUNTED IN THE SLOTS OF A NONMAGNETIC AND INSULATING MATERIAL. EACH PHASE WINDING, FABRICATED IN THE FORM OF A PANCAKE-COIL, IS DISTRIBUTED IN SLOTS AS 60-DEGREE INTERVALS. YBCO MELT-TEXTURED PUCKS WERE INCORPORATED INTO THE ROTOR AND THE RELUCTANCE WAS TESTED.THE RACE-TRACK HTS COIL WILL BE PRESENTED, INCLUDING IT GEOMETRY STRUCTURE AND BENDING DEGREES IN RACE-TRACK SHAPE. IN ADDITION, A CRITICAL CURRENT AND AC TRANSPORT LOSS MEASUREMENT SYSTEM IS DESCRIBED. IT IS ABLE TO MEASURE DIFFERENT AC LOSS RESULTS FOR BENDED, MULTI-LAYERED AND JOINTED TAPES.FINALLY, THE BASIC PRINCIPLE AND ALGORITHM FOR CALCULATION AND MEASUREMENT OF IC AND AC TRANSPORT LOSS WILL BE EXPLAINED. BY COMPARING ANALYTICAL CALCULATIONS, MODELING CALCULATION AND EXPERIMENTAL DATA, WE FIND HOW IC GRADUALLY CHANGES BASED ON THE DIFFERENT STACKED CONDITIONS, AS WELL AS GIVING ANALYSIS FOR THE AC TRANSPORT LOSSES.

4MPA-05

INFLUENCE OF REPEATED MECHANICAL STRESSES ON AC MAGNETIZATION LOSSES IN MULTI-FILAMENTARY BI2223/AG-SHEATHED WIRES ***T. OJIMA***[1]*, T. UNO*[1]*, S. MITSUI*[1]*, T. TAKAO*[1]*, O. TSUKAMOTO*[2]*, T. MIMURA*[3]*;* [1]FACULTY OF SCIENCE AND TECHNOLOGY SOPHIA UNIVERSITY, TOKYO, JAPAN, [2]OFFICE OF INDUSTRY AND COMMUNITY LIAISON ENGINEERING YOKOHAMA NATIONAL UNIVERSITY, YOKOHAMA, JAPAN, [3]SUPERCONDUCTIVITY TECHNOLOGY GROUP, R&D CENTER, TOKYO ELECTRIC POWER COMPANY, TOKYO JAPAN. — AC LOSSES IN SUPERCONDUCTORS ARE THE MAJOR LOSSES GENERATED IN HTS AC POWER APPARATUSES, E.G. POWER CABLES AND TRANSFORMERS AND DIRECTLY AFFECT THEIR EFFICIENCY AND ECONOMIC FEASIBILITY. THEREFORE, IT IS IMPORTANT TO KNOW AC LOSS CHARACTERISTICS OF HTS WIRES. HTS WIRES IN THE APPARATUSES ARE SUBJECTED TO REPEATED MECHANICAL STRESSES CAUSED BY THERMAL CONTRACTION AND ELECTROMAGNETIC FORCES. REPEATED MECHANICAL STRESSES CAUSE DEGRADATION OF THE CRITICAL CURRENTS AND MAY INFLUENCE AC LOSS CHARACTERISTICS. IN THE PREVIOUS WORK, WE STUDIED INFLUENCE OF REPEATED STRESSES ON AC TRANSPORT CURRENT LOSSES IN TWO KINDS OF MULTI-FILAMENTARY BI2223/AG-SHEATHED WIRES FOR AC POWER CABLES, TWISTED AND NON-TWISTED AND IN THIS WORK WE INVESTIGATE THAT ON AC MAGNETIZATION LOSSES. REPEATED UNI-AXIAL TENSILE STRESSES WERE APPLIED TO THE WIRES IN THE LONGITUDINAL DIRECTION AND MAGNETIZATION LOSSES WERE MEASURED ELECTRICALLY AT 77K. IT WAS FOUND THAT MANNERS OF DEPENDENCE OF AC MAGNETIZATION LOSSES AND AC TRANSPORT CURRENT LOSSES ON WIRE CRITICAL CURRENTS WHICH WERE DEGRADED BY REPEATED MECHANICAL STRESSES WERE DIFFERENT. IN THE PAPER DIFFERENCES ARE INVESTIGATED AND EXPLAINED BY DIFFERENCES IN DISTRIBUTIONS OF

MAGNETIZATION AND TRANSPORT CURRENTS AROUND CRACKS IN SUPERCONDUCTORS WHICH ARE DEVELOPED AND GROWN BY THE REPEATED STRESSES.

BI2223/AG SHEATHED WIRES USED IN THE EXPERIMENT WERE SUPPLIED BY SUMITOMO ELECTRIC INDUSTRIES, LDT.

4MPA-06

STUDY ON METHOD TO SUPPRESS DECAY OF TRAPPED MAGNETIC FLUXES IN THE HTS BULK SUBJECTED TO PERTURBATION OF EXTERNAL MAGNETIC FIELD BY USE OF SHIELDING RING WOUND OF HTS WIRE ***K. YAMAGISHI***[1]*, O. TSUKAMOTO*[1]*, J. OGAWA*[2]*, D. MIYAGI*[3]*;* [1]YOKOHAMA NATIONAL UNIVERSITY, [2]NIIGATA UNIVERSITY, [3]OKAYAMA UNIVERSITY. — IT WAS FOUND IN OUR PREVIOUS WORK THAT TRAPPED MAGNETIC FLUXES IN HTS BULKS ARE DECAYED WHEN THE BULKS ARE SUBJECTED TO PERTURBATION OF EXTERNAL MAGNETIC FIELDS. THIS PHENOMENON IS INCONVENIENT FOR THE APPLICATIONS OF HTS BULKS, SUCH AS HTS BULK MOTORS AND MAGNETIC LEVITATION BEARINGS, BECAUSE IN THESE APPLICATIONS, THE BULKS ARE INEVITABLY SUBJECTED TO PERTURBATIONS OF THE EXTERNAL MAGNETIC FIELDS. THEREFORE, IT IS NECESSARY TO DEVELOP METHODS TO SUPPRESS THE DECAY. IT WAS PROVEN IN OUR PREVIOUS EXPERIMENTS ALSO THAT THE DECAY IS CAUSED BY TEMPERATURE RISES OF THE BULKS DUE TO AC LOSSES IN THE BULKS. THE PROPOSED A METHOD TO ATTACH A SHORTED SHIELDING RING WOUND OF HTS WIRE AROUND THE BULK TO REDUCE THE AC LOSSES IN THE BULK. IT WAS EXPERIMENTALLY PROVEN THAT AC LOSSES IN THE BULK WERE REDUCED AND THAT THE DECAY OF THE TRAPPED MAGNETIC FLUX WAS EFFECTIVELY SUPPRESSED BY THE SHIELDING RING. THE SHIELDING TIME CONSTANT OF THE RING SHOULD BE SMALLER THAN THE RISING TIME OF THE APPLIED MAGNETIC FIELD TO MAGNETIZE THE BULK AND LARGE ENOUGH TO SHIELD THE PERTURBATION OF THE EXTERNAL FIELD. IN THIS PAPER, OPTIMUM DESIGN METHOD OF THE SHIELDING RING IS INVESTIGATED COMPARING RESULTS OF A NUMERICAL SIMULATION OF ELECTRO-MAGNETIC BEHAVIOR WITH A SHIELDING RING AND AN EXPERIMENT.

THIS WORK WAS SUPPORTED IN PART BY MEXT GRANT-IN-AID FOR SCIENTIFIC RESEARCH (C) (21560292).

4MPA-08

MEASUREMENTS OF AC LOSSES IN BISCOO HTS COIL AT DIFFERENT FREQUENCIES USING ELECTRICAL METHOD ***S. BENDALI****;* GREEN-UHP. — NOWADAYS, THE INTEREST IN HTSS FOR USE IN ELECTRIC POWER APPLICATIONS IS HIGH. MANY APPLICATIONS WERE DEVELOPED: ELECTRICAL MOTOR, SMES AND TRANSFORMER. AN IMPORTANT ISSUE IN THE DESIGN OF HTS COILS IS RELATED TO THEIR AC LOSSES. INDEED, THEIR THERMAL PERFORMANCES HEAVILY DEPEND ON THESE LOSSES, SO IT IS IMPORTANT TO QUANTIFY THEM IN ORDER TO DESIGN THE REFRIGERATION SYSTEM.THIS PAPER PRESENTS AC LOSSES MEASUREMENTS UNDER SELF-FIELD CONDITIONS (SINUSOIDAL TRANSPORT CURRENT) OF A BI2223/AG-SHEATHED COIL AT DIFFERENT FREQUENCIES. THE TEST BENCH DEVELOPED FOR THIS PURPOSE INCLUDES A POWER AMPLIFIER ALLOWING VARIABLE FREQUENCIES BETWEEN 3 AND 50 HZ. THESE VALUES ARE WIDELY USED IN LARGE SCALE APPLICATIONS LIKE ELECTRICAL MACHINES. THE MEASUREMENTS WERE PERFORMED AT 77 K BY AN ELECTRICAL METHOD. THE INDUCTIVE PART OF THE VOLTAGE IS DIRECTLY COMPENSATED BY ANOTHER COPPER COIL. THE MEASUREMENT SYSTEM WILL BE DESCRIBED IN DETAIL.THE EXPERIMENTAL RESULTS SHOW THAT THE AC LOSSES HAVE A LINEAR DEPENDENCE ON THE CUBED VALUE OF THE CURRENT WHATEVER THE FREQUENCY. THIS MEANS THAT ONLY MAGNETIZATION LOSSES ARE PRESENT IN THE COIL FOR THE CONSIDERED CURRENT VALUES.

4MPB-01

INFLUENCE OF DC OFFSET TRANSPORT CURRENT ON AC LOSS CHARACTERISTICS IN HTS TAPES ***J. OGAWA****, S. FUKUI, T. OKA, T. SATO, H. KOJIMA, M. SHIBAYAMA, M. EGAWA;* NIIGATA UNIVERSITY. — IN SUPERCONDUCTING POWER INSTRUMENTS, THE HTS CONDUCTORS ARE IN A MIXED DC AND AC ELECTRO-MAGNETIC CONDITION BECAUSE OF THE DC TRANSPORT CURRENT VARIATION AND AC RIPPLE. THE MIXED DC AND AC ELECTRO-MAGNETIC CONDITION CONSISTS OF THE TRANSPORT CURRENT AND THE EXTERNAL MAGNETIC FIELD. MANY PAPERS REPORT THE AC LOSS CHARACTERISTICS, AND DC MAGNETIC FIELD AFFECTS ON THE AC LOSS CHARACTERISTICS AS THE CRITICAL CURRENT VARIATION. THEREFORE, WE REPORT THE LOSS IN A MIXED DC AND AC ELECTRO-MAGNETIC CONDITION WHICH CONSISTS OF DC TRANSPORT CURRENT, AC TRANSPORT CURRENT AND AC MAGNETIC FIELD. TO VERIFY THE ELECTRICAL MEASUREMENT METHOD UNDER DC AND AC MIXED CONDITIONS, THE LOSS WAS MEASURED BY THE CALORIMETRIC AND ELECTRICAL METHODS IN THE SAME SECTION. THE ELECTRIC MEASUREMENT RESULTS CORRESPONDED WITH THE CALORIMETRIC RESULTS. FROM THESE RESULTS, WE REPORT THE LOSS CHARACTERISTICS IN AN HTS TAPE UNDER MIXED DC AND AC ELECTRO-MAGNETIC CONDITIONS.

4MPB-02

EXPERIMENTAL AND ANALYTICAL STUDIES ON THE ENERGY LOSS OF A HTS COIL DURING CHARGING AND DISCHARGING CONDITION ***Y. HWANG****, K. CHANG, Y. KIM, S. CHOI, J. NA, S. CHU, T. KO;* YONSEI UNIVERSITY. — ONE OF THE IMPORTANT CHARACTERISTICS OF A SUPERCONDUCTING COIL FOR NUCLEAR MAGNETIC RESONANCE (NMR) SPECTROSCOPY IS THAT ENERGY DISSIPATION IS OCCURRED DURING RAMPING. IT IS BECAUSE THIS DISSIPATION IS THE LOAD OF THE COOLING SYSTEM. THEREFORE, IT IS NECESSARY TO DEAL WITH THE ENERGY DISSIPATION CHARACTERISTICS IN AN ASSEMBLED SUPERCONDUCTING COIL EXPERIMENTALLY. IN THIS WORK WE INVESTIGATED ENERGY LOSS OF A HIGH TEMPERATURE SUPERCONDUCTING COIL BY CHARGING AND DISCHARGING CURRENT. THE OPERATION OF THE HTS COIL WAS CONDUCTED IN LIQUID HELIUM AND THE LOSS WAS MEASURED BY A CALORIMETRIC METHOD. WE USED A FINITE ELEMENT METHOD TO PROVE VALIDITY OF MEASUREMENTS BY THE CALORIMETRIC METHOD. MEASURED DATA SHOW

THAT THE LOSS IS INFLUENCED BY CURRENT RAMPING. MOREOVER, IT VARIES WITH MAGNITUDE OF CHARGING CURRENT. PROPOSED RESULTS IN THIS PAPER WOULD BE UTILIZED TO OPERATE HTS INSERT COIL FOR A HIGH-FIELD NMR SPECTROSCOPY.

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4MPB-03

THE TEMPERATURE SCALING OF TRANSPORT AC LOSSES ACCORDING TO SUPERCONDUCTING TAPE ARRAY GEOMETRY

Y. HWANG[1], *K. CHANG*[1], *Y. KIM*[1], *S. CHOI*[1], *H. KIM*[1], *J. LEE*[2], *H. LEE*[2], *T. KO*[1]; [1]YONSEI UNIVERSITY, [2]KOREA UNIVERSITY. — BOTH AC TRANSPORT CURRENT AND MAGNETIC FIELD WHICH IS GENERATED BY AC TRANSPORT CURRENT LEAD TO ENERGY LOSS SO CALLED TRANSPORT AC LOSS IN POWER EQUIPMENTS USING SUPERCONDUCTING TAPES. THE TRANSPORT AC LOSS IS CLOSELY RELATED TO STABILITY AND EFFICIENCY OF SUPERCONDUCTING POWER EQUIPMENTS. THEREFORE, WE NEED TO DEAL WITH THE TRANSPORT AC LOSS CHARACTERISTICS OF THE SUPERCONDUCTING TAPES UNDER VARIOUS CONDITIONS. IN THIS WORK WE INVESTIGATED TEMPERATURE DEPENDENCE OF THE TRANSPORT AC LOSS WITH RESPECT TO SUPERCONDUCTING TAPE ARRAY GEOMETRY. THE TRANSPORT AC LOSS WAS MEASURED BY AN ELECTRICAL METHOD. THE EXPERIMENT WAS CONDUCTED AT TEMPERATURE FROM 65K TO 77K. WE PROVED VALIDITY OF MEASUREMENTS BY A FINITE ELEMENT METHOD. MEASURED DATA SHOW THAT THE TRANSPORT AC LOSS IS INFLUENCED BY NOT ONLY SUPERCONDUCTING TAPES ARRAY GEOMETRY BUT OPERATING TEMPERATURE. PROPOSED RESULTS IN THIS PAPER WOULD BE UTILIZED TO DESIGN SUPERCONDUCTING POWER EQUIPMENTS.

THIS RESEARCH WAS SUPPORTED BY NATIONAL RESEARCH LAB. PROGRAM THROUGH THE KOREA SCIENCE AND ENGINEERING FOUNDATION FUNDED BY THE MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY (R0A-2007-000-20063-0).

4MPB-04

YBCO COATED CONDUCTORS PATTERNED USING MICROCONTACT PRINTING

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4MPB-05

LOW LOSS NBTI SUPERCONDUCTING RUTHERFORD CABLE MANUFACTURE FOR THE SIS300 INFN MODEL DIPOLE

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4MPB-06

LOW LOSS MAGNESIUM DIBORIDE WIRES - DEVELOPMENT STATUS, AC LOSS MEASUREMENTS, AND SIMULATIONS WITH NUMERICAL METHODS

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THEREFORE, THIS WORK PRESENTS NEW TYPE OF WIRES WITH NONMAGNETIC MATRIX AND MULTI-FILAMENTARY STRUCTURE. IN THIS PAPER, AC LOSSES OF THREE DIFFERENT LOW LOSS SAMPLES ARE MEASURED IN EXTERNAL ALTERNATING MAGNETIC FIELD UP TO 100 MT AT VARIOUS FREQUENCIES FROM 0.1 HZ TO 144 HZ TO DETERMINE WHICH LOSS PART ARISE FROM THE SUPERCONDUCTOR AND WHICH PART IS RELATED TO COUPLING AND EDDY CURRENTS. MOREOVER, THE SAMPLES WERE MEASURED FROM 20 K UP TO OVER CRITICAL TEMPERATURE TO FIND OUT THE SOLE CONTRIBUTION OF EDDY CURRENTS. IN COMPARISON, THE SUPERCONDUCTOR'S LOSSES ARE COMPUTED WITH BRANDT'S METHOD AND FEM, WHICH ARE MODIFIED TO TAKE JC(B)-DEPENDENCE INTO ACCOUNT. FINALLY, THE COUPLING LOSSES ARE ESTIMATED BASED ON ANALYTICAL APPROACH.

4MPB-07

HYSTERESIS LOSS MEASUREMENTS FOR NBTI AND NB3SN WIRES ***H. GAO****, S. ZHU, J. LI, W. LIU, L. YAN, T. WANG, Y. FENG, X. LIU;* WESTERN SUPERCONDUCTING TECHNOLOGIES, CO. LTD; NATIONAL ENGINEERING LABORATORY FOR SUPERCONDUCTING MATERIALS PREPARATION. — NBTI AND NB_3SN ARE THE MOST WIDELY USED SUPERCONDUCTORS. THEY ARE COMMONLY APPLIED IN SUPERCONDUCTING MAGNET TO GENERATE A HIGH MAGNETIC FIELD, WHERE A HIGH LOSS EXISTING MAY CAUSE UNNECESSARY WASTE. THEREFORE, ESTIMATING THE LOSS BECOMES IMPORTANT TO JUDGE AN APPLIED SUPERCONDUCTOR. ON THE OTHER HAND, THE INFORMATION TRANSFERRED BY THE LOSSES, SUCH AS EFFECTIVE FILAMENT DIAMETER D_{EFF}, WILL HELP THE MANUFACTURER TO IMPROVE THEIR MANUFACTURE PROCESS.THE HYSTERESIS LOSSES OF NBTI AND NB_3SN COMPOSITE SUPERCONDUCTING WIRES HAVE BEEN STUDIED. THE SPECIMENS WERE MULTIFILAMENTARY ROUND WIRES WITH THE FILAMENTS JUST SEVERAL MICRONS. THE METHOD OF HYSTERESIS LOSS MEASUREMENT WAS INTRODUCED AND THE RESULT WAS REPORTED AS AN IMPORTANT ITEM TO ESTIMATE THE PERFORMANCE OF THE SUPERCONDUCTING WIRE. FURTHERMORE, THE EFFECTIVE FILAMENT DIAMETER D_{EFF} DETERMINED FROM THE MAGNETIZATION AND ITS CORRESPONDING CRITICAL CURRENTS WAS UTILIZED TO DETERMINE THE UNIFORMITY OF FILAMENT AND THE PRODUCING PROCESS.

THE AUTHORS GRATEFULLY ACKNOWLEDGE THE COLLABORATION OF YU WU, FANG LIU, FENG LONG ET AL. (IPP) AND YAN ZHANG (PKU) WHO HAVE PROVIDED THE IC AND MAGNETIZATION MEASUREMENTS.

4MPB-08

AC LOSS OF MGB_2 SUPERCONDUCTING WIRES IN VARIOUS TEMPERATURES ***S. CHOI****[1], T. KIYOSHI[1], J. KIM[2], S. DOU[2];* [1]NATIONAL INSTITUTE FOR MATERIALS SCIENCE, [2]UNIVERSITY OF WOLLONGONG. — A DISCOVERY OF SUPERCONDUCTIVITY IN MGB_2 HAS RAISED SIGNIFICANT INTEREST IN THE FIELD OF WIRE DEVELOPMENT. A STUDY FOR FURTHER IMPROVEMENT IN THE PROPERTIES OF MGB_2 HAS ACCELERATED AND RESULTED IN LARGE CURRENT CAPACITY AT HIGHER MAGNETIC FIELD. HOWEVER, THERE SEEMS TO BE MUCH ROOM TO ENHANCE THE CONDUCTOR PERFORMANCE, HENCE THE POTENTIAL OF MGB_2 WIRE IS GETTING HIGHER IN PRACTICAL APPLICATION. THE RESEARCH ON THE FAULT CURRENT LIMITER FOR POWER GRID AND MRI FOR BIO-MEDICAL INSTRUMENT USING MGB_2 HAS ALREADY TRIED IN SOME INSTITUTES AND COMPANY.UNDERSTANDING OF THE ELECTROMAGNETISM AND AC LOSS BEHAVIOUR OF MGB2 WIRES SHOULD BE INVESTIGATED IN TIME VARYING TRANSPORT CURRENT AND/OR EXTERNAL FIELD. A NUMERICAL METHOD IS PROPOSED TO CALCULATE THE AC LOSS OF MGB_2 WIRE. GOVERNING EQUATION WAS FORMULATED WITH MAGNETIC VECTOR POTENTIAL AND ELECTRIC SCALAR POTENTIAL, TAKING ACCOUNT OF NON-LINEAR E-J CHARACTERISTICS. ALSO, FIELD DEPENDENCE OF CRITICAL CURRENT OF RELEVANT MGB_2 WIRE WAS INCORPORATED INTO DEVELOPED NUMERICAL CODE. FOR THIS, WE MEASURED THE E-J CHARACTERISTICS ACCORDING TO THE EXTERNAL FIELD AS WELL AS VARIOUS TEMPERATURES. FIRSTLY, A COMPUTATION WAS CARRIED OUT WHEN AC TRANSPORT CURRENT WAS SUBJECTED INTO MGB_2 WIRES. THEN, WE EXAMINED THE AC MAGNETIZATION LOSS WAS CALCULATED ACCORDING TO EXTERNAL MAGNETIC FIELD. TEMPERATURE DEPENDENCE WAS STUDIED IN EACH AC LOSS CALCULATION.

4MPB-09

CALCULATION OF MAGNETIZATION LOSSES OF SUPERCONDUCTING COILS MADE OF MULTICORE MGB_2 CABLE ***A. MORANDI****, M. FABBRI;* UNIVERSITY OF BOLOGNA, DIE - DEPT. OF ELECTRICAL ENGINEERING, VIALE RISORGIMENTO 2, 40136 BOLOGNA, ITALY. — A NUMERICAL MODEL TO CALCULATE THE CURRENT DISTRIBUTION WITHIN A SINGLE TURN OF A VOLTAGE DRIVEN SUPERCONDUCTING COIL IS PRESENTED. THE TURN IS MADE OF A MULTI-CORE MGB_2 CABLE SUBJECT TO TRANSPORT CURRENT AND EXPOSED BY THE LOCAL MAGNETIC FIELD PRODUCED BY THE WHOLE COIL. THE MODEL, WHICH IS BASED ON THE INTEGRAL FORMULATION OF MAXWELL EQUATIONS, IS ABLE TO CALCULATE BOTH THE CURRENT SHARING BETWEEN THE SUPERCONDUCTING FILAMENTS AND THE STABILIZATION MATERIAL AND THE DETAIL OF CURRENT DISTRIBUTION WITHIN EACH SINGLE FILAMENT UNDER THE REALISTIC CONDITION OF MAGNETIC FIELD DEPENDENT CRITICAL CURRENT DENSITY. FURTHERMORE, LOSSES DUE TO HYSTERETIC MAGNETIZATION MAY BE DEDUCED FROM THE DETAIL OF CURRENT DISTRIBUTION AT EACH CYCLE OF THE MAGNETIC FIELD. THE PROPOSED MODEL IS USED TO INVESTIGATE THE AC LOSSES OCCURRING IN A COIL FOR FAULT CURRENT LIMITER APPLICATION SUBJECT TO DIFFERENT CURRENT CONDITIONS, INCLUDING AC REGIME AND DC REGIME WITH A RIPPLE SUPERIMPOSED.

4MX-01

(INVITED) **CROSSOVER FROM NANOROD LIKE VORTEX PINNING TO NANOPARTICLE LIKE PINNING IN THE YBCO FILMS WITH THE ENGINEERED ARTIFICIAL PINNING CENTERS** ***K. MATSUMOTO****[1], P. MELE[1], A. ICHINOSE[2], Y. YOSHIDA[3], M. MUKAIDA[4], R. KITA[5];* [1]KIT, [2]CRIEPI, [3]NAGOYA UNIV., [4]KYUSHU

UNIV., [5]SHIZUOKA UNIV.. — *JC* OF ONE-DIMENSIONAL ARTIFICIAL PINNING CENTERS (APCS) SUCH AS $BAZRO_3$, $BASNO_3$, $BA(Y_{0.5}NB_{0.5})O_3$ NANORODS DECREASES SIGNIFICANTLY WHEN THE MAGNETIC FIELD IS INCLINED FROM THE *C*-AXIS OF THE EPITAXIAL YBCO FILMS; IN CONTRAST, *JC* OF THREE-DIMENSIONAL APCS SUCH AS Y2O3 NANOPARTICLES IS HARDLY CHANGED. THESE BEHAVIORS DEPEND ON THE DIFFERENT MECHANISM OF VORTEX DEPINNING FROM APCS. IN THE CASE OF NANORODS, A STAIRCASE STATE OF THE VORTEX LINE COMES TO STABILIZE IN ENERGY AS THE DIRECTION OF THE MAGNETIC FIELD IS TILTED FROM THE C-AXIS; HOWEVER, THE ANGULAR DEPENDENCE OF THE PINNING ENERGY OF NANOPARTICLE IS MORE GRADUAL THAN THAT OF NANOROD. NANORODS CAN BE CHANGED INTO NANOPARTICLES BY CONTROLLING THE NANOROD LENGTH (8 NM - 120 NM IN THE PRESENT EXPERIMENT) BY THE TARGET EXCHANGE METHOD. THE AVERAGE DISTANCE AMONG NANORODS CAN BE ALSO EASILY TUNED BY CHANGING THE AMOUNT OF THE $BAZRO_3$ OR $BASNO_3$ ADDITION. THE BROAD PEAK OF *JC* IN THE *C*-AXIS DIRECTION ON THE ANGULAR DEPENDENCE OF *JC* BECOMES SMALL GRADUALLY AS THE LENGTH OF THE NANOROD SHORTENS. SIMULTANEOUSLY, THE SHAPE OF THE IRREVERSIBILITY LINES CLEARLY DEVIATES FROM THE BOSE GLASS LIKE BEHAVIOR TO THE VORTEX GLASS LIKE ONE. THE RELATION BETWEEN THE DIMENSION AND THE PINNING MECHANISM OF APCS WILL BE DISCUSSED AT THE CONFERENCE.

4MX-02

(INVITED) **NANO-ENGINEERING OF PHASE SEPARABLE INCLUSIONS IN HIGH PERFORMANCE YBCO THICK FILMS FOR COATED CONDUCTORS** ***T. G. HOLESINGER****, D. M. FELDMANN, J. Y. COULTER, F. J. BACA, B. MAIOROV, L. CIVALE;* LOS ALAMOS NATIONAL LABORATORY. — HIGH CRITICAL CURRENT DENSITIES (JC) IN YBA2CU3OY (YBCO) COATED CONDUCTORS DEPEND DIRECTLY UPON THE CONNECTIVITY AND DEFECT DENSITY WITHIN THE FILMS. HENCE, ONE NEEDS TO DEVELOP METHODOLOGIES FOR CONTROLLABLY INTRODUCING DEFECT STRUCTURES THAT ARE SUFFICIENT FOR TAILORING THE SUPERCONDUCTING PROPERTIES WHILE, ON THE OTHER HAND, MAINTAINING HIGH CRITICAL CURRENT AND UNIFORMITY OVER LENGTHS EXCEEDING A KILOMETER. A NUMBER OF DEFECT STRUCTURES HAVE BEEN SHOWN TO BE EFFECTIVE FLUX PINNING CENTERS, AMONG THEM THE UBIQUITOUS Y2O3 AND THE GENERAL CLASS OF DOUBLE-PEROVSKITES, A2BB´O6 WHERE A = BA AND B CAN INCORPORATE A WIDE RANGE OF ELEMENTS. FOR THIS TALK, WE WILL PRESENT OUR RESULTS FOR B = Y, ZR, NB, SN, AND RU. THROUGH CHANGES IN COMPOSITION AND TARGETED SETS OF ADDITIONS, WE SHOW THAT IT IS POSSIBLE TO SIGNIFICANTLY REDUCE DETRIMENTAL DEFECTS WHILE PRECISELY CONTROLLING THE TYPES AND DENSITIES PINNING DEFECTS WITHIN FILMS, LEADING TO ENHANCED PERFORMANCE IN THICK YBCO FILMS. JC VALUES (SF, 75.6K) OF 5 MA/CM2 (1000 A/CM-W) HAVE BEEN REACHED IN 2 MICRON THICK FILMS. FLUX PINNING FORCES OF 32.3 AND 122 GN/M3 (75.5 AND 65K, RESPECTIVELY) HAVE BEEN OBTAINED IN A 0.5 MICRON YBCO FILM WITH BA2YNBOY ADDITIONS.

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4MX-03

UNUSUAL FLUX PINNING PROPERTIES OF YBCO WITH LAYERED $BAZRO_3$ NANOPARTICLE ADDITIONS ***T. J. HAUGAN[1], J. N. REICHART[1], M. J. MULLINS[1], E. L. BREWSTER[1], J. S. OLDS[1], P. N. BARNES[1], F. J. BACA[2], H. WANG[3];*** [1]U.S. AIR FORCE RESEARCH LABORATORY, [2]LOS ALAMOS NATIONAL LABORATORY, [3]TEXAS A&M UNIVERSITY. — THE ADDITION OF NANOSIZED DEFECTS TO ENHANCE FLUX PINNING OF $YBA_2CU_3O_{7-Z}$ (YBCO) SUPERCONDUCTORS IS BEING STUDIED BY MANY GROUPS WORLD-WIDE. HOWEVER FLUX PINNING PROPERTIES ARE GENERALLY MEASURED FOR H//C AND T = 65-77 K, AND MEASUREMENTS FOR H//AB AND T < 65 K ARE NOT CONSIDERED AS MUCH. IN THIS PAPER WE DEMONSTRATE THAT FLUX PINNING ENHANCEMENTS AT 77 K DO NOT ALWAYS CORRELATE WITH ENHANCEMENTS FOR T ≤ 65 K. WE SHOW THAT A $(BZO_{0.4NM}/YBCO_{5.4NM})_N$ MULTILAYER FILM WITH AVERAGE FLUX PINNING AT 77 K HAS CLEARLY THE STRONGEST PINNING PROPERTIES AT 30 K AND H > 1 T, WHEN COMPARED TO OPTIMIZED STRONG FLUX PINNING FILMS OF YBCO+M WITH M = Y_2O_3 OR Y_2BACUO_5 NANOPARTICLE OR M = BZO NANOROD ADDITIONS. THESE RESULTS WERE ACHIEVED FOR FILMS PREPARED BY PULSED LASER DEPOSITION, WITH DEPOSITION TEMPERATURES RANGING FROM 775-840 °C AND VOLUME PERCENT ADDITIONS OF M = 0-10 VOL%. OTHER UNUSUAL FLUX PINNING PROPERTIES WERE OBSERVED FOR THE $(BZO/YBCO)_N$ MULTILAYER FILMS, INCLUDING 3-4X HIGHER J_C(77K,H//AB) AND ALSO STRONG DECREASE OF J_C(77K,H//C=2T) FOR $(BZO_{\sim 0.5NM}/YBCO)_N$ FOR YBCO LAYER THICKNESS LESS THAN 10 NM. POSSIBLE EXPLANATIONS OF THESE UNUSUAL FLUX PINNING PROPERTIES WILL BE PRESENTED.

AIR FORCE OFFICE SCIENTIFIC RESEARCH

4MX-04

C-AXIS CORRELATED PINNING BY NATURAL LINER DEFECTS IN YBCO FILM ***Y. YOSHIDA[1], Y. ICHINO[1], S. TAKAGI[1], Y. TAKAI[1], K. MATSUMOTO[2], A. ICHINOSE[3];*** [1]NAGOYA UNIVERSITY, [2]KYUSHU INSTITUTE OF TECHNOLOGY, [3]CENTRAL RESEARCH INSTITUTE OF ELECTRIC POWER INDUSTRY. — RECENTLY INCREASING THE J_C AT MAGNETIC FIELD CAN BE ACCOMPLISHED BY INTRODUCING ARTIFICIAL PINNING CENTER (APC) INTO REBCO COATED CONDUCTOR AND FILMS. IN THIS WORK, WE FOCUS ON THE *C*-AXIS CORRELATED PINNING BY NATURAL LINER DEFECTS IN YBCO FILM GROWN ON THE SINGLE CRYSTALLINE SUBSTRATE, FOR IMPROVING THE MAGNETIC FLUX PINNING IN COATED CONDUCTOR.THE FILMS GROWN ON THE $SRTIO_3$ AND $LAALO_3$ SUBSTRATE SHOW A LARGE PEAK AT *B//C*, INDICATING THAT AXIAL PINNING BY *C*-AXIS CORRELATED DEFECT, WHEREAS IN THE CASE OF THE FILM ON MGO AND LSAT SUBSTRATE WE OBSERVE A SMOOTH ANGULAR DEPENDENCE. FROM THE TEM IMAGES AND EDX MAPS OF

YBCO ON $SRTIO_3$, THESE SEEM TO THE COMPRISED OF MANY STACKING FAULTS ALONG *C*-AXIS OF YBCO. THE STACKING FAULTS ARE GROWN FROM THE STEPS OF THE SUBSTRATE AND IN THE COURSE OF THE FILM GROWTH, WITH THE INTERVAL OF ABOUT 20 NM. HOWEVER IT'S AN ORIGIN OF THE GROWTH MECHANISM OF THE STACKING FAULTS IS STILL UNCLEAR. NOW WE INVESTIGATE THE RELATION THE ANGULAR DEPENDENCE WITH THE STACKING FAULTS BY EMPLOYING THE YBCO FILM ON VICINAL SUBSTRATE.

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4MX-05

INDUCING SELF-ASSEMBLY OF NANOPARTICLES IN YBCO VIA CA-DOPING ***P. N. BARNES***[1]*, T. HAUGAN*[1]*, T. CAMPBELL*[1]*, F. J. BACA*[2]*;* [1]AIR FORCE RESEARCH LABORATORY, [2]LOS ALAMOS NATIONAL LABORATORY. — CA-DOPING HAS BEEN USED AS A MEANS TO IMPROVE THE INTERGRANULAR CURRENT DENSITIES IN HIGH TEMPERATURE SUPERCONDUCTING FILMS. ONE MEANS TO INTRODUCE CA INTO THE GRAIN COULD BE BY DOPING THE PINNING MATERIAL. PREVIOUS WORK HAS DEMONSTRATED SOME PREFERENTIAL GROWTH OF Y211 NANOPARTICLES NEAR THE GRAIN BOUNDARIES IN YBCO THIN FILMS. FOR THIS REASON, YBCO + Y211 SAMPLES WERE CREATED BY PULSED LASER DEPOSITION WITH ALTERNATING TARGETS OF YBCO WITH Y211 AND Y211 DOPED WITH CA. THE FILMS NOT ONLY HAD IMPROVED INTERGRANULAR CURRENT DENSITIES, BUT ALSO INTRAGRANULAR CURRENT DENSITIES. WE HAVE DEMONSTRATED THAT CA-DOPING OF THESE Y211 NANOPARTICLES, VIA ADDITION TO THE Y211 TARGET MATERIAL A PRIORI, CAUSES THE NANOPARTICLES TO INITIATE SELF-ASSEMBLY INTO NANORODS. IN THIS MANNER THE CA-DOPED Y211 BEGINS TO PRODUCE A SIMILAR NANOCOLUMNAR MICROSTRUCTURE AS WITH BZO OR BSO ADDITIONS, WHILE STILL INCORPORATING NANOPARTICULATES. THE SELF-ASSEMBLY OF THE NANOPARTICLES INTO SHORT NANOCOLUMNS PROVIDES AN ADDITIONAL INCREASE TO THE JC(H)//C-AXIS OVER THAT OF THE STANDARD Y211 PINNING.

4MX-06

SYNERGETIC PINNING CENTRES IN $YBA_2CU_3O_X$ FILMS THROUGH A COMBINATION OF AG NANO-DOT SUBSTRATE DECORATION, AG/YBCO QUASI-MULTILAYERS, AND THE USE OF $BAZRO_3$-DOPED TARGET *P. MIKHEENKO*[1]*, V. DANG*[1]*, M. AWANG KECHIK*[1]*, A. SARKAR*[1]*, P. PATURI*[2]*, H. HUHTINEN*[2]*, J. S. ABELL*[1]*,* ***A. CRISAN***[1]*;* [1]UNIVERSITY OF BIRMINGHAM, [2]UNIVERSITY OF PORI. — WE REPORT ON A ORIGINAL TECHNIQUE FOR NANOENGINEERED PINNING CENTRES THAT COMBINE THREE OF PREVIOUSLY REPORTED APPROACHES: SUBSTRATE DECORATION[1], QUASI-MULTILAYERS[2] AND TARGETS WITH SECONDARY PHASE NANOINCLUSIONS[3]. WE HAVE USED A 4% BZO-DOPED YBCO TARGET, AND AG NANODOTS, ALL GROWN BY PLD. SUCH APPROACH GAVE INTERESTING RESULTS IN TERMS OF PINNING LANDSCAPE, AS PROVED BY TEM STUDIES. ANGLE-DEPENDENT MEASUREMENTS OF CRITICAL CURRENT I_C SHOWED THAT, FOR SMALLER FIELDS, THE ABSOLUTE MAXIMUM IN I_C OCCURES FOR FIELDS PERPENDICULAR TO THE *A-B* PLANES, WHILE AT LARGER FIELDS THE ABSOLUTE MAXIMUM IN I_C OCCURS FOR FIELDS PARALLEL TO THE *A-B* PLANES, IN BOTH CASES WITH CLEAR SECOND, LOCAL MAXIMA. MEASUREMENTS ALSO SHOWED A SMOOTH CHANGE IN THE CHARACTER OF PINNING WITH MAGNETIC FIELD, FROM THE OUT-OF-PLANE TO IN-PLANE-DOMINANT PINNING. FOR THE OUT-OF-PLANE MAGNETIC FIELD, THE HIGHEST $I_{C\text{-}CW}$ OBTAINED SO FAR, AT 77.3 K, OCCURRED IN A 5.8 MM AG NANODOTS / BZO-DOPED YBCO TRILAYER: 782 A/CM-W IN SELF-FIELD, 167 A/CM-W IN 1 T AND 18 A/CM-W IN 3 T.[1]A. CRISAN, ET AL., APPL. PHYS. LETT. 79**,** 4547 (2001).[2]T. HAUGAN, ET AL., NATURE 430, 867 (2004).[3]J.L. MACMANUS-DRISCOLL, ET AL., NAT. MATER. 3, 439 (2004).

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4MY-01

ANALYTICAL MODEL OF THE AC LOSSES IN POWER CABLES WITH TWO LAYER SUPERCONDUCTING TAPES ***Y. MAWATARI***[1]*, A. P. MALOZEMOFF*[2]*;* [1]NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY, [2]AMERICAN SUPERCONDUCTOR CORP. — HIGH-TEMPERATURE SUPERCONDUCTING TAPES ARE WOUND AS COAXIAL MULTIPLE LAYERS IN AC POWER TRANSMISSION CABLES, AND ELECTROMAGNETIC INTERACTION AMONG MULTIPLE LAYERS OF SUPERCONDUCTING TAPES IS IMPORTANT TO UNDERSTAND THE BEHAVIOR OF THE AC LOSSES IN POWER CABLES.IN THE PRESENT WORK A SIMPLE ANALYTICAL MODEL IS PROPOSED TO INVESTIGATE AC LOSSES IN POWER TRANSMISSION CABLES WITH TWO LAYERS OF STRAIGHT SUPERCONDUCTING TAPES CARRYING AC TRANSPORT CURRENTS. THE INNER LAYER CARRIES A TOTAL CURRENT OF MAGNITUDE I_1, AND THE OUTER LAYER CARRIES A TOTAL CURRENT OF MAGNITUDE I_2. WHEN WE CONSIDER THE AC LOSS Q_2 IN THE OUTER LAYER, THE MAGNETIC FIELD PRODUCED BY THE INNER-LAYER CURRENT I_1 IS REGARDED AS A UNIFORM AZIMUTHAL FIELD DUE TO A LINE CURRENT I_1 AT THE CENTRAL AXIS OF THE CABLE. WHEN WE CONSIDER THE AC LOSS Q_1 IN THE INNER LAYER, ON THE OTHER HAND, THE EFFECT OF THE MAGNETIC FIELD PRODUCED BY THE OUTER-LAYER CURRENT I_2 IS NEGLECTED IN THIS MODEL WITH STRAIGHT SUPERCONDUCTING TAPES. THE TOTAL AC LOSS IN THE TWO-LAYER CABLE IS THEN GIVEN BY Q_1+Q_2. THEORETICAL INVESTIGATION BASED ON THIS SIMPLE ANALYTICAL MODEL EXPLAINS ONE IMPORTANT MECHANISM OF THE AC LOSSES IN POWER CABLES WITH MULTILAYERS OF SUPERCONDUCTING TAPES, NAMELY THE SUPERCONDUCTING HYSTERETIC LOSS DUE TO GAPS AND THE POLYGONAL CONFIGURATION OF THE TAPES.

A PART OF THIS WORK IS SUPPORTED BY NEDO THROUGH ISTEC.

4MY-02

AC MAGNETIZATION LOSS OF YBCO COATED CONDUCTOR TAPE MEASURED BY THREE DIFFERENT TECHNIQUES ***M. MAJOROS***[1]*, M. D. SUMPTION*[1]*, E. W. COLLINGS*[1]*, J. SOUC*[2]*, F. GOMORY*[2]*, M. VOJENCIAK*[2]*, L. M. FISHER*[3]*, A. V. KALINOV*[3]*, I. F. VOLOSHIN*[3]*;* [1]THE OHIO STATE UNIVERSITY, [2]INST. ELECTRICAL ENGN., SLOVAK ACADEMY OF SCIENCES, BRATISLAVA, [3]ALL-RUSSIAN ELECTRICAL ENGN. INSTITUTE, MOSCOW. — IN-FIELD AC LOSS WAS MEASURED ON 2G YBCO TAPES BY 3 METHODS - AN M(H) LOOP METHOD AND 2 DIFFERENT CALIBRATION-FREE METHODS. M(H) LOOP METHOD USED A PICK-UP COIL (WITH SAMPLE IN IT) CONNECTED IN SERIES WITH, AND IN OPPOSITION TO, A COMPENSATION COIL. THE VOLTAGE OF THIS CONNECTION IS DIRECTLY PROPORTIONAL TO THE MAGNETIC MOMENT OF THE SAMPLE. AC LOSS WAS DETERMINED FROM THE AREA OF THE HYSTERESIS LOOP. THE 1ST CALIBRATION-FREE METHOD USES A COIL WOUND IN PARALLEL WITH THE AC MAGNET WINDING AS THE PICK-UP COIL. 2 IDENTICAL SYSTEMS ARE USED, EACH CONTAINING AC MAGNET EQUIPPED WITH A MEASURING COIL. ONE OF THE MAGNETS CONTAINS THE SAMPLE AND THE OTHER ONE IS LEFT EMPTY. AC LOSS IS MEASURED BY A LOCK-IN TECHNIQUE. 2ND CALIBRATION-FREE METHOD MEASURES COMPONENTS OF MAGNETIC MOMENT IN A TRANSVERSE AC MAGNETIC FIELD. IT USES 2 PICK-UP COILS PLACED OUTSIDE OF THE MAGNET GENERATING AC MAGNETIC FIELD AND CONTAINING THE SAMPLE. THE AC MAGNET (OF A RECTANGULAR SHAPE) IS NARROW AND TALL, PROVIDING A HOMOGENEOUS FIELD IN THE SAMPLE SPACE AND ALMOST NO STRAY FIELDS AT THE POSITIONS OF THE PICK-UP COILS. TO MEASURE AC LOSS IN A SUPERCONDUCTING TAPE, A Z-COMPONENT OF THE MAGNETIC MOMENT OF THE TAPE IS DETERMINED USING A DIPOLE APPROXIMATION. IN THIS PAPER AC LOSSES IN FIELDS UP TO 0.140 T (PEAK) PERPENDICULAR TO THE FACE OF THE TAPE WERE MEASURED AT 72 - 75 HZ IN LN2 BATH. A SATISFACTORY AGREEMENT OF THE RESULTS WAS OBTAINED.

4MY-03

EVALUATION OF DIFFERENT APPROACHES TO AC LOSS REDUCTION IN 2G YBCO TAPE ***G. MAJKIC***[1]*, I. KESGIN*[1]*, Y. ZHANG*[1]*, Y. QIAO*[2]*, B. SCHMIDT*[2]*, V. SELVAMANICKAM*[1]*;* [1]UNIVERSITY OF HOUSTON, [2]SUPERPOWER INC.. — WE PRESENT RESULTS OF A STUDY AIMED AT INVESTIGATING SEVERAL APPROACHES TO REDUCING AC LOSSES IN 2G REBCO-BASED TAPES. THE PERFORMANCE OF EACH APPROACH IS ANALYZED WITH RESPECT TO MAGNETIZATION AND TRANSPORT AC LOSSES, AC LOSS COUPLING, MICROSTRUCTURE AND SCALABILITY, COST AND RELIABILITY. IN PARTICULAR, THIS STUDY IS FOCUSED ON EVALUATING THE AC LOSS PERFORMANCE OF A NUMBER OF STRIATION TECHNIQUES, THEIR LIMITS IN TERMS OF STRIATION WIDTH, FILAMENT-TO-FILAMENT COUPLING, MECHANICAL ROBUSTNESS, AS WELL AS OTHER RELATED ASPECTS ASSOCIATED WITH SUBDIVIDING A SUPERCONDUCTING TAPE INTO FILAMENTS. THE EXTREME LIMITS OF STRIATION WIDTH, ACCOMPLISHED BY USING FOCUSED ION BEAM TO ACHIEVE STRIATIONS IN THE SUB-MICRON RANGE, WILL ALSO BE ADDRESSED.

4MY-04

(INVITED) **EFFECT OF STRIATED STRANDS IN 2G ROEBEL CABLE** ***S. TERZIEVA***[1]*, W. GOLDACKER*[1]*, R. NAST*[1]*, F. GRILLI*[1]*, A. KUDYMOW*[1]*, M. VOJENCIAK*[2]*, J. SOUC*[2]*;* [1]KARLSRUHE INSTITUTE OF TECHNOLOGY, INSTITUTE FOR TECHNICAL PHYSICS, KARLSRUHE, GERMANY, [2]INSTITUTE OF ELECTRICAL ENGINEERING, SLOVAK ACADEMY OF SCIENCES, BRATISLAVA, SLOVAKIA. — THE APPLICATION OF LONGITUDINAL STRIATIONS TO COATED CONDUCTOR ROEBEL STRANDS CAN BE AN OPTION TO CREATE A FILAMENT STRUCTURE FOR FURTHER POSSIBLE REDUCTION OF THE AC LOSSES. THE AIM OF THIS WORK IS TO EXPERIMENTALLY INVESTIGATE THE EFFECTS OF THE FILAMENT STRUCTURE ON THE LOSS BEHAVIOUR. DUE TO THE COMPLEX ROEBEL STRAND GEOMETRY, IT WAS IMPORTANT TO IDENTIFY THE MOST SUITABLE AND RELIABLE TECHNIQUE TO PRODUCE SUCH STRUCTURES USING A PICOSECONDS-INFRARED (IR) LASER FOR THE GROOVE ETCHING PROCESS.WE ANALYZED THE HOMOGENEITY OF THE CRITICAL CURRENT ACROSS THE WIDTH OF THE STRIATED ROEBEL STRANDS. WE COMPARED MEASUREMENTS ON THE STRIATED STRANDS AND ON REFERENCE STRANDS WITH NO STRUCTURE. WE CHARACTERIZED THE CURRENT HOMOGENEITY WHICH GAVE INDICATIONS FOR THE DIFFERENT POSSIBLE CONTRIBUTIONS WHEN CURRENT DEGRADATIONS WERE OBSERVED IN THE FILAMENTS. WE PRESENT RESULTS OF CRITICAL CURRENT AND AC TRANSPORT LOSS MEASUREMENTS FOR CABLES WITH DIFFERENT DESIGN AND PERFORMANCE AND DISCUSS THE NEED OF FILAMENT COUPLING.

4MY-05

(INVITED) **AC LOSS REDUCTION IN FILAMENTIZED YBCO COATED CONDUCTORS WITH VIRTUAL TRANSVERSE CROSS-CUTS** ***Y. ZHANG***[1]*, R. C. DUCKWORTH*[1]*, S. W. COOK*[1]*, F. A. LIST*[1]*, T. T. HA*[1]*, M. J. GOUGE*[1]*, Y. CHEN*[2]*, X. XIONG*[2]*, V. SELVAMANICKAM*[2]*;* [1]OAK RIDGE NATIONAL LABORATORY, [2]SUPERPOWER INC.. — WHILE THE PERFORMANCE OF $YBA_2CU_3O_{7-X}$ (YBCO)-BASED COATED CONDUCTORS UNDER DC CURRENTS HAS IMPROVED SIGNIFICANTLY IN RECENT YEARS, FILAMENTIZATION IS BEING INVESTIGATED AS A TECHNIQUE TO REDUCE AC LOSS SO THAT THE 2ND GENERATION (2G) HIGH TEMPERATURE SUPERCONDUCTING (HTS) WIRES CAN ALSO BE UTILIZED IN VARIOUS AC POWER APPLICATIONS SUCH AS CABLES, TRANSFORMERS AND FAULT CURRENT LIMITERS. EXPERIMENTAL STUDIES HAVE SHOWN THAT SIMPLY FILAMENTIZING THE SUPERCONDUCTING LAYER ALONG THE LENGTH OF THE TAPE IS NOT EFFECTIVE ENOUGH TO REDUCE AC LOSS BECAUSE OF INCOMPLETE FLUX PENETRATION BETWEEN THE FILAMENTS. TO INTRODUCE FLUX PENETRATION IN BETWEEN THE FILAMENTS MORE UNIFORMLY, VIRTUAL CROSS-CUTS WERE MADE IN THE SUPERCONDUCTING FILAMENTS OF THE COATED CONDUCTORS FABRICATED USING THE METAL ORGANIC CHEMICAL VAPOR DEPOSITION (MOCVD) METHOD. THE VIRTUAL CROSS-CUTS WERE FORMED BY MAKING CROSS-CUTS

(17 ~ 120 MM WIDE) ON THE IBAD (ION BEAM ASSISTED DEPOSITION)-MGO TEMPLATES USING LASER SCRIBING FOLLOWED BY DEPOSITING THE SUPERCONDUCTING LAYER (~ 0.6 MM THICK). AC LOSSES WERE MEASURED AND COMPARED FOR FILAMENTIZED CONDUCTORS WITH AND WITHOUT THE CROSS-CUTS UNDER APPLIED PEAK AC FIELDS UP TO 100 MT. THE RESULTS WERE ANALYZED TO EVALUATE THE EFFICACY OF FILAMENT DECOUPLING BY THE CROSS-CUT METHOD AND THE FEASIBILITY OF USING THIS METHOD TO ACHIEVE AC LOSS REDUCTION.

RESEARCH SPONSORED BY THE U.S. DOE OFFICE OF ELECTRICITY DELIVERY AND ENERGY RELIABILITY – ADVANCED CABLES AND CONDUCTORS PROGRAM UNDER CONTRACT DE-AC05-00OR22725 WITH OAK RIDGE NATIONAL LABORATORY, MANAGED AND OPERATED BY UT-BATTELLE, LLC.

4MZ-01

(INVITED) **A MODEL EXPLAINING THE IMPROVED SUPERCONDUCTING PROPERTIES OF *IN SITU* MGB_2 WIRES AFTER COLD HIGH PRESSURE DENSIFICATION** ***C. SENATORE**, M. S. A. HOSSAIN, R. FLÜKIGER;* DEPARTMENT OF CONDENSED MATTER PHYSICS & MANEP/NCCR, UNIVERSITY OF GENEVA. — THE COLD HIGH PRESSURE DENSIFICATION TECHNIQUE (CHPD) WAS RECENTLY DEVELOPED IN GENEVA FOR IMPROVING THE IN-FIELD CRITICAL CURRENT DENSITY J_C IN *IN SITU* BINARY AND ALLOYED MGB_2 WIRES AND TAPES [1, 2]. FOR SQUARE WIRES ALLOYED WITH MALIC ACID ($C_4H_6O_5$), THE HIGHEST J_C VALUES WERE RECENTLY REPORTED AS $J_C = 10^4$ A/CM^2 AT 13.0 T [2], THE BEHAVIOR BEING ALMOST ISOTROPIC. IN ORDER TO UNDERSTAND THE FUNDAMENTAL MECHANISM BEHIND THIS IMPROVEMENT OF J_C, THE PROPERTIES OF BINARY AND ALLOYED MGB_2 WIRES HAVE BEEN INVESTIGATED BEFORE AND AFTER CHPD, USING RESISTIVITY AND MAGNETIZATION MEASUREMENTS IN THE TEMPERATURE RANGE BETWEEN 5 AND 35 K AT MAGNETIC FIELDS UP TO 15 T.IT WAS FOUND THAT THE EFFECT OF THE DENSIFICATION PROCESS ON THE ELECTRICAL AND TRANSPORT PROPERTIES IS RELATED TO THE ENHANCEMENT OF THE MGB_2 FILAMENT MASS DENSITY AND THUS TO THE IMPROVED GRAIN CONNECTIVITY. A MODEL IS PROPOSED FOR EXPLAINING THE REPORTED ENHANCEMENT OF J_C AND B_{IRR} ON THE BASIS OF THE T_C DISTRIBUTION MEASURED ON BINARY AND ALLOYED MGB_2 WIRES AND BULK SAMPLES.[1] R. FLÜKIGER, M.S.A. HOSSAIN, C. SENATORE, *SUPERCOND. SCI. TECHNOL.* **22** (2009) 085002.[2] M.S.A. HOSSAIN, C. SENATORE, M.A. RINDFLEISCH, M.J. TOMSIC, J. H. KIM, S. X. DOU , R. FLÜKIGER, *SUPERCOND. SCI. TECHNOL.* **22** (2009) 095004.

4MZ-02

SIGNIFICANTLY ENHANCED JC-B PROPERTIES IN MGB_2 TAPES BY CARBOHYDRATE $C_9H_{11}NO$ DOPING *X. ZHANG, **Y. MA**, D. WANG;* INSTITUTE OF ELECTRICAL ENGINEERING, CHINESE ACADEMY OF SCIENCES. — MGB_2 IS A PROMISING SUPERCONDUCTOR FOR LARGE-SCALE APPLICATIONS FOR BOTH HIGH FIELD MAGNETS AND CRYOCOOLER-COOLED MAGNET OPERATED AT TEMPERATURES AROUND 20 K. IN THIS PRESENTATION, BY UTILIZING $C_9H_{11}NO$ AS DOPANT, WE DEMONSTRATE A SIGNIFICANT J_C IMPROVEMENT AT BOTH 4.2K AND 20K ACHIEVED IN MGB_2 TAPES. IT IS FOUND THAT $C_9H_{11}NO$ DOPING WILL CAUSE A SMALL DEPRESSION IN T_C, WHILE THE J_C AND H_{C2} VALUES ARE STRONGLY ENHANCED. THE HIGHEST J_C WAS OBTAINED IN $C_9H_{11}NO$-DOPED SAMPLE SINTERED AT 800°C, WHICH WAS 3.7×10^4A/CM^2 AT 4.2K, 10T. THIS IS THE HIGHEST J_C VALUES IN MGB_2 TAPES USING CARBOHYDRATES AS DOPING MATERIALS. MOREOVER, AT 20K, 5T, A TRANSPORT J_C VALUE AS HIGH AS 1.9×10^4A/CM^2 IS OBSERVED, SUGGESTING THAT MGB_2 ARE PROMISING FOR PRACTICAL APPLICATIONS. BESIDES THE IMPROVEMENT OF GRAIN LINKAGES, THE CLEARLY ENHANCED H_{C2} IS THOUGHT AS THE MAIN REASON FOR THE PROMINENT IN-FIELD J_C PERFORMANCE IN $C_9H_{11}NO$ DOPED MGB_2 SAMPLES.

4MZ-03

NOVEL *C*-AXIS ORIENTED *EX-SITU* MGB_2 CONDUCTORS ***A. YAMAMOTO**[1], T. MOCHIZUKI[1], H. TANAKA[1], H. OGINO[1], J. SHIMOYAMA[1], K. KISHIO[1], S. HORII[2], K. WADA[3], Y. YAMADA[3], Y. SHIMADA[4], S. HATA[4], K. IKEDA[4], H. NAKASHIMA[4];* [1]UNIVERSITY OF TOKYO, [2]KOCHI UNIV. OF TECH., [3]TOKAI UNIVERSITY, [4]KYUSHU UNIVERSITY. — THOUGH THE WEAK-LINK FREE NATURE OF MGB_2 CONTRIBUTES TO HIGH CRITICAL CURRENT DENSITY J_C IN RANDOMLY ORIENTED POLYCRYSTALS, IT IS CONSIDERED THAT MACROSCOPIC TRANSPORT CURRENT IS AFFECTED BY THE INTRINSIC ANISOTROPY (Γ~2-4) AND TWO-BAND CONDUCTIVITY, ESPECIALLY UNDER MAGNETIC FIELDS. *IN-SITU* SYNTHESIS OF MGB_2 YIELDS STRONGER GRAIN COUPLING RESULTING IN HIGHER J_C, WHILE J_C OF *EX-SITU* MGB_2 CONDUCTORS IS SUPPRESSED BY WETTING OXIDE PHASES. HOWEVER, SINCE POWDERS CAN BE MORE DENSELY AND HOMOGENEOUSLY PACKED, HIGHER J_C CAN BE EXPECTED IN *EX-SITU* MGB_2 IF THE GRAIN CONNECTIVITY IS IMPROVED. IN THIS STUDY, WE APPLIED MECHANICAL PRESSING AND MAGNETIC ALIGNMENT TECHNIQUE COMBINED WITH ELECTROPHORETIC DEPOSITION AND OBTAINED HIGHLY *C*-AXIS ORIENTED AND DENSE *EX-SITU* MGB_2 CONDUCTORS. X-RAY DIFFRACTION ANALYSIS SHOWS (00*L*) REFLECTIONS ARE SIGNIFICANTLY ENHANCED, INDICATIVE OF TEXTURING. AS A RESULT, *MACROSCOPIC* ANISOTROPY ~2 APPEARS IN IRREVERSIBILITY FIELDS AND J_C IS GREATLY IMPROVED BY A FACTOR OF 3 UP TO ~0.7 MA/CM^2 AT 20 K. THESE SUGGEST THE *INTRINSIC* ANISOTROPY AFFECTS THE *MACROSCOPIC* ELECTROMAGNETIC PROPERTIES THROUGH A PARTIAL *C*-AXIS ALIGNMENT OF MGB_2 GRAINS. WE WILL DISCUSS THE ORIGINS OF HIGH J_C AND *MACROSCOPIC* ANISOTROPY BASED ON THE TRANSPORT AND MICROSTRUCTURAL ANALYSES.

4MZ-04

THE INFLUENCE OF STRAND DESIGN, MALIC ACID, AND DIRECT CARBON-BORON DOPING IN MGB2 STRANDS ***Y. YANG**[1], M. SUSNER[1], M. D. SUMPTION[1], M. RINDFLEISCH[2], M. TOMSIC[2], E. W. COLLINGS[1];* [1]CENTER FOR SUPERCONDUCTING AND MAGNETIC MATERIALS, THE OHIO STATE UNIVERSITY, [2]HYPER TECH RESEARCH, COLUMBUS, OH. — THE PROPERTIES OF VARIOUS MULTIFILAMENTARY MGB2 STRANDS AND STRAND DESIGNS WERE STUDIED. STRANDS WITH DIFFERENT FILAMENT NUMBERS (6,18,36) DIFFERENT BARRIERS (FE,NB)

AND DIFFERENT CONSTRUCTIONS (SHEATH TYPE, MATRIX TYPE, PLACEMENT) WERE MEASURED. JC VALUES FOR MULTIFILAMENTARY (18) STRANDS REACHED IN SOME CASES 104A/CM2 AT 11 T AND AT 4.2 K. THE INFLUENCE OF STRAND DIAMETER IN MULTIFILAMENTARY STRANDS WAS ALSO INVESTIGATED, AND RESULTS WERE PRESENTED. IN ADDITION, THE INFLUENCE OF MALIC ACID DOPING OF STRANDS USING DIFFERENT TYPES OF BORON WAS INVESTIGATED, INCLUDING CRYSTALLINE, AMORPHOUS, AND PLASMA SPRAY TYPE B. THE JC RESULTS OF SAMPLES WITH DIFFERENT TYPES OF BORON WERE OBTAINED AT 4.2 K; THE VALUES REACHED 104A/CM2 AT 10 T IN SOME CASES. FINALLY, THE TRANSPORT PROPERTIES OF A SERIES OF MGB2 IN-SITU TYPE POWDER-IN-TUBE STRANDS MADE WITH B CONTAINING DIFFERENT LEVELS OF C WERE STUDIED FOR THEIR UPPER CRITICAL FIELD AND JC PROPERTIES. THE LEVEL OF CARBON DOPING WAS RANGING FROM 1% TO 4%. THE CRITICAL CURRENT DENSITY AT 4.2 K WAS SIGNIFICANTLY INCREASED. THE BEST JC VALUES AT 4.2 K WERE FOUND WITH 3% C ADDITIONS WITH 105 A/CM2 AT 7 T AND 104 A/CM2 AT 13 T. BC2 AND BIRR WERE MEASURED AS A FUNCTION OF TEMPERATURE, AND THE DB/DT SLOPES WERE COMPARED FOR THE DIFFERENT LEVEL OF C-DOPING. THE RESULTS WERE COMPARED TO THE RESULTS OF STRANDS WITH C ADDED EXTERNAL TO THE POWDER IN THE FORM OF SIC AND MALIC ACID.

4MZ-05

EX SITU VERSUS IN-SITU CARBON-DOPING IN MGB2 SUPERCONDUCTING STRANDS ***M. A. SUSNER***[1]*, Y. YANG*[1]*, S. D. BOHNENSTIEHL*[1]*, M. D. SUMPTION*[1]*, M. MAJOROS*[1]*, C. J. KOVACS*[1]*, M. A. RINDFLEISCH*[2]*, J. V. MARZIK*[3]*, E. W. COLLINGS*[1]*;* [1]THE OHIO STATE UNIVERSITY, [2]HYPER TECH RESEARCH, INC., [3]SPECIALTY MATERIALS, INC.. — EX SITU VERSUS IN-SITU C-DOPING OF MGB2 ARE COMPARED. EX SITU C-DOPING CAN BE DESCRIBED AS AN EXTRINSIC ADDITION OF A C-CONTAINING COMPOUND SUCH AS SIC INTO THE MGB2 POWDER DIRECTLY OR ADDED TO A B+MG POWDER MIXTURE. THE IN SITU C-DOPING METHOD INVOLVES PRE-DOPING THE B POWDER WITH C. THIS CAN BE ACCOMPLISHED BY REACTING THE B POWDER WITH AN APPROPRIATE C-CONTAINING MATERIAL SUCH AS MALIC ACID, OR THROUGH DIRECT ADDITION TO B BY INCLUDING CH4 IN THE PLASMA SYNTHESIS OF THE B POWDER. THE DOPING EFFICIENCY OF SIC, MALIC ACID, AND PLASMA-DOPED MGB2 STRANDS ARE COMPARED, BOTH IN TERMS OF THE TRANSPORT PROPERTIES AND THE RESULTING C-AXIS LATTICE PARAMETERS. IN GENERAL, MORE EFFICIENT C-DOPING WAS SEEN TO LEAD TO SIGNIFICANT IMPROVEMENTS IN THE 4.2 K TRANSPORT PROPERTIES. AT HIGHER TEMPERATURES, CRITICAL TEMPERATURES AND FIELDS WERE INVESTIGATED AND CORRELATED TO THE VARIOUS DOPING MECHANISMS. IT WAS SUSPECTED THAT MORE UNIFORM DOPING WAS ACHIEVED USING THE IN-SITU C DOPING ROUTE. THIS WAS ATTRIBUTED TO A SHORTER C-DIFFUSION LENGTH. THIS IDEA WAS INVESTIGATED WITH THE USE OF HEAT CAPACITY MEASUREMENTS WHICH ALLOWED THE HOMOGENEITY OF THE DOPING TO BE INVESTIGATED.

4MZ-06

MGB2 SYNTHESIS REACTION AND TAPE SINTERING PROCESS INVESTIGATION WITH *IN-SITU* HEXRD TECHNIQUE. ***M. VIGNOLO****, E. BELLINGERI, A. MARTINELLI, G. ROMANO, A. MALAGOLI, V. BRACCINI, C. FERDEGHINI;* CNR-SPIN. — WE REPORT ABOUT IN-SITU HIGH ENERGY X-RAY DIFFRACTION AT ESRF, GRENOBLE, ON VARIOUS STEPS OF THE REALIZATION OF MAGNESIUM DIBORIDE TAPE WITH THE EX-SITU PIT METHOD. THE EXPERIMENTS WERE PERFORMED IN A SPECIFICALLY DESIGNED FURNACE WORKING IN REDUCING ATMOSPHERE COMPATIBLE WITH LAUE DIFFRACTION EXPERIMENT. WE ANALYZED THE MGB2 SYNTHESIS UNDER DIFFERENT CONDITIONS, NAMELY REACTION TEMPERATURE, CRUCIBLES AND ATMOSPHERE DURING THE COOLING PROCESS. TAPES WERE PREPARED WITH POWDER PREVIOUSLY PREPARED IN SIMILAR WAYS AND THE SINTERING PROCESSES OF THESE TAPES WAS ANALYZED WITH THE SAME TECHNIQUE.THE PHASE EVOLUTIONS, THE MICRO-STRUCTURE AND CRYSTALLOGRAPHIC STRUCTURE WERE MONITORED DURING THE DIFFERENT THERMAL TREATMENTS.AMONG THE MAIN RESULTS, WE OBSERVED THE FORMATION OF MGB2 PHASE AT VERY LOW TEMPERATURE (T=300°C) FROM A SOLID STATE REACTION BETWEEN THE MAGNESIUM HYDRIDE AND THE BORON. MOREOVER WE ESTABLISHED THE ROLE OF THE MGO FORMATION ON THE MICRO- STRUCTURAL AND TRANSPORT PROPERTIES (JC) OF THE TAPES.

4MZ-07

REVIEW OF CARBOHYDRATE-DOPED MgB_2 CONDUCTORS *J. KIM*[1]*, H. KUMAKURA*[2]*, M. TOMSIC*[3]*,* ***S. DOU***[4]*;* [1]NATIONAL INSTITUTE FOR MATERIALS SCIENCE, UNIVERSITY OF WOLLONGONG, [2]NATIONAL INSTITUTE FOR MATERIALS SCIENCE, [3]HYPER TECH RESEARCH INCORPORATED, [4]UNIVERSITY OF WOLLONGONG. — A NUMBER OF CARBOHYDRATES HAVE BEEN USED AS A CARBON SOURCE TO DOPE MgB_2 IN THE PAST THREE YEARS. THEIR EFFECT ON $J_C(B)$ IMPROVEMENT VARIES SIGNIFICANTLY DEPENDING ON WHAT COMPOUND IS USED. ACCORDING TO THE DUAL REACTION MODEL THE OPTIMAL DOPING CONDITION CAN BE ACHIEVED IF THE FRESHLY FORMED AND HIGHLY REACTIVE CARBON IS MADE AVAILABLE WHEN THE MgB_2 FORMATION REACTION TAKES PLACE AT LOW TEMPERATURES. IN ADDITION, OXYGEN CONTENT AND EVOLUTION OF RESULTANT GASES FROM THE CARBOHYDRATES ARE ALSO IMPORTANT FACTORS TO $J_C(B)$ IN LOW FIELDS. THE MALIC ACID TURNS OUT TO MEET ALL THE REQUIREMENTS AND HENCE THE BEST CANDIDATE FOR CARBON DOPING AMONG ALL CARBOHYDRATES. FIELD AND TEMPERATURE DEPENDENCE OF THE J_C WERE MEASURED FOR BOTH UN-DOPED AND MALIC ACID DOPED MgB_2/NB/MONEL WIRES MANUFACTURED BY HYPER TECH RESEARCH, INC. IT WAS FOUND THAT MALIC ACID IS NOT ONLY HIGHLY EFFICIENT FOR CARBON INCORPORATION INTO THE MgB_2 STRUCTURE BUT ALSO HAS THE LEAST NEGATIVE EFFECT ON SELF-FIELD J_C WHICH IS A COMMON PROBLEM FOR ALL DOPANTS. THE EFFECTIVE CROSS SECTION OF AROUND 12% IS CLEARLY BETTER THAN MOST OTHER DOPED MgB_2. ESPECIALLY, THE J_C OF THE MALIC ACID DOPED WIRE AT 20 K STILL RETAINS THE IMPROVEMENT BY A FACTOR OF 4 COMPARED TO THAT OF THE BEST PRISTINE WIRES. THE MECHANISM FOR THE ENHANCEMENT IS EXPLAINED BY USING TEM OBSERVATION,

PERCOLATION MODEL, 3D X-RAY TOMOGRAM, AND SPRING 8 X-RAY -RAY RESULTS.

THIS WORK WAS SUPPORTED BY THE AUSTRALIAN RESEARCH COUNCIL (ARC) AND HYPER TECH RESEARCH INC., USA. THIS STUDY WAS ALSO SUPPORTED BY THE JAPAN SOCIETY FOR THE PROMOTION OF SCIENCE (JSPS) UNDER GRANT-IN-AID FOR JSPS FELLOWS.

4MZ-08

PROGRESSIVE REDUCTION OF AC-LOSSES IN MULTIFILAMENTARY MAGNESIUM DIBORIDE CONDUCTORS ***E. A. YOUNG****, H. WEN, Y. YANG;* UNIVERSITY OF SOUTHAMPTON. — AC LOSSES OF NON MAGNETIC SHEATH MULTIFILAMENTARY MGB2 TAPES, SQUARE WIRE, AND TWISTED SQUARE WIRE IN APPLIED FIELD WERE STUDIED SYSTEMATICALLY AT DIFFERENT TEMPERATURES, AND EXTERNAL AC FIELDS (0.3 T), AND FREQUENCY (3-2000 HZ) AND THE BEHAVIOR ANALYSED WITHIN SEMI-QUANTITATIVE CALCULATIONS. PREVIOUS WORK ON NICR NON MAGNETIC ALLOY SHEATH SHOWED THAT DESPITE A CONSIDERABLE LOSS REDUCTION COMPARED WITH MAGNETIC SHEATH, THE RESULTING LOSSES WERE STILL SIGNIFICANTLY HIGHER THAN THAT OF THE SUPERCONDUCTOR AS THE NICR SHEATH WAS WEAKLY MAGNETIC AFTER THERMAL PROCESSING. IN ORDER TO DISTINGUISH THE CONTRIBUTION OF INDIVIDUAL LOSS COMPONENTS SUCH AS COUPLING LOSS IT WAS NECESSARY TO ETCH THE SHEATH. IN THIS WORK IMPROVEMENTS IN CONDUCTOR SHEATH MATERIAL AND THERMAL PROCESSING HAVE REDUCED THE MAGNETIC LOSS FURTHER. AS A RESULT OF REDUCED MAGNETIC LOSS, THE CONTRIBUTION AND FIELD AND FREQUENCY BEHAVIOR OF COUPLING LOSS, AND SUPERCONDUCTOR LOSS CAN BE BETTER RESOLVED. REDUCTION OF THE ASPECT RATIO BY A FACTOR OF 13 IN THE SQUARE WIRE COMPARED TO THE TAPE LEAD TO A SUBSEQUENT LARGE REDUCTION IN LOSSES, WHICH ARE FURTHER REDUCED BELOW THE COUPLING FIELD BC, IN THE TWISTED SAMPLE.

5EA-01

(INVITED) **ADVANCED READOUT AND PACKAGING OF SUPERCONDUCTING NANOWIRE SINGLE-PHOTON DETECTORS** ***A. J. KERMAN****, E. A. DAULER, R. MOLNAR, J. YOON, J. D. MOORES;* MIT LINCOLN LABORATORY. — SUPERCONDUCTING NANOWIRE SINGLE PHOTON DETECTORS (SNSPDS) PROVIDE A UNIQUE COMBINATION OF HIGH SPEED, HIGH SINGLE-PHOTON DETECTION EFFICIENCY, AND LOW DARK COUNT RATES. HOWEVER, BECAUSE OF THEIR SMALL PIXEL SIZE, ARRAYS OF DETECTORS ARE DESIRABLE IN MANY APPLICATIONS WHICH REQUIRE BOTH LARGE ACTIVE AREAS AND VERY HIGH COUNT RATES. TO THIS END, WE ARE DEVELOPING HYBRID INTEGRATED READOUT CIRCUITS AND OPTICAL COUPLING TECHNIQUES WHICH MAY ALLOW SCALING TO LARGER ARRAYS OF NANOWIRES THAN CURRENTLY POSSIBLE, WHILE MAINTAINING HIGH SYSTEM DETECTION EFFICIENCY AND LOW TIMING JITTER. WE WILL REPORT ON PROGRESS IN BOTH OF THESE AREAS.

THIS WORK IS SPONSORED BY THE DEPARTMENT OF THE AIR FORCE UNDER CONTRACT FA8721-05-C-0002. OPINIONS, INTERPRETATIONS, CONCLUSIONS, AND RECOMMENDATIONS ARE THOSE OF THE AUTHOR AND ARE NOT NECESSARILY ENDORSED BY THE US GOVERNMENT.

5EA-02

(INVITED) **HIGH-EFFICIENCY SUPERCONDUCTING NANOWIRE SINGLE PHOTON DETECTORS AT >4K** ***E. A. DAULER***[1]*, R. J. MOLNAR*[1]*, J. U. YOON*[1]*, A. J. KERMAN*[1]*, V. BOLKHOVSKY*[1]*, X. HU*[2]*, K. K. BERGGREN*[2]*, J. D. MOORES*[1]*;* [1]MIT LINCOLN LABORATORY, [2]MIT. — SUPERCONDUCTING NANOWIRE SINGLE PHOTON DETECTORS (SNSPDS) CAN OFFER A UNIQUE COMBINATION OF HIGH SPEED, LOW NOISE AND HIGH DETECTION EFFICIENCY UNMATCHED BY OTHER SINGLE-PHOTON DETECTION TECHNOLOGIES, PARTICULARLY AT SHORT-WAVE INFRARED WAVELENGTHS. IN THIS WORK, WE DEMONSTRATE AN SNSPD WITH A PEAK DEVICE DETECTION EFFICIENCY OF 86% AT 2K OPERATING TEMPERATURE AND 50% DETECTION EFFICIENCY AT 4K OPERATING TEMPERATURE AT A BIAS CURRENT OF 97.5% OF THE CRITICAL CURRENT. SIMILARLY, >50% DETECTION EFFICIENCY CAN BE ACHIEVED AT BIAS CURRENTS BELOW 85% OF THE CRITICAL CURRENT WITH A 2K OPERATING TEMPERATURE. THIS HIGH LEVEL OF PERFORMANCE IS ENABLED BY NBN FILMS WITH TRANSITION TEMPERATURE >10K ON OXIDIZED SILICON SUBSTRATES. IN ADDITION TO HIGH DETECTION EFFICIENCY, THESE DETECTORS HAVE SUB-30-PS TIMING JITTER, MATCHING THE PERFORMANCE OF SIMILAR DETECTORS FABRICATED ON SAPPHIRE SUBSTRATES. FINALLY, PROGRESS TOWARD HIGH YIELD ARRAYS, MORE FLEXIBLE PACKAGING ARRANGEMENTS, AND OPERATION AT AN INTERMEDIATE BIAS TO SIMULTANEOUSLY ACHIEVE VERY LOW DARK COUNTS AND HIGH DETECTION EFFICIENCY WILL ALSO BE DISCUSSED.THIS WORK WAS SPONSORED IN PART BY THE UNITED STATES AIR FORCE UNDER AIR FORCE CONTRACT #FA8721-05-C-0002. OPINIONS, INTERPRETATIONS, RECOMMENDATIONS AND CONCLUSIONS ARE THOSE OF THE AUTHORS AND ARE NOT NECESSARILY ENDORSED BY THE UNITED STATES GOVERNMENT.

5EA-03

(INVITED) **RSFQ BASED READOUT OF SUPERCONDUCTING SINGLE PHOTON DETECTORS** ***T. ORTLEPP***[1]*, M. HOFHERR*[2]*, K. ILIN*[2]*, S. ENGERT*[1]*, D. RALL*[2]*, S. WUENSCH*[2]*, H. TOEPFER*[1]*, M. SIEGEL*[2]*;* [1]ILMENAU UNIVERSITY OF TECHNOLOGY, [2]KARLSRUHE INSTITUTE OF TECHNOLOGY. — SUPERCONDUCTING NANOWIRE SINGLE-PHOTON DETECTORS (SNSPD) ARE EXPECTED TO BE OF ADVANCE IN INSTRUMENTS FOR APPLICATIONS LIKE CORRELATION SPECTROSCOPY OR QUANTUM CRYPTOGRAPHY WHERE FAST DETECTORS WITH ULTIMATE SENSITIVITY AND HIGH DETECTION EFFICIENCY ARE REQUIRED. SMALL SNSPDS PRODUCE A FAST VOLTAGE PULSE AS A DIGITAL RESPONSE OF EACH SINGLE PHOTON. FROM THE TYPICAL PULSE HEIGHT OF 20 MV AND WIDTH OF 1 NS, THE PROBLEM OF LOW-NOISE AMPLIFICATION FOR COUNTING THE PULSES EMERGES.MOREOVER, THE DEVELOPMENT OF IMAGING SYSTEMS REQUIRES THE READOUT OF SEVERAL

PIXELS ARRANGED AS DETECTOR ARRAY OR MATRIX TO ALLOW SPATIAL RESOLUTION. DUE TO MINIMIZING REQUIREMENTS OF THE SYSTEM A SINGLE PARALLEL READOUT IS NECESSARY.WE DESCRIBE A NEW READOUT CONCEPT BASED ON SINGLE FLUX QUANTUM (SFQ) ELECTRONICS. A SPECIAL CONVERTER CIRCUIT FOR TRANSFORMING THE SNSPD OUTPUT PULSES INTO SINGLE FLUX QUANTUM PULSES HAS BEEN DESIGNED AND TESTED WITH IMITATED INPUT PULSES. THE REQUIRED HIGH SENSITIVITY AND HIGH SPEED FOR THE PULSE DETECTION IS CONFIRMED IN EXPERIMENTS.WE WILL REPORT ON THE EXPERIMENTAL RESULTS OF A SINGLE CHANNEL SNSPD-SFQ PULSE TRANSFER AT LOW SPEED AND WE WILL DISCUSS CIRCUIT ARCHITECTURES FOR SCALABLE ARRAY READOUT.

5EA-04

SINGLE PHOTON DETECTION AND FABRICATION OF MGB_2 NANOWIRE BY THE LIFTOFF PROCESS ***H. SHIBATA****, H. TAKESUE, T. HONJO, T. AKAZAKI, Y. TOKURA;* NTT BASIC RESEARCH LABORATORY. — TODAY, THE SUPERCONDUCTING SINGLE PHOTON DETECTOR (SSPD) BASED ON NBN SHOWS A HIGHEST PERFORMANCE AMONG THE SINGLE PHOTON DETECTORS IN THE INFRARED REGION. IF WE CAN REPLACE NBN TO MGB_2 IN SSPD, IT MAY BECOME AN ULTRAFAST SINGLE PHOTON DETECTOR WITH HIGHER OPERATING TEMPERATURE. ONE OF THE PROBLEMS USING MGB_2 IS THE NANO-FABRICATION PROCESS. HERE WE PRESENT THE NANOWIRE FABRICATION USING LIFTOFF PROCESS AND ITS SINGLE PHOTON DETECTION CAPABILITY. THE PATTERN IS DEFINED ON A SUBSTRATE USING AMORPHOUS SILICON AND CARBON BILAYER BY THE STANDARD LIFTOFF PROCESS. THEN, THE 10 NM- THICK MGB_2 FILM IS DEPOSITED BY THE MOLECULAR BEAM EPITAXY METHOD AND LIFTED OFF. THE 100 NM-WIDTH NANOWIRE WITH A T_C ~ 19 K AND I_C ~ 11 MA ARE OBTAINED BY THE METHOD. THE OPTICAL RESPONSES OF THE NANOWIRE ARE INVESTIGATED AT 405, 633, AND 1560 NM WAVELENGTHS. AT ALL WAVELENGTHS, SINGLE PHOTON DETECTION IS CONFIRMED AT APPROPRIATE BIAS CONDITIONS.

5EA-05

NEW GENERATION OF NANOWIRE NBN SUPERCONDUCTING SINGLE-PHOTON DETECTOR FOR MID-INFRARED ***G. GOLTSMAN****, Y. KORNEEVA, I. FLORYA, M. ELEZOV, P. AN, A. KORNEEV;* MOSCOW STATE PEDAGOGICAL UNIVERCITY. — WE PRESENT A BREAK-THROUGH APPROACH TO SINGLE-PHOTON DETECTION IN MIDDLE INFRARED BASED ON NANOWIRE NBN SUPERCONDUCTING SINGLE-PHOTON DETECTOR (SSPD). ALTHOUGH FOR TELECOM WAVELENGTHS (1.3 -1.55 UM) SSPD BECAME A MATURE TECHNOLOGY GIVING A BENEFIT OF HIGH COUNTING RATE, LOW DARK COUNTS, PICOSECOND TIMING RESOLUTION AND COMMERCIAL AVAILABILITY ITS FURTHER EXPANSION TO MID INFRARED WAS ESSENTIALLY HAMPERED BY A DRAMATICAL SENSITIVITY REDUCTION ABOVE 2 UM WAVELENGTH. WE MANAGED TO OVERCOME THIS LIMIT BY THE REDUCTION OF THE NANOWIRE WIDTH TO 50 NM COMPARED TO 100-120 NM FOR TYPICAL SSPD. TO PRODUCE A VOLTAGE RESPONSE OF SUFFICIENT MAGNITUDE WE CONNECTED THE WIRES IN PARALLEL COVERING 10 UM X 10 UM AREA. ALTHOUGH A CASCADE SWITCHING MECHANISM IN PARALLEL NANOWIRES HAS ALREADY BEEN REPORTED [1] WE WERE THE FIRST WHO MANAGED TO REDUCE THE WIRE WIDTH SIGNIFICANTLY WITHOUT ANY NOTICEABLE DAMAGE OF SUPERCONDUCTIVITY. THE NEW DEVICE EXHIBITS 20 TIMES BETTER SENSITIVITY AT 5 UM WAVELENGTH COMPARED TO "STANDARD" SSPD AND A SINGLE-PHOTON RESPONSE AT 10 UM WAVELENGTH.[1] M. EJRNAES, R. CRISTIANO, O. QUARANTA, S. PAGANO, A. GAGGERO, F. MATTIOLI, R. LEONI, B. VORONOV, G. GOLTSMAN "A CASCADE SWITCHING SUPERCONDUCTING SINGLE PHOTON DETECTOR" APL 91, (2007) 262509

5EPA-01

DATA-FLOW MICROARCHITECTURE FOR WIDE DATAPATH RSFQ PROCESSORS: DESIGN STUDY ***M. DOROJEVETS****, C. AYALA, A. KASPEREK;* STONY BROOK UNIVERSITY. — DEVELOPMENT OF AN EFFICIENT PROCESSOR ARCHITECTURE WITH APPROPRIATE CLOCKING MECHANISMS AND DATAPATH ORGANIZATION IS ONE OF THE MOST CHALLENGING DESIGN ISSUES FOR 32/-64 BIT RSFQ PROCESSORS. THE CELL-LEVEL DESIGN OF A 32-BIT RSFQ DUAL-LANE INTEGER PROCESSOR MICROARCHITECTURE WITH DATA-FLOW INSTRUCTION CONTROL HAS BEEN DEVELOPED AT STONY BROOK UNIVERSITY IN AN EFFORT TO IDENTIFY AND STUDY TECHNIQUES CAPABLE OF TOLERATING SIGNIFICANT DELAY VARIATIONS IN FUTURE WIDE DATAPATH SUPERCONDUCTOR PROCESSOR CIRCUITS. SEVERAL KEY PROCESSOR BLOCKS HAVE BEEN DESIGNED AND QUANTITATIVELY EVALUATED AT THE CELL-LEVEL, SPECIFICALLY: INSTRUCTION ISSUE & DECODE LOGIC, A MULTI-PORTED REGISTER FILE, A WAVE-PIPELINED ARITHMETIC-LOGIC UNIT, AND INTRA-PROCESSOR DATA ROUTING INTERCONNECT. SIMULATION AND ANALYSIS OF THESE BLOCKS HAVE BEEN DONE WITH THE USE OF A GENERIC VHDL CELL LIBRARY DEVELOPED AT STONY BROOK UNIVERSITY WITH CELL PARAMETERS TUNED TO HYPRES' 1.5 μM, 4.5 KA/CM^2 PROCESS. AFTER ASSEMBLING THESE BLOCKS TOGETHER INTO A 32-BIT PROCESSOR DATAPATH, AN ITERATIVE APPROACH HAS BEEN USED TO OPTIMIZE THE DESIGN AND REACH A 20 GHZ PROCESSING RATE. OVERALL, THE DATAPATH HAS THE TOTAL LATENCY OF ~20 CYCLES WITH THE DESIGN COMPLEXITY EXCEEDING 50K JJS.

THE CIRCUIT-LEVEL DESIGN OF THE CELL LIBRARY HAS BEEN DONE BY HYPRES, INC. THIS WORK HAS BEEN SUPPORTED THROUGH US ARO GRANTS W911NF-08-1-0239 AND W911NF-10-1-0012.

5EPA-02

ADVANCED BEHAVIORAL MODELING OF DIGITAL SUPERCONDUCTING ELECTRONICS BY INCLUDING TIMING AND JITTER INFORMATION *T. STOYADINOVA[1],* ***T. ORTLEPP[2]****, B. EBERT[2], V. MLADENOV[1], T. HADDAD[2], H. TOEPFER[2];* [1]TECHNICAL UNIVERSITY OF SOFIA, [2]ILMENAU UNIVERSITY OF TECHNOLOGY. — THE IMPEDANCE OF GATES IN DIGITAL SUPERCONDUCTING ELECTRONICS IS ONLY A FEW OHMS CAUSING A STRONG INTERACTION BETWEEN ADJACENT CELLS.

THE TERMINAL CURRENTS OF RSFQ CELLS ARE DATA-DEPENDENT, WHEREAS THE MAIN ASSUMPTION FOR STANDARD CELL-BASED DESIGN IS A WELL-DEFINED CONDITION AT ALL TERMINALS. THE TRANSITION FROM ANALOG CIRCUIT SIMULATION TO HIGH LEVEL BEHAVIORAL MODELS GOES ALONG WITH SIMPLIFICATIONS. OUR HIGH LEVEL BEHAVIOR MODELS CONTAIN TIMING INFORMATIONS SUCH AS PROPAGATION DELAY AND JITTER AS WELL AS SETUP AND HOLD TIME CONSTRAINTS. ALL TIMING INFORMATIONS ACCOUNT FOR THE DEPENDENCE ON THE DATA AND VOLTAGE SUPPLY WHICH ENABLES AN ADVANCED TIMING ANALYSIS.WE CREATED BEHAVIOR MODELS FOR A COUPLE OF LOGIC GATES WHICH INCLUDE A TEST OF ALL EXISTING TIMING CONSTRAINTS. ALL INFORMATIONS WERE EXTRACTED FROM ANALOG SIMULATIONS INCLUDING THERMAL NOISE. WE MODELED THE RESULTING TRANSITION REGIONS BETWEEN CORRECT OPERATION AND SWITCHING ERRORS AND DEMONSTRATE THE CAPABILITIES BY ANALYZING DECIMATION FILTERS. IT IS DEMONSTRATED THAT THE METHOD ALLOWS A PREDICTION OF THE OPERATION RANGE AND EVEN OF THE BIT ERROR RATE VERSUS CLOCK FREQUENCY AND VERSUS SUPPLY VOLTAGE.

5EPA-03

VHDL MODELS OF COMBINATORIAL GATES IN RECIPROCAL QUANTUM LOGIC ***A. HERR;*** NORTHROP GRUMMAN CORPORATION. — WE HAVE DEVELOPED A VHDL LIBRARY FOR A NEW RECIPROCAL QUANTUM LOGIC THAT USES SFQ DATA ENCODING BUT AC CLOCK REFERENCE. THE LOGIC ALLOWS IMPLEMENTATION OF COMBINATIONAL GATES WITH VHDL MODELS SIMILAR TO CMOS. THE VHDL MODELS USE TIMING PARAMETERS EXTRACTED FROM PHYSICAL SIMULATION AND FIT TO A FUNCTION OF AC CLOCK FREQUENCY AND PHASE. THE VHDL MODELS WERE VALIDATED BY COMPARING DIGITAL AND PHYSICAL SIMULATION OF AN EIGHT-BIT CARRY-LOOK AHEAD ADDER, RESULTING IN A 20 GHZ MAXIMUM CLOCK FREQUENCY AND 1.25 CLOCK CYCLES LATENCY.

5EPB-01

INTRINSIC JOSEPHSON JUNCTIONS MADE FROM THIN-FILM-LIKE BSCCO SINGLE CRYSTALS *X. WANG[1], **L. YOU**[1], X. YANG[1], Z. WANG[2];* [1]SHANGHAI INSTITUTE OF MICROSYSTEM AND INFORMATION TECHNOLOGY (SIMIT), CHINESE ACADEMY OF SCIENCE (CAS), [2]DEPARTMENT OF MATHEMATICS, SHANGHAI JIAOTONG UNIVERSITY. — CONVENTIONAL INTRINSIC JOSEPHSON JUNCTIONS (IJJS) MADE OF BI2SR2CACU2O(8+X) SINGLE CRYSTALS HAVE A THICK SUPERCONDUCTING PEDESTAL AND/OR A THICK GLUE LAYER BETWEEN IJJS AND THE SUBSTRATE, WHICH CAUSE AN INFERIOR THERMAL CONTACT BETWEEN IJJS AND THE SUBSTRATE. BESIDES, IT IS INCOMPATIBLE WITH THE MICRO/NANO-FABRICATION PROCESS WHEN A FINE DEVICE STRUCTURE AND PRECISE ALIGNMENT ARE REQUIRED. ON THE OTHER HAND, THE THICK SUPERCONDUCTING PEDESTAL MAY BLOCK THE SIGNAL WHEN IJJS WORK AS A DETECTOR AND THE SIGNAL IS IRRADIATED FROM THE BACKSIDE OF THE SUBSTRATE. WE PRODUCE THIN-FILM-LIKE BSCCO SINGLE CRYSTALS, WHICH HAS A TYPICAL THICKNESS OF 30-200 NM. IT IS SIGNIFICANT FOR IJJS' FABRICATION AND APPLICATIONS. IJJS MADE OF THIN-FILM-LIKE BSCCO SINGLE CRYSTALS ARE REALIZED AND MEASURED. THIS TYPE OF MATERIALS MAY ALSO BE INTERESTING FOR FABRICATING NOVEL DEVICES LIKE SUPERCONDUCTING HOT ELECTRON BOLOMETERS AND SINGLE PHOTON DETECTORS.

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5EPB-02

INTRINSIC JOSEPHSON JUNCTIONS IN BI-2212 THIN FILMS FABRICATED BY METAL-ORGANIC DECOMPOSITION *K. HAMANAKA, K. OHO,* ***T. TACHIKI,*** *T. UCHIDA;* NATIONAL DEFENSE ACADEMY. — BI-2212 INTRINSIC JOSEPHSON JUNCTIONS (IJJS) ARE GOOD CANDIDATES FOR CW SOLID-STATE OSCILLATORS IN A TERAHERTZ (THZ) RANGE. OZYUZER ET AL. HAVE OBSERVED THZ WAVES EMITTED FROM A MESA FABRICATED IN A BULK SINGLE CRYSTAL OF BI-2212 [1]. FOR PRACTICAL APPLICATIONS, HOWEVER, IT IS IMPORTANT TO FABRICATE IJJS IN HIGHLY ORIENTED BI-2212 THIN FILMS WITH LARGE FLAT GRAINS INCLUDING HUNDREDS OF IJJS. METAL-ORGANIC DECOMPOSITION (MOD) IS A SUITABLE METHOD FOR OBTAINING SUCH FILMS WITH A LOW RUNNING COST. WE FABRICATED BI-2212/MGO THIN FILMS BY MOD WITH FACE-TO-FACE ANNEALING [2]. THE FILMS WITH THICKNESSES OF 120 AND 240 NM SHOWED EXCELLENT UNIFORMITY IN THE BI-2212 PHASE AND IN-PLANE ORIENTATION. MESAS SURROUNDED BY CAF_2 INSULATING LAYERS WERE FABRICATED IN THE 240-NM THICK FILMS BY STANDARD PHOTOLITHOGRAPHY AND AR-ION MILLING TECHNIQUE. AN AREA OF THE MESA WAS 10 BY 10 SQUARE MICROMETERS, AND A MESA HEIGHT WAS MORE THAN 150 NM. A MULTI-BRANCH STRUCTURE WITH APPROXIMATELY 100 BRANCHES WAS CLEARLY OBSERVED IN I-V CHARACTERISTICS OF THE MESA. CRITICAL CURRENT DENSITIES OF THE INDIVIDUAL BRANCHES WERE AROUND 1 KA/CM^2 AT 4.2 K. THESE RESULTS IMPLY THAT THE THIN FILMS FABRICATED BY MOD HAVE ELECTRICAL PROPERTIES OF IJJS WHICH ARE APPLICABLE TO THZ-WAVE OSCILLATORS. [1] L. OZYUZER ET AL. SCIENCE (2007) 1291. [2] K.HAMANAKA ET AL. JPN. J. APPL. PHYS. 48 (2009) 125502.

5EPB-03

CHARACTERIZATION OF BI2SR2CACU2OX STACKS FABRICATED BY ACID TREATMENT PROCESS ***T. KATO[1]**, H. MIZUMARU[1], T. ASANO[1], H. SHIMAKAGE[2], J. CHEN[3], K. HAMASAKI[1];* [1]NAGAOKA UNIVERSITY OF TECHNOLOGY, [2]NATIONAL INSTITUTE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY, [3]NANJING UNIVERSITY. — WE FABRICATED $BI_2SR_2CACU_2O_X$ (BI-2212) STACKS OF THE INTRINSIC JOSEPHSON JUNCTIONS BY AN ACID-TREATMENT PROCESS FROM INSIDE A SINGLE CRYSTAL. THE KEY POINT OF THIS PROCESS IS THAT THE SURROUNDING ACID-TREATED PRODUCT (BIOCL) IS TRANSPARENT MATERIAL. IN THE PROCESS, WE USED THE OPTICAL ADHESIVE NOA-61 TO FIX THE PEACE OF THE CRYSTAL ON A GLASS SUBSTRATE AND TO COAT THE SURFACE OF THE SAMPLE. AT *T*=77K THE CURRENT-

VOLTAGE CHARACTERISTICS OF THE STACKS EXHIBITED LARGE HYSTERESES AND MULTIPLE BRANCHES WITH VOLTAGE SPACING OF ABOUT 2 MV. IN EXTERNAL MICROWAVE FIELDS OF THE FREQUENCY RANGE 2-18 GHZ, CLEAR SHAPIRO STEPS WERE OBSERVED AT THE VOLTAGES OF (H/2E)F MULTIPLES. ALSO, WE INVESTIGATED THE THERMAL CYCLING PROPERTIES OF THE CRITICAL CURRENT (I_C). NO APPARENT DEGRADATION OF THE I_C WAS OBSERVED DURING REPEATED THERMAL CYCLING BETWEEN 300 K AND 77 K

5EPB-04

SHAPIRO STEP RESPONSE OF INTRINSIC JOSEPHSON JUNCTIONS WITH HIGH CRITICAL CURRENTS OF ($BI_{1-x}PB_x)_2SR_2CACU_2O_Y$ *N. OTHMAN, **G. OYA**, M. KITAMURA, A. IRIE;* UTSUNOMIYA UNIVERSITY. — WE HAVE STUDIED THE RESPONSE OF INTRINSIC JOSEPHSON JUNCTIONS (IJJS) IN MINIATURIZED CROSS-SHAPED SAMPLES OF ($BI_{1-x}PB_x)_2SR_2CACU_2O_Y$ WITH HIGH CRITICAL CURRENTS (I_C) AT 4.2 K TO INJECTION OF MICROWAVE WITH FREQUENCIES (F_{RF}) OF 2-20 GHZ. AT THE EARLY STAGE OF MEASUREMENTS JOSEPHSON VORTEX FLOW IS INDUCED IN THE IJJS BY SUPPLYING HIGH CURRENTS (I) TO THEM. AFTER THAT, BY INJECTION OF MICROWAVE POWER (P) TO THEM CLEAR CONSTANT VOLTAGE STEPS ARE SUCCESSFULLY OBSERVED ON THEIR CURRENT-VOLTAGE (I - V) CHARACTERISTICS, ALTHOUGH THEIR PLASMA FREQUENCY (F_{PL}) IS MUCH HIGHER THAN F_{RF} AND THEY ARE NOT RESISTIVELY SHUNTED. THE CONSTANT VOLTAGE STEPS APPEAR FROM AN IJJ OF EACH SAMPLE TO SATISFY THE JOSEPHSON FREQUENCY-VOLTAGE RELATION AND BEHAVE LIKE SHAPIRO STEPS DEPENDING ON P. SUCH BEHAVIOR OF STEPS IS WELL SHOWN BY NUMERICAL SIMULATIONS ON SHAPIRO STEP RESPONSE OF A JJ WITH A SHUNT RESISTIVITY CORRESPONDING TO THE OBSERVED RESISTIVITY OF JOSEPHSON VORTEX FLOW. CONSEQUENTLY, THE OBSERVED CONSTANT VOLTAGE STEPS MAY BE SHAPIRO STEPS AS A MICROWAVE RESPONSE OF THE IJJ WITH A JOSEPHSON VORTEX FLOW RESISTIVITY.

THIS WORK WAS SUPPORTED IN PART BY THE GRANT-IN-AID FOR SCIENCE RESEARCH FROM THE MINISTRY OF EDUCATION, SCIENCE, SPORTS AND CULTURE OF JAPAN, AND ALSO PARTLY SUPPORTED BY TUN HUSSEIN ONN UNIVERSITY, MALAYSIA.

5EPB-05

EXPERIMENT EVIDENCE OF QUANTUM FLUCTUATION AT 30 K IN SUBMICRON AREA OF BI2SR2CACU2O8+Δ (BI-2212) SINGLE CRYSTAL WHISKER ***S. SAINI**, S. KIM;* JEJU NATIONAL UNIVERSITY. — TO OBSERVE QUANTUM EFFECT AT 30 K WE HAVE FABRICATED VARIOUS IN-PLANE AREA INTRINSIC JOSEPHSON JUNCTION (IJJ) STACKS FROM 4 μM2 DOWN TO 0.16 μM2 IN BI2SR2CACU2O8+Δ (BI-2212) SINGLE CRYSTAL WHISKER THROUGH THREE-DIMENSIONAL FOCUSED ION BEAM ETCHING TECHNIQUE. THE TUNNELING OF COOPER PAIRS IS MORE PRECISE WHEN THE NORMAL RESISTANCE OF A SUBMICRON JUNCTION BELONGS IN THE RANGE OF QUANTUM RESISTANCE AND THE CHARACTERISTICS OF JUNCTIONS ARE CHANGED WITH QUANTUM EFFECT. A STRONG SUPPRESSION IN CRITICAL CURRENT DENSITY (JC) IS NOTICED IN CURRENT-VOLTAGE CHARACTERISTICS FOR STACKS OF IN-PLANE AREA S < 1 μM2 AT 30 K. THIS SUPPRESSION IN JC IS ATTRIBUTED DUE TO QUANTUM FLUCTUATIONS OF PHASE AND HAS REPORTED FOR THE FIRST TIME EVER AT 30 K. THE CONDITIONS FOR QUANTUM REGION (CHARGING ENERGY > JOSEPHSON ENERGY, THERMAL ENERGY, AND DAMPING RATE) ARE OBEYED BY SUBMICRON JUNCTIONS AT 30 K. THE ESTIMATED RATIO OF JOSEPHSON ENERGY AND CHARGING ENERGY IS LESS THAN 1 FOR SUBMICRON STACKS WHICH INDUCED THESE QUANTUM FLUCTUATIONS. THE ARRAY OF IJJS STACK IS FOLLOWING THE AMBEGAOKAR-BARATOFF RELATION AND REFLECTS A GOOD QUALITY JUNCTION IN SUBMICRON RANGE AS WELL.

5EPB-06

FOCUSSED-ION-BEAM DEPOSITION OF COMPACT ON-CHIP RESISTORS FOR ENVIRONMENTAL ISOLATION OF INTRINSIC JOSEPHSON JUNCTIONS ***S. SALEEM**[1], J. C. FENTON[1], M. KORSAH[2], S. C. SPELLER[2], C. R. M. GROVENOR[2], P. A. WARBURTON[1];* [1]UNIVERSITY COLLEGE LONDON, [2]UNIVERSITY OF OXFORD. — THE IMPEDANCE OF THE ENVIRONMENT INFLUENCES BOTH THE DYNAMICS OF [1] AND THE COUPLING OF R.F. RADIATION TO [2,3] INTRINSIC JOSEPHSON JUNCTIONS (IJJS). TO ISOLATE A JUNCTION FROM ITS ENVIRONMENT, RESISTORS ARE PLACED IN SERIES WITH IT, THESE HAVING RESISTANCE OF ORDER A KILOOHM. IN ORDER THAT THE IMPEDANCE SEEN BY THE JUNCTION AT ITS PLASMA FREQUENCY F_P IS PURELY RESISTIVE, THE SIZE OF THE RESISTOR AND ITS SEPARATION FROM THE JUNCTION MUST BE MUCH LESS THAN THE WAVELENGTH. FOR TLBACACUO IJJS (F_P ~ 800 GHZ) ON $LAALO_3$ SUBSTRATES, THIS CRITICAL SIZE IS ~10 MICRONS. WE HAVE GROWN SUCH RESISTORS USING FOCUSSED-ION-BEAM (FIB) DEPOSITION. HERE $W(CO)_6$ IS ADSORBED ONTO THE SUBSTRATE AND CRACKED BY A 30 KEV GA^+ ION BEAM, RESULTING IN DIRECT-WRITING OF A W-RICH AMORPHOUS MATERIAL WITH RESISTIVITY OF ORDER 0.1 MOHM CM. THE CONTACT RESISTANCE BETWEEN THE FIB-DEPOSITED RESISTORS AND THE TLBACACUO FILM IS MINIMISED BY USE OF AN INTERPOSED GOLD FILM. AS A RESULT THE RESISTANCE IS DOMINATED BY THE BULK RESISTANCE OF THE FIB-DEPOSITED MATERIAL. FURTHERMORE THE W-RICH MATERIAL SHOWS A SUPERCONDUCTING TRANSITION AT T_{CW}=5.2 K, ALLOWING US TO COMPARE THE DYNAMICS OF THE IJJS WHEN THEY ARE COUPLED TO THE ENVIRONMENT ($T<T_{CW}$) AND DECOUPLED FROM IT ($T >T_{CW}$).[1] P. A. WARBURTON *ET AL. PHYS. REV. LETT.* **103** 217002 (2009)[2] S. SALEEM *ET AL. IEEE TRANS. APPL. SUPERCOND.* **19** 734 (2009)[3] J. LEINER *ET AL. APPL. PHYS. LETT.* **95** 252505 (2009)

THIS WORK IS SUPPORTED BY EPSRC

5EPC-01

SYMMETRY OF THE ENERGY GAP IN MGB2 FROM MICROWAVE MEASUREMENTS AND IMPLICATIONS FOR APPLICATIONS ***D. E. OATES**[1], Y. D. AGASSI[2], B. H. MOECKLY[3];* [1]MIT LINCOLN LABORATORY, [2]NAVAL SURFACE WARFARE CENTERCARDEROCK DIVISION, BETHESDA MD, USA, [3]STI INC.

SANTA BARBARA, CA, USA. — MGB2 IS OF INTEREST FOR MICROWAVE APPLICATIONS THAT UTILIZE THE LOW LOSSES, HIGH POWER HANDLING, AND HIGH TEMPERATURE OF OPERATION. WE HAVE MEASURED THE LINEAR AND NONLINEAR MICROWAVE-FREQUENCY PROPERTIES OF MGB2 THIN FILMS DEPOSITED BY A REACTIVE EVAPORATION PROCESS THAT HAS BEEN DESCRIBED PREVIOUSLY. THE MEASUREMENTS FROM T =1.6 K TO THE TC OF 39 K WERE CARRIED OUT IN A STRIPLINE RESONATOR AT 2.2 GHZ FOR FILMS ON DIELECTRIC SUBSTRATES AND IN A DIELECTRIC RESONATOR AT 10.7 GHZ FOR FILMS ON METALLIC SUBSTRATES. LOSSES ARE LOWER THAN NIOBIUM FILMS AT COMPARABLE TEMPERATURES. INTERMODULATION DISTORTION (IMD) MEASUREMENTS SHOW AN INCREASE AT LOW TEMPERATURE THAT IS CHARACTERISTIC OF THE NONLINEAR MEISSNER EFFECT, INDICATING UNCONVENTIONAL SYMMETRY WITH NODAL LINES IN ONE OF THE TWO ENERGY GAPS OF MGB2. GOOD AGREEMENT BETWEEN OUR THEORY AND EXPERIMENT IS ACHIEVED WITH A SIX-FOLD SYMMETRY CONSISTENT WITH THE HEXAGONAL SYMMETRY OF MGB2, LEADING TO SIX NODAL DIRECTIONS IN THE BASAL PLANE. WE HAVE ALSO OBSERVED A PARAMAGNETIC MEISSNER EFFECT IN WHICH THE PENETRATION DEPTH INCREASES AT LOW TEMPERATURES. THIS EFFECT RESULTS FROM ANDREEV-BOUND STATES AT THE SURFACE OF A NODAL SUPERCONDUCTOR. OUR THEORETICAL CALCULATIONS SHOW EXCELLENT AGREEMENT WITH THE MEASUREMENTS THUS CONFIRMING THE UNCONVENTIONAL SYMMETRY. WE WILL DISCUSS THE IMPLICATIONS OF THESE FINDINGS FOR POTENTIAL APPLICATIONS.

THIS WORK WAS SUPPORTED BY THE OFFICE OF NAVAL RESEARCH.

5EPC-02

MECHANISMS FOR ELECTROMAGNETIC RADIATION FROM SINGLE AND STACKED JOSEPHSON JUNCTIONS IN A CAVITY *S. MADSEN[1], V. PIERRO[2], G. FILATRELLA[2], P. L. CHRISTIANSEN[3],* ***N. F. PEDERSEN***[3]*;* [1]UNIVERSITY OF SOUTHERN DENMARK, [2]UNIVERSITY OF SANNIO, [3]TECHNICAL UNIVERSITY OF DENMARK. — RADIATION FROM A SINGLE JOSEPHSON JUNCTION IN A CAVITY HAS BEEN KNOWN FOR A LONG TIME. ONE MODEL SUGGESTS THAT BY PARAMETRIC INTERACTION BETWEEN THE JUNCTION AND THE CAVITY A NEGATIVE INPUT IMPEDANCE MAY BE CREATED - LEADING TO RADIATION EMISSION. THIS IS THE CASE WHEN THE JUNCTION IS BIASED AT FINITE VOLTAGE AS WELL AS AT ZERO VOLTAGE WITH A PUMP SIGNAL. RECENTLY, EMISSION OF ELECTROMAGNETIC RADIATION FROM BSCCO SAMPLES AT THZ FREQUENCIES HAS BEEN REPORTED. IN SEVERAL CASES THIS EMISSION TOOK PLACE WHEN THE IV-CURVE HAD A NEGATIVE DIFFERENTIAL RESISTANCE. WE THEREFORE PROPOSE TO EMPLOY THE STANDARD MODEL OF EXTERNALLY PUMPED JOSEPHSON JUNCTIONS COUPLED TO A RESONATOR AND A CIRCULATOR. IN THE LONG JUNCTION CASE, THE KEY POINT FOR THE OSCILLATOR PERFORMANCE IS THE MOTION OF FLUXONS IN THE JUNCTIONS, SHUTTLING NEAR THE RESONANCE FREQUENCY OF THE RESONATOR, WHERE THE IV-CURVE POTENTIALLY SHOWS NEGATIVE DIFFERENTIAL RESISTANCE. WE PLAN TO EXPLOIT THE SIMILARITY WITH EXTERNALLY PUMPED SHORT JUNCTION AT ZERO VOLTAGE, WHERE THE NEGATIVE INPUT IMPEDANCE MAY BE TREATED ANALYTICALLY. WE SPECULATE THAT EMISSION DUE TO A NEGATIVE DIFFERENTIAL RESISTANCE IS GENERIC. THE GUNN DIODE IS A WELL KNOWN EXAMPLE.

5EPC-03

INTRINSIC SURFACE RESISTANCE OF YBCO THIN FILMS UNDER THE DC MAGNETIC FIELD ***K. NAKAGAWA***[1]*, T. HONMA[1], S. NAKAYAMA[1], S. ONO[1], H. KAI[2], A. SAITO[1], M. MUKAIDA[2], K. NAKAJIMA[1], S. OHSHIMA[1];* [1]YAMAGATA UNIVERSITY, [2]KYUSHU UNIVERSITY. — WE INVESTIGATED THE DC MAGNETIC FIELD AND TEMPERATURE DEPENDENCES OF THE MICROWAVE INTRINSIC SURFACE RESISTANCE (RS^{INT}) OF YBCO SUPERCONDUCTING THIN FILMS WITH VARIOUS THICKNESS. WE USED FROM 100 NM TO 700 NM THICK YBCO FILMS DEPOSITED ON MGO SUBSTRATES. THE RS^{INT} MEANS THE SURFACE RESISTANCE OF YBCO FILM WITHOUT THE DIELECTRIC LOSS OF THE SUBSTRATES. THE RS^{INT} COULD BE OBTAINED FROM MEASURED SURFACE RESISTANCE (RS) BY USING THE PHENOMENOLOGICAL EQUATION. THE RS WAS MEASURED USING THE DIELECTRIC RESONATOR METHOD AT 21.8 GHZ. A DC MAGNETIC FIELD OF UP TO 5.0 T WAS APPLIED PARALLEL TO THE C-AXIS OF THE SUPERCONDUCTING THIN FILMS DURING THE RS MEASUREMENTS. THE RS^{INT} OF THE YBCO THIN FILMS WAS INCREASED WITH THE APPLIED DC MAGNETIC FIELD. THESE RELATION COULD BE EXPLAINED BY USING THE TWO-FLUID MODEL FOR HIGH FREQUENCY AND LOW MAGNETIC FIELD LIMITS. THE RS^{INT} RATIO (DEFINED AS RS^{INT} (5T)/RS^{INT} (0T)) LINEARLY INCREASED WITH THE FILM THICKNESS. THESE RELATION CAN BE EXPRESSED BY THE VISCOUS DRAG COEFFICIENT OF YBCO FILMS.

THIS WORK WAS SUPPORTED BY GRANT-IN-AID FOR YOUNG SCIENTISTS (B) (21760246) AND TELECOMMUNICATIONS ADVANCEMENT FOUNDATION. A PART OF THIS WORK WAS CARRIED OUT IN THE CLEAN ROOM OF YAMAGATA UNIVERSITY.

5EPC-04

MM WAVE SURFACE IMPEDANCE CHARACTERIZATION OF HTS FILMS AND SINGLE CRYSTALS USING QUASI-OPTICAL SAPPHIRE RESONATORS ***N. T. CHERPAK***[1]*, A. A. BARANNIK[1], S. A. BUNYAEV[1], Y. V. PROKOPENKO[1], K. I. TOROKHTII[2], S. A. VITUSEVICH[3];* [1]USIKOV IRE NAS OF UKRAINE, [2]NATIONAL TECHNICAL UNIVERSITY-KHPI, [3]INSTITUT FUER BIO- UND NANOSYSTEME (IBN), JUELICH-AACHEN RESEARCH ALLIANCE FOR FUTURE INFORMATION TECHNOLOGY (JARA-FIT),FORSCHUNGSZENTRUM JUELICH. — HIGH-Q QUASI-OPTICAL DIELECTRIC RESONATORS (QDRS), I.E. RESONATORS EXCITED ON WHISPERING-GALLERY MODES (WGM), ARE KEY TECHNIQUES FOR ACCURATE CHARACTERIZATION OF SURFACE IMPEDANCE IN MM WAVELENGTH RANGE OF HTS LARGE-AREA FILMS AND SMALL SINGLE CRYSTALS, INCLUDING VARIOUS UNCONVENTIONAL SUPERCONDUCTORS. A NUMBER

OF MODIFICATIONS OF MILLIMETER-WAVE QDRS WERE PROPOSED BY THE AUTHORS FOR CHARACTERIZATION OF SURFACE RESISTANCE FOR LARGE AREA FILM. IN THIS WORK, TECHNIQUE FOR CHARACTERIZATION OF SURFACE IMPEDANCE FOR HTS FILMS USING HEMISPHERICAL QDR IS ANALYSED THEORETICALLY AND CONFIRMED EXPERIMENTALLY. IN ADDITION, WE DEMONSTRATE THAT QDR OF MODIFIED FORMS CAN BE USED. THE SPECTRAL PECULIARITIES OF TWO KINDS OF SAPPHIRE RESONATORS: HEMISPHERICAL AND RADIALLY-SLOTTED DISC ARE ANALYSED. THE FIRST KIND OF THE RESONATORS IS DEVELOPED FOR CHARACTERIZATION OF LARGE-AREA FILMS AND THE SECOND - FOR SMALL SAMPLES. THE TEMPERATURE DEPENDENCES OF SURFACE IMPEDANCE PROPERTIES ARE STUDIED IN KA-BAND FOR THE YBACUO FILMS USING HEMISPHERICAL RESONATOR AND FOR THE FE-BASED PNICTIDE SINGLE-CRYSTAL USING RADIALLY-SLOTTED ONE. ADVANTAGES AND DISADVANTAGES OF THE PROPOSED MEASUREMENT TECHNIQUES ARE CONSIDERED AND COMPARED WITH OTHER RESONATOR APPROACHES. PERSPECTIVES FOR APPLICATION OF THE PROPOSED SAPPHIRE QDRS FOR HTS CHARACTERIZATION AND FUNDAMENTAL RESEARCH ARE DISCUSSED.

THIS WORK WAS SUPPORTED IN PART UNDER IRE NAS OF UKRAINE

5EPC-05

EVEN AND ODD ORDER INTERMODULATION NONLINEARITY FROM A SUPERCONDUCTIVE MICROSTRIP LINE ***S. K. REMILLARD***[1]*, V. BUNNELL*[1]*, E. K. PEASE*[1]*, S. C. LEE*[2]*;* [1]HOPE COLLEGE, [2]MERCER UNIVERSITY. — THREE-TONE INTERMODULATION DISTORTION (IMD) WAS USED TO MEASURE THE EVEN AND ODD ORDER MICROWAVE NONLINEARITY OF A SUPERCONDUCTING $TL_2BA_2CACU_2O_8$ RESONATOR. BY USING AN OFF-RESONANCE PROBE SIGNAL, THE IMD GENERATION IS STIMULATED LOCALLY IN THE VICINITY OF THE PROBE. BOTH 2^{ND} AND 3^{RD} ORDER IMD APPEAR AT THE MICROWAVE RESONANT FREQUENCY, PROVIDING A SYNCHRONOUS COMPARISON OF THE LOCAL EVEN AND ODD ORDER NONLINEARITIES AND A QUANTITATIVE DETERMINATION OF THE CURRENT DENSITIES THAT PRODUCE THE INTERMODULATION DISTORTIONS. COMPARISON OF SYNCHRONOUS 2^{ND} AND 3^{RD} ORDER IMD PROVIDES A CHARACTERIZATION OF THE EXTENT OF TIME REVERSAL SYMMETRY BREAKING (TRSB) IN THE SUPERCONDUCTOR. AS THE PROBE IS SCANNED ACROSS THE RESONATOR, THE DEGREE OF TRSB IS SEEN TO VARY IN DIFFERENT REGIONS, BUT IN ALL LOCATIONS A SIGNIFICANT RISE IS SEEN IN THE 3^{RD} ORDER IMD AT THE CRITICAL TEMPERATURE, T_C, CONSISTENT WITH EXPECTATION FROM THE NONLINEAR MEISSNER EFFECT AND VANISHING 2^{ND} ORDER IMD INDICATING A REDUCTION IN TRSB AT T_C.

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5EPC-06

SUPERCONDUCTING LUMPED ELEMENT RESONATORS AS PROBES OF DIELECTRICS ***T. LINDSTROM***[1]*, J. E. HEALEY*[2]*, Y. HARADA*[3]*, Y. SEKINE*[3]*, M. S. COLCLOUGH*[2]*, C. M. MUIRHEAD*[2]*, A. Y. TZALENCHUK*[4]*;* [1]NATIONAL PHYSICAL LABORATORY&ROYAL HOLLOWAY, UNIVERSITY OF LONDON, [2]UNIVERSITY OF BIRMINGHAM, [3]NTT BASIC RESEARCH LABORATORIES, [4]NATIONAL PHYSICAL LABORATORY. — MOST METHODS FOR INVESTIGATING THE PROPERTIES OF DIELECTRICS CAN ONLY BE USED TO PROBE THE PROPERTIES OF THE BULK, BUT THERE ARE NOW AN INCREASING NUMBER OF APPLICATIONS WHERE THE PROPERTIES OF THIN DIELECTRIC FILMS, SURFACES AND INTERFACES ARE CRITICAL. THIS IS PARTICULARLY TRUE IN AREAS LIKE QIP WHERE DEVICES ARE OPERATED AT MK TEMPERATURES AND SINGLE-PHOTON ENERGIES.HERE WE DISCUSS HOW WE USE PLANAR LUMPED ELEMENT RESONATORS TO PROBE THE PROPERTIES OF DIELECTRICS (1). OUR RESONATORS ARE DESIGNED TO HAVE RESONANCE FREQUENCIES IN THE C-BAND (4-8GHZ) AND HAVE INTRINSIC QUALITY FACTORS IN THE RANGE 75 000-300 000. MANY RESONATORS ARE FABRICATED ON THE SAME CHIP AND MEASURED IN PARALLEL USING FREQUENCY MULTIPLEXING. THEY ARE CHARACTERIZED IN THE TEMPERATURE RANGE 40MK-1K AND AT VERY LOW POWER LEVELS. THIS GIVES US DIRECT INFORMATION ABOUT LOSSES AND LOSS MECHANISM OVER A WIDE FREQUENCY RANGE.BY SELECTIVELY DEPOSITING DIELECTRIC FILMS ON ONE OR A FEW RESONATORS ON A CHIP IT IS ALSO POSSIBLE TO EVALUATE DIFFERENT MATERIALS AS WELL AS DIFFERENT DEPOSITION METHODS.1. T. LINDSTRÖM, J. E. HEALEY, M. S. COLCLOUGH, C.M. MUIRHEAD AND A. YA. TZALENCHUK, PHYSICAL REVIEW B. VOL 80, 132501(2009)

THIS WORK WAS SUPPORTED BY EPSRC AND THE NATIONAL MEASUREMENT OFFICE

5EPC-07

MICROWAVE PROPERTIES OF FE-BASED SUPERCONDUCTING THIN FILMS ***S. LUO***[1]*, Y. WU*[1]*, S. ZHOU*[2]*, X. WANG*[2]*, L. CAO*[2]*, Y. HE*[2]*, N. T. CHERPAK*[3]*, V. N. SKRESANOV*[3]*, A. BARANNIK*[3]*;* [1]DEPARTMENT OF PHYSICS, UNIVERSITY OF SCIENCE AND TECHNOLOGY BEIJING, [2]INSTITUTE OF PHYSICS, CHINESE ACADEMY OF SCIENCES, [3]INSTITUTE OF RADIO-PHYSICS AND ELECTRONICS, NATIONAL ACADEMY OF SCIENCES OF UKRAINE. — HIGH QUALITY EPITAXIAL THIN FILMS OF $FESE_{1-X}TE_X$ (X=0-1) HAVE BEEN SUCCESSFULLY FABRICATED. THEIR SUPERCONDUCTING TRANSITION TEMPERATURES ARE AROUND 8-13 K. ONE INTRIGUING FACT HAS BEEN FOUND THAT SUPERCONDUCTIVITY APPEARS WHEN THE FIRST-ORDER MAGNETIC AND STRUCTURAL PHASE TRANSITION SOFTENS, AND WHEN THE FE-TE-FE BOND ANGLES BECOME LARGER. MICROWAVE PROPERTIES OF THESE FILMS WERE STUDIED BY A SAPPHIRE DIELECTRIC CAVITY AT 9.315 GHZ. THE CAVITY HAS A Q-FACTOR OF 45000 IN ROOM TEMPERATURE WITH TE_{011}-MODE. THIN FILM SAMPLE WITH DIMENSION OF 1-2 MM CAN BE PUT IN THE MIDDLE OF THE SMALL HOLE OF THE SAPPHIRE CYLINDER, SUPPORTED BY A VERY THIN SAPPHIRE ROD. THE CAVITY IS SEALED IN A VACUUM CHAMBER SOAKED IN THE LIQUID ^{4}HE AND THE TEMPERATURE OF THE THIN SAPPHIRE

ROD (HENCE THE SAMPLE) CAN BE CONTROLLED FROM 1.6K TO 60K WITH A STABILITY ABOUT +/- 1 MK. TEMPERATURE DEPENDENCE OF TRANSMISSION RESPONSE AND Q-FACTORS WERE MEASURED BY A NETWORK ANALYZER (AGILENT N5230C). PRELIMINARY RESULTS SHOWED NO EVIDENCES OF EXISTENCE OF NODE IN THE ENERGY GAP AS THE NORMALIZED CHANGE IN THE SURFACE REACTANCE AND THE CORRESPONDING NORMALIZED CHANGE IN THE IN-PLANE PENETRATION DEPTH HAVE FLAT DEPENDENCE AT LOW TEMPERATURES. MOREOVER THE NORMALIZED TEMPERATURE DEPENDENT SUPERFLUID DENSITY INDICATES A FULL-GAP SUPERCONDUCTING STATE. FURTHER ANALYSIS IS BEING CARRIED OUT.

THIS WORK WAS SUPPORTED IN PART BY CHINESE NATURAL SCIENCE FOUNDATION (GRANT NO. 10974014), AND BY THE EXTERNAL COOPERATION PROGRAM OF THE CHINESE ACADEMY OF SCIENCES (GRANT NO. GJHZ1007)

5EPC-08

MICROWAVE DEPENDENCE OF A-AXIS ORIENTED YBA2CU3O7 THIN FILM ***S. SAINI***[1]*, M. TAKAMURA*[2]*, M. MUKAIDA*[2]*, S. KIM*[1]*;* [1]JEJU NATIONAL UNIVERSITY, [2]FACULTY OF ENGINEERING, KYUSHU UNIVERSITY. — A-AXIS ORIENTED YBA2CU3O7 (Y-123) THIN FILMS WERE GROWN ON SRLAGAO4 (100) SUBSTRATE WITH A BUFFER LAYER OF 50 NM THICK GD2CUO4 USING PULSED LASER DEPOSITION. THE THICKNESS OF Y-123 THIN FILM IS ABOUT 500 NM. CUO2 PLANES ARE ALIGNED PERPENDICULAR TO THE SUBSTRATE IN THE THIN FILMS. THE BRIDGE TYPE PATTERN WAS FABRICATED USING FOCUSED ION BEAM MILLING TECHNIQUE IN SUCH A WAY THAT THE CURRENT WAS FORCED TO FLOW ALONG THE C-AXIS IN THIN FILM. THE DIMENSIONS OF BRIDGE ARE 1 μM IN LENGTH ALONG THE C-AXIS AND 3 μM IN WIDTH ALONG THE B-AXIS. THE RESISTANCE VS TEMPERATURE (R-T) CHARACTERISTICS ACROSS THE BRIDGE SHOW TRANSITION TEMPERATURE (TC ON) OF 89 K. THE CRITICAL CURRENT DENSITY (JC) OF 5 X 106 A/CM2 WAS MEASURED FROM CURRENT-VOLTAGE (I-V) CHARACTERISTICS AT 30 K. THE SAMPLES WERE IRRADIATED WITH EXTERNAL MICROWAVE UP TO 40 GHZ AND THE JC WAS SUPPRESSED AS WE INCREASED THE POWER. THIS SUPPRESSION IN JC INDICATES THE FORMATION OF LAYERED STRUCTURE WITH STRONG COUPLING. THE TRANSPORT CHARACTERISTICS OF THESE THIN FILMS WILL BE DISCUSSED IN DETAIL.

5EPC-09

MODELING OF NONLINEAR PROPERTIES OF HIGH TEMPERATURE SUPERCONDUCTING THIN FILMS, USING BARDEEN, COOPER, SCHRIEFFER AND LUMPED ELEMENT CIRCUIT THEORIES, FOR APPLICATIONS IN ULTRA HIGH FREQUENCY MICRO- AND NANO-ELECTRONICS ***D. O. LEDENYOV***[1]*, J. MAZIERSKA*[1]*, V. O. LEDENYOV*[2]*;* [1]JAMES COOK UNIVERSITY, TOWNSVILLE, QUEENSLAND 4811, AUSTRALIA, [2]JAMES COOK UNIVERSITY. — RESEARCH ON NONLINEAR SURFACE RESISTANCE OF YBA2CU3O7-D THIN FILMS ON MGO SUBSTRATES WAS CONDUCTED USING A HAKKI-COLEMAN DIELECTRIC RESONATOR (HCDR) AT FREQUENCY OF 25GHZ AND MICROSTRIP RESONATORS AT FREQUENCY OF 1.985GHZ. MICROWAVE PROPERTIES OF MGO SUBSTRATES WERE INVESTIGATED IN THE SPLIT POST DIELECTRIC RESONATOR (SPDR) AT FREQUENCY OF 10.48GHZ. MICROWAVE POWER P FOR TESTS OF HTS FILMS WAS VARIED FROM -18DBM TO +30DBM, AND TEMPERATURE T FROM 15K TO 90K. YBA2CU3O7-D FILMS EXHIBITED NONLINEAR CHARACTERISTICS IN FORM OF S-TYPE DEPENDENCE OF SURFACE RESISTANCE RS ON MICROWAVE POWER (P) AT ELEVATED MICROWAVE POWER LEVELS, WHEN HRF WAS HIGHER THAN HC1 IN HCDR. MICROSTRIP RESONATORS OF YBA2CU3O7-D ALSO EXPRESSED THE S-TYPE NONLINEARITY AT THE SAME POWER LEVELS. MGO SUBSTRATES DID NOT CONTRIBUTE TO THE NONLINEAR PROPERTIES OF YBA2CU3O7-D THIN FILMS GROWN ON THE MGO SUBSTRATES AT GIVEN RF POWER AND TEMPERATURE RANGES. TWO MODELS TO SIMULATE MICROWAVE RESPONSES WERE CREATED BASED ON LUMPED ELEMENT RLC CIRCUITS AND BCS THEORIES. SIMULATION RESULTS DEMONSTRATED THAT THE NONLINEAR BEHAVIOUR OF RS(P) DEPENDENCE NEAR MAGNETIC FIELD HC1 COULD BE CLOSELY APPROXIMATED BY THE BCS THEORY.

[2] C.J. KIKKERT RF & MICROWAVE ELECTRONICS DESIGN COURSE JAMES COOK UNIVERSITY, TOWNSVILLE, QUEENSLAND, AUSTRALIA 2009

5EPD-01

DESIGN AND ELABORATION OF 9K NBN ADC CIRCUITS ***J. C. VILLEGIER***[1]*, D. RENAUD*[2]*, C. BORNIER*[3]*, P. FEBVRE*[4]*, P. DESGREYS*[5]*, P. LOUMEAU*[5]*, M. MAIGNAN*[6]*;* [1]CEA-GRENOBLE INAC, [2]CEA-GRENOBLE LETI, [3]ID-3 SEMICONDUCTORS, [4]UNIV SAVOIE IMEP-LAHC, [5]TELECOM PARISTECH, [6]THALES ALENIA SPACE. — FUTURE REMOTE TELECOMS, HIGH DATA RATE TRANSFER AND IMAGING APPLICATIONS ARE THE FOCUS OF THE HYPERSCAN ANALOG-TO-DIGITAL CONVERTER PROJECT. IT RELIES ON CIRCUITS OPERATING AT 9K, REDUCING A LOT THE COOLING CONSTRAINTS, THANKS TO THE USE OF NBN-TAN-NBN-NBTIN SELF-SHUNTED SNS JUNCTIONS WITH RN.IC>1.5MV AT 9K AND OF NBTIN WIRINGS AND GROUND-PLANE WITH REDUCED PENETRATION DEPTH. A BAND-PASS SIGMA-DELTA ADC ARCHITECTURE ANALYTICAL CIRCUIT BASED ON VHDL DESIGN HAS BEEN IMPLEMENTED WITH A MODULATOR CLOCK FREQUENCY OF 120 GHZ AND DECIMATION FILTERS BASED ON A COMB DESIGN LEADING TO SNR OF 59 DB OVERALL PERFORMANCES. THE NITRIDE TECHNOLOGY PROCESS INCLUDING TWO WIRING LEVELS HAS BEEN PROVED FEASIBLE BY APPLYING THE HIGH RELIABILITY, LOW SPREAD LITHOGRAPHY AND CMP PLANARIZATION, MANAGED AT THE CMOS CEA PLATFORM ON 200MM SI WAFERS. GOOD ACCURACY HAS BEEN OBTAINED IN SUBMICRON JUNCTION LITHOGRAPHY OF 716 NM DIAMETERS (3 SIGMA ~ 40NM). A FLEXIBLE AND COMPACT CRYO-PACKAGE HAS BEEN PRODUCED TO REDUCE THE OVERALL POWER DISSIPATION IN OPERATING NBN RSFQ FUNCTIONS WHICH WILL BE PRESENTED.

GRANTED BY ANR06-TCOM-026 & MINALOGIC

5EPD-02

NOVEL MATERIAL BASED TUNNEL JUNCTIONS FOR HIGH PERFORMANCE ELECTRONIC REFRIGERATION AND THERMOMETRY. ***S. CHAUDHURI****, M. R. NEVALA, I. J. MAASILTA;* UNIVERSITY OF JYVÄSKYLÄ. — VOLTAGE INDUCED QUASI-PARTICLE TUNNELING IN A SUPERCONDUCTOR-INSULATOR-NORMAL METAL-INSULATOR-SUPERCONDUCTOR (SINIS) BASED TUNNEL JUNCTION IS IDEAL CANDIDATE FOR SOLID STATE COOLING AND THERMOMETRY. TRADITIONALLY MOST SINIS JUNCTIONS EMPLOY ALUMINUM (AL) AS THE SUPERCONDUCTOR WHICH HAS SOME DISADVANTAGES. FIRSTLY, THE USE OF AL LIMITS THE APPLICATION OF SUCH THERMOMETRY AND REFRIGERATION TO SUB-KELVIN TEMPERATURES OWING TO ITS LOW SUPERCONDUCTING TRANSITION TEMPERATURE (TC) ~ 1.5K. SECONDLY, THE COOLING POWER, WHICH DEPENDS DIRECTLY ON THE SUPERCONDUCTING GAP (Δ), IS LOW FOR AL DUE TO ITS LOW Δ ~ 0.22MV. IN VIEW OF SUCH LIMITATIONS, NIOBIUM NITRIDE (NBN) HAVING TC ~ 16 K AND Δ ~ 3 MV APPEARS TO BE AN IDEAL CANDIDATE FOR MORE PRACTICAL AND HIGHER TEMPERATURE USE OF SUCH JUNCTION BASED DEVICES. WE HAVE FABRICATED THIN FILMS OF NBN ON (100) ORIENTED MGO SINGLE CRYSTAL USING PULSED LASER DEPOSITION TECHNIQUE. THE 1.17 EV EV PHOTONS OF A ND:YAG LASER WAS USED FOR ABLATION. THE FILMS REVEAL A LOW PARTICULATE DENSITY AND SURFACE ROUGHNESS. THE TC OF OUR FILMS DEPENDS STRONGLY ON THE NITROGEN BASE PRESSURE WITH A HIGHEST TC OF 15.4 K. WE HAVE ALSO SUCCESSFULLY GROWN A THIN LAYER ~ 10NM OF INSULATING ALN ON TOP OF NBN AND MGO. THIS MAKES THE PRACTICAL REALIZATION OF A NBN-ALN-CU-ALN-NBN BASED SINIS TUNNEL JUNCTION LIKELY. WE ALSO PLAN TO INVESTIGATE OTHER BARRIER MATERIALS LIKE ALOX TO OPTIMIZE PERFORMANCE.

5EPD-03

STUDY OF SHUNT RESISTOR MATERIALS FOR MGB_2/MGO/MGB_2 JOSEPHSON JUNCTIONS ***D. CUNNANE****[1], K. CHEN[1], W. DAI[2], C. ZHUANG[1], Q. LI[2], X. X. XI[1];* [1]TEMPLE UNIVERSITY, [2]THE PENNSYLVANIA STATE UNIVERSITY. — SANDWICH-TYPE MGB_2/MGO/MGB_2 JOSEPHSON JUNCTIONS HAVE BEEN REPORTED TO HAVE A HIGHER I_CR_N-PRODUCT THAN NB JOSEPHSON JUNCTIONS [CHEN *ET AL.* APPL. PHYS. LETT. 96, 042506 (2010)]. CIRCUITS MADE BY THESE JUNCTIONS MAY POTENTIALLY FUNCTION AT 1 THZ. THE *I-V* CHARACTERISTIC OF THE JUNCTION IS HYSTERETIC AT 4 K, WHICH HAS TO BE ELIMINATED BY A SHUNT RESISTOR. THE SHUNT RESISTOR MATERIAL IS PREFERABLY TO HAVE A CONSTANT RESISTIVITY BELOW THE T_C OF MGB_2, A NEGLIGIBLE CONTACT RESISTANCE WITH MGB_2, AND NO REACTION WITH MGB_2, MG, OR B IN THE DEPOSITION PROCESS. AMONG THE CANDIDATE MATERIALS (TI, CR, TIB_2, ZRB_2, AND MO) DEPOSITED BY DC MAGNETRON SPUTTERING, MO IS THE BEST WITH A RESISTIVITY VARIATION OF 0.3% AT TEMPERATURES BELOW 42 K. THE SPUTTERING CONDITIONS WERE OPTIMIZED TO REACH THE LOWEST RESISTIVITY 17 MICROOHMCM, WHICH IS ABOUT 5 TIMES OF THE MO BULK VALUE. THE CONTACT RESISTIVITY BETWEEN EX-SITU GROWN MO AND MGB_2 FILM IS ABOUT 10^5 OHM MICRON SQUARED, WHICH WOULD RESULT IN THE CONTACT RESISTANCE 10 TIMES LARGER THAN THE REQUIRED SHUNT RESISTOR (~10 OHM) ASSUMING A TYPICAL CONTACT AREA OF 100 SQUARE MICRONS, DUE TO THE NATIVE OXIDE LAYER ON THE SURFACE OF AS-GROWN MGB_2 FILMS. WE USE ION MILLING TO REMOVE THIS NATIVE OXIDE LAYER IMMEDIATELY BEFORE THE EX SITU MO DEPOSITION AND THE CONTACT RESISTIVITY IS REDUCED BY 3 ORDERS OF MAGNITUDE AND IS NEGLIGIBLE.

THIS WORK IS PARTIALLY SUPPORTED BY ONR AND DOE.

5EPD-04

MGB_2 JOSEPHSON JUNCTIONS WITH IMPROVED INITIAL GROWTH OF COUNTER ELECTRODE ***N. MITAMURA****[1], H. AKAIKE[1], A. FUJIMAKI[1], Y. NIIHARA[2], Y. IWATA[2], M. NAITO[2];* [1]NAGOYA UNIVERSITY, [2]TOKYO UNIVERSITY OF AGRICULTURE AND TECHNOLOGY. — WE REPORT MGB_2 JOSEPHSON JUNCTIONS WITH IMPROVED INITIAL GROWTH OF COUNTER ELECTRODE. OUR PREVIOUS MGB_2 JUNCTIONS INDICATED POOR SUPERCONDUCTIVITY NEAR THE BARRIER INTERFACES DUE TO LOW I_CR_N PRODUCT OF ABOUT 0.1 MV AND LOW CRITICAL TEMPERATURE T_C OF THE JUNCTIONS OF BELOW 10 K. SO, WE FOCUSED ON INITIAL GROWTH OF COUNTER ELECTRODES WHICH CAN CONTRIBUTE THE DETERIORATION. WE HAVE FORMED MGB_2 FILMS BY CO-EVAPORATION METHOD. TO IMPROVE INITIAL GROWTH, OUR MGB_2 FILMS WERE GROWN WITH GRADUAL CHANGE OF MG RATE (MG_XB_2) FROM 3.5 TO 1.2 AND SUBSTRATE TEMPERATURE FROM 190°C TO 200°C. THUS, 50-NM-THICK MGB_2 FILM BASED ON AN AMORPHOUS BORON LAYER INDICATED IMPROVEMENT OF INITIAL GROWTH DUE GOOD CRYSTALLINE EVALUATED BY RHEED AND FAIRLY HIGH CRITICAL TEMPERATURE OF 27 K EVEN THOUGH THE FILM WAS RELATIVELY THIN.THEN, WE HAVE FABRICATED MGB_2/B/MGB_2 JUNCTIONS WITH COUNTER ELECTRODE FORMED WITH FOREGOING CONDITION. A 100-MM-SQUARE JUNCTION WITH A 10-NM-THICK BORON BARRIER SHOWED HYSTERESIS CURRENT-VOLTAGE (*I-V*) CHARACTERISTICS AT 4.2 K WITH A CRITICAL CURRENT I_C OF 170 MA AND GAP VOLTAGE OF ABOUT 4 MV. I_CR_N PRODUCT WAS 0.31 MV AND T_C OF THE JUNCTION WAS 11.5K. THEY WERE IMPROVED COMPARED WITH OUR PREVIOUS JUNCTIONS.

THIS WORK WAS SUPPORTED BY A GRANT-IN-AID FOR SCIENCE RESEARCH IN A PRIORITY AREA “SINGLE-FLUX-QUANTUM LOCALIZED ELECTROMAGNETIC WAVE INTEGRATED CIRCUITS” FROM THE MINISTRY OF EDUCATION, SPORTS, CULTURE, SCIENCE, AND TECHNOLOGY, JAPAN.

5EPD-05

RESONANT ACTIVATION FROM THE ZERO-VOLTAGE STATE OF A CURRENT-BIASED MGB_2 JOSEPHSON JUNCTION ***R. C. RAMOS****, J. G. LAMBERT, S. A. CARABELLO, J. T. MLACK, Z. E. THRAILKILL;* DREXEL UNIVERSITY. — IN THE PRESENCE OF WEAK RESONANT MICROWAVE PERTURBATION, THE ZERO-VOLTAGE STATE OF A CURRENT-BIASED JOSEPHSON JUNCTION SWITCHES TO THE RUNNING STATE. WE REPORT THE RESULTS OF MICROWAVE RESONANT ACTIVATION EXPERIMENTS ON

MGB_2 JOSEPHSON JUNCTIONS AS A FUNCTION OF TEMPERATURE, MICROWAVE FREQUENCY AND POWER. WE PLOT HISTOGRAMS OF SWITCHING EVENTS, ESCAPE RATES AND ENHANCEMENTS, WHICH APPEAR TO BE CLASSICAL EVEN AT VERY LOW TEMPERATURES. WE REPORT ON THE PROGRESS OF OUR ONGOING WORK TO MEASURE ENERGY LEVEL QUANTIZATION AND THE CORRESPONDING METASTABLE QUANTUM STATES IN MGB2 JUNCTIONS.

WE THANK PROFS. X. XI AND K. CHEN (TEMPLE UNIVERSITY) FOR PROVIDING HIGH QUALITY MGB2 JUNCTIONS.

5EPD-06

EXPLORING THE SIGMA AND PI BAND GAPS OF MGB2 BY CHARACTERIZING MGB2/INSULATOR/PB AND MGB2/INSULATOR/NB JOSEPHSON JUNCTIONS BELOW 1 KELVIN ***S. CARABELLO**, J. LAMBERT, J. MLACK, Z. THRAILKILL, R. RAMOS;* DREXEL UNIVERSITY. — JOSEPHSON JUNCTIONS INCORPORATING MAGNESIUM DIBORIDE THIN FILMS PROVIDE A USEFUL PLATFORM FOR MAKING PRECISE MEASUREMENTS OF THE ENERGY GAPS OF MGB2. WE REPORT THE RESULTS OF MEASUREMENTS AT TEMPERATURES AS LOW AS 20 MK OF MGB2-BASED JUNCTIONS, WITH PB AND NB AS THE COUNTER ELECTRODE. 2-POINT AND 4-POINT MEASUREMENTS ARE USED TO OBTAIN I-V AND DI/DV-V CURVES, WHICH EXHIBIT CLEAR STRUCTURE CORRESPONDING TO THE ENERGY GAPS OF THE ELECTRODE MATERIALS. A THESE LOW TEMPERATURES, DETAILS IN THE STRUCTURE OF THE SIGMA- AND PI-BAND GAPS ARE APPARENT.

5EPE-01

OPTICAL RESPONSES OF SUPERCONDUCTING NANOBRIDGES UNDER THE IRRADIATION OF FEMTOSECOND LASER PULSES ***I. KAWAYAMA**[1], K. KAJINO[2], M. INOUE[2], A. FUJIMAKI[2], M. TONOUCHI[1];* [1]OSAKA UNIVERSITY, [2]NAGOYA UNIVERSITY. — ULTRAFAST OPTICAL DEVICES WITH VERY LOW POWER CONSUMPTION ARE STRONGLY DESIRED TO PROCESS LARGE-CAPACITY DATA-TRAFFIC ON EXPANDING INFORMATION NETWORKS. TONOUCHI ET AL. DEMONSTRATED THAT MAGNETIC FLUX WAS OPTICALLY GENERATED IN SUPERCONDUCTING LOOPS BY FEMTOSECOND LASER IRRADIATION [1], AND WE HAVE PROPOSED TO UTILIZE THIS PHENOMENON FOR ADVANCED SUPERCONDUCTING OPTO-ELECTRONIC DEVICES, E. G. A MEMORY, AN INTERFACE AND A SWITCH. ON THE OTHER HAND, WE CONSIDER THAT NANO-FABRICATION WITH SUPERCONDUCTOR THIN FILMS WILL BECOME A KEY TECHNOLOGY FOR HIGHLY INTEGRATED SUPERCONDUCTING OPTO-ELECTRONICS.IN THIS STUDY, WE HAVE OBSERVED OPTICAL RESPONSES OF YBCO NANOBRIDGES UNDER THE IRRADIATION OF FEMTOSECOND LASER PULSES. THE SUPERCONDUCTING NANOBRIDGES WITH THE WIDTH OF 100 NM WERE PREPARED BY THE RE-DEPOSITION METHOD [2]. PHOTO-INDUCED VOLTAGES AND RESPONSE TIMES OF YBCO NANOBRIGES WERE MEASURED USING AN OPTICAL SAMPLING METHOD WITH A FEMTOSECOND PULSED LASER. WE WILL SHOW THE DETAILS OF EXPERIMENTAL RESULTS AND DISCUSS FEASIBILITY OF THE NOVEL OPTO-ELECTRONICS WITH SUPERCONDUCTING NANOBORIGES.[1] M. TONOUCHI ET AL., APPL. PHYS. LETT. 71 (1997) 2364.[2] K. KAJINO ET AL., IEEE TRANS. APPL. SUPERCOND. 19 (2009) 182

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5EPE-02

METASTABILITY IN A NB DC SQUID HAVING NANOBRIDGE JUNCTIONS ***E. SEGEV**[1], O. SUCHOI[1], D. BIRMAN[1], F. XUE[2], O. SHTEMPLUCK[1], E. BUKS[1];* [1]TECHNION, [2]UNIVERSITY OF BASSEL. — WE STUDY THE METASTABLE RESPONSE OF A DC SQUID TO AN ALTERNATING APPLIED CURRENT AND APPLIED DC MAGNETIC FLUX. THE DC SQUID IS MADE OF A NIOBIUM LOOP INTERRUPTED BY TWO NANOBRIDGES. USING A LOCKIN AMPLIFIER, WE MEASURE THE VOLTAGE ACROSS THE DC SQUID, AS A FUNCTION OF THESE PARAMETERS, AND FIND THAT IT EXHIBITS A DIAMOND-LIKE STRUCTURE, MADE OF DIFFERENT REGIONS SEPARATED BY SHARP TRANSITIONS. MEASUREMENTS IN THE TIME DOMAIN, OBTAINED WITH AN OSCILLOSCOPE, REVEAL THAT IN EACH REGION THE MEASURE VOLTAGE EXHIBITS A CHARACTERISTIC PATTERN CONTAINING SEVERAL SHARP JUMPS PER PERIOD.TO ACCOUNT FOR THE RESULTS WE HAVE CALCULATED, BOTH ANALYTICALLY AND NUMERICALLY, THE REGIONS OF STABILITY IN THE PLANE OF CURRENT AMPLITUDE AND FLUX OF THE DIFFERENT METASTABLE STATES OF THE DEVICE. NON-SINUSOIDAL CURRENT-PHASE RELATION OF THE NANOBRIDGES HAS BEEN TAKEN INTO ACCOUNT IN THE CALCULATION. GOOD AGREEMENT IS FOUND BETWEEN EXPERIMENTAL AND THEORETICAL RESULTS.

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5EPE-03

CURRENT/VOLTAGE CHARACTERISTICS OF LOW TEMPERATURE SUPERCONDUCTING NANOWIRES ***A. JAFARI-SALIM**, A. MAJEDI;* ELECTRICAL AND COMPUTER ENGINEERING DEPARTMENT AND INSTITUTE FOR QUANTUM COMPUTING, UNIVERSITY OF WATERLOO. — THE ADVANCEMENT IN THE FABRICATION OF HIGHLY HOMOGENOUS LOW TEMPERATURE SUPERCONDUCTING NANOWIRES HAS REVEALED EVIDENCE THAT QUANTUM FLUCTUATIONS ARE PLAYING THE DOMINANT ROLE IN THE RESIDUAL RESISTIVITY OF NANOWIRES IN THE SUPERCONDUCTING PHASE. STARTING FROM THE BCS ACTION GOVERNING THE BULK SUPERCONDUCTOR, WE INTEGRATE OUT ALL THE DEGREES OF FREEDOM WHICH ARE IRRELEVANT TO OUR LOW DIMENSIONAL MODEL. OUR METHOD RELIES ON THE EFFECTIVE ACTION METHOD WHICH IN THE CONTEXT OF NANO-SUPERCONDUCTORS WAS PIONEERED BY GOLUBEV, ZAIKIN AND ET AL. WE DERIVE EXPLICITLY THE DC CURRENT/VOLTAGE CHARACTERISTICS AND AC

CONDUCTIVITY. WE WILL DISCUSS HOW QUANTUM FLUCTUATIONS MANIFEST IN THE ELECTRICAL CHARACTERISTICS OF THE NANOWIRE. SOME FUTURISTIC APPLICATIONS OF ELECTRICALLY-BIASED NANOWIRE WILL BE PRESENTED.

5EPE-04

ANALOG MODELS OF NEURONS USING JOSEPHSON JUNCTIONS ***K. SEGALL****, P. CROTTY, D. SCHULT;* COLGATE UNIVERSITY. — WITH AN EYE TOWARD LARGE-SCALE ANALOG SIMULATIONS OF NEURON NETWORKS OVER LONG TIMESCALES, WE PRESENT JOSEPHSON JUNCTION CIRCUITS WHICH MODEL BIOLOGICALLY REALISTIC NEURONS. OUR "JOSEPHSON JUNCTION NEURON" (JJ NEURON) [1] IS COMPOSED OF TWO JUNCTIONS AND IS SIMILAR TO A DC-TO-SFQ CONVERTER FROM RSFQ DIGITAL LOGIC. THE JJ NEURON REPRODUCES MANY CHARACTERISTIC BEHAVIORS OF NEURONS INCLUDING ACTION POTENTIALS, REFRACTORY PERIODS, AND FIRING THRESHOLDS. TWO JJ NEURONS CAN BE COUPLED TOGETHER IN A WAY THAT MIMICS ELECTRICAL OR CHEMICAL SYNAPSES. USING EXISTING FABRICATION TECHNOLOGY, LARGE INTERCONNECTED NETWORKS WOULD OPERATE FULLY IN PARALLEL. THEY WOULD BE ORDERS OF MAGNITUDE FASTER THAN BOTH TRADITIONAL COMPUTER SIMULATIONS AND BIOLOGICAL NEURON NETWORKS. WE WILL PRESENT COMPUTER SIMULATIONS OF JJ NEURON CIRCUITS AND DISCUSS CONSIDERATIONS FOR ANALOG MODELS OF LARGE NEURON NETWORKS.[1] HTTP://ARXIV.ORG/ABS/1002.2892

5EPE-05

LOCAL SUPERCONDUCTING PROPERTIES THROUGH TORQUE MEASUREMENT AND INTERACTION OF ORDER PARAMETERS UNDER THE PRESSURE AND MAGNETIC FIELD ***Y. JO***[1]*, J. KIM*[2]*, M. EOM*[2]*, S. NA*[2]*;* [1]EWHA UNIVERSITY, [2]POHANG UNIVERSITY OF SCIENCE AND TECHNOLOGY. — THE GOAL OF OUR WORK IS TO OPTIMIZE THE CURRENT TRANSPORT CAPACITY IN IMPURITY DOPED FE-PNICTIDES AND TESTIFY THE DELICATE BALANCE AMONG THE CHARGE, SPIN, LATTICE, AND ORBITAL DEGREES OF FREEDOM WHICH DEPEND ON THE EXTERNAL PHYSICAL AND CHEMICAL CHANGES. CONCRETELY, (1) UNDERSTAND THE PRINCIPAL SUPERCONDUCTING PARAMETERS FOR DIFFERENT IMPURITY DOPED FE-PNICTIDES, (2) STUDY THE FLUX PINNING EFFECT IN GRAIN BOUNDARY BY LOCAL TORQUE MEASUREMENT, (3) STUDY THE EXTERNAL MAGNETIC FIELD AND PRESSURE EFFECT ON THE STRONGLY CORRELATED SUPERCONDUCTING SYSTEM.ACCORDING TO THE SIGNIFICANT RESEARCH TO OPTIMIZE THE CURRENT-CARRYING CAPACITY OF COMMERCIAL SUPERCONDUCTING WIRES, IT IS FOUND THAT THE TRANSPORT CURRENT DENSITY IN WIRES DEPENDS ON THE CHEMICAL COMPOSITION, GRAIN BOUNDARY MORPHOLOGY AND STRAIN STATE. WE MAKE AN EFFORT TO CONTROL ELECTRON OR HOLE-DOPED FE PNICTIDES SINGLE CRYSTAL. MICROSTRUCTURE ANALYSIS CAN BE ACCOMPLISHED WITH FE-SEM AND EDS IN CONJUNCTION WITH MAGNETIC CHARACTERIZATION. FURTHERMORE WE HAVE A POTENTIAL TO CONTROL THE GRAIN SIZE AND STRAIN STATE IN SUPERCONDUCTOR. THE ELECTRICAL PROPERTIES ARE MEASURED BY RESISTANCE, HALL EFFECT AND THERMOELECTRIC POWER AND FERMI STRUCTURE IN METALS CAN BE OBSERVED IN ANGLE DEPENDENT MAGNETORESISTANCE. MAGNETIC PROPERTIES CAN BE MEASURED BY AC SUSCEPTIBILITY AND PIEZO-CANTILEVER TORQUE MAGNETOMETER. TORQUE MEASUREMENT IS A POWERFUL TECHNIQUE FOR THE UNDERSTANDING OF INTRINSIC MAGNETIC PROPERTIES. THIS TECHNIQUE HAS SEVERAL IMPORTANT ADVANTAGES. (1) THE SIGNAL INCREASES LINEARLY WITH FIELD FOR A GIVEN MAGNETIC MOMENT. (2) A COMMERCIAL MAGNETOMETRY SYSTEM SUCH AS SQUID IS VERY SENSITIVE IN MEASURING MAGNETIZATION, BUT RATHER SLOW TO MEASURE AND NEEDS A SUITABLE SIZE, WHILE TORQUEMETERS HAVE A MUCH FASTER TIME RESPONSE AND ENTIRE DEVICE CAN BE CONFINED TO A VERY SMALL VOLUME ($1CM^3$) AND THUS EASY TO INSTALL. ULTRA-SENSITIVE MINIATURE TORQUEMETER BASED ON MICRO-FABRICATED SILICON PIEZO-RESISTIVE CANTILEVER ENABLES TO MEASURE EXTREMELY SMALL MAGNETIC OR SUPERCONDUCTING PARTICLES HAVING MASSES AS SMALL AS NANO-GRAMS WITHOUT ANY SPECIFIC PRECAUTIONS. THE RESOLUTION OF THIS DEVICE IS FAR SMALLER THAN A COMMERCIAL MAGNETOMETER.THE KNOW-HOW AND EXPERIMENTAL RESULTS IN THIS STUDY WILL GIVE MORE EFFECTIVE APPROACH TO THE GOAL OF PROMPT PRACTICAL APPLICATION IN LOW AND HIGH T_C SUPERCONDUCTIVITY. ALSO IT WILL SUPPORT UNDERSTANDING THE RELATION BETWEEN SPIN-CHARGE-ORBITAL-LATTICE ORDER PARAMETERS. ACCORDING TO THE FUNDAMENTAL UNDERSTAND OF SUPERCONDUCTING PROPERTIES AT THE GRAIN BOUNDARY AND NUMERICAL MEASUREMENTS, DESIGN AND MODELING OF NEW SUPERCONDUCTING SYSTEM AND HOW TO MAKE VERY STRONG VORTEX PINNING WITHOUT OBSTRUCTING CRITICAL CURRENTS CAN BE PERFORMED. IN ORDER TO STUDY THE PRESSURE EFFECT IN SUPERCONDUCTING SYSTEM, THE HIGHER PRESSURE RANGE IS NEEDED WHICH CAN BE OBTAINED FROM BRIDGMAN ANVIL CELL. PRESSURE CAN MODIFY INTER-ATOMIC DISTANCES AND CONSEQUENTLY MODIFIES VARIOUS PHYSICAL PARAMETERS RELATED WITH MAGNETIC PROPERTIES.

5EPE-06

RADIATION HARDNESS OF NANOSTRUCTURED YBA2CU3O7 FILM-BASED DETECTORS OPERATING IN ENVIRONMENTS WITH POTENTIAL RADIATION HAZARD ***B. MINETTI***[1]*, R. GERBALDO*[1]*, G. GHIGO*[1]*, L. GOZZELINO*[1]*, F. LAVIANO*[1]*, G. LOPARDO*[1]*, R. CHERUBINI*[2]*, E. MEZZETTI*[1]*;* [1]POLITECNICO DI TORINO, DEPARTMENT OF PHYSICS AND INFN SEZ. TORINO, TORINO, ITALY, [2]INFN, LABORATORI NAZIONALI DI LEGNARO, LEGNARO (PD), ITALY. — MICRO COLLIMATED IMPLANTATION OF HIGH-DENSITY NANOTRACKS IN YBA2CU3O7/CEO2/YSZ FILMS BY MEANS OF 0.25 GEV AU-ION IRRADIATION-BEAM LEADS TO A FUNCTIONAL DECOUPLING BETWEEN THE R VS. T CHARACTERISTICS OF AS-GROWN AND NANOSTRUCTURED CONTIGUOUS REGIONS. THE DEPRESSION OF THE CRITICAL TEMPERATURE OF THE NANOSTRUCTURED PARTS ALLOWS ONE (ONCE SUITABLY CHOSEN THE WORKING TEMPERATURE) TO LOCALIZE EXTERNAL ELECTROMAGNETIC EXCITATIONS BY

MEANS OF THE DISSIPATIVE SIGNALS ONLY INDUCED INTO THE NANOSTRUCTURED REGION. IN THIS FRAMEWORK, SEVERAL PROTOTYPES OF MAGNETIC FIELD SENSORS AND PHOTO-DETECTORS OPERATING IN THE MIR/FIR [B. MINETTI ET AL, APL 89 (2006) 082514; IEEE SENSORS IN PRESS] ARE UNDER TEST WITH RESPECT TO THE ESTIMATION OF RADIATION HARDNESS THRESHOLDS UNDER IONIZING AND NEUTRON BEAMS, IN PARTICULAR 3.5 MEV PROTONS AND FAST NEUTRONS (ENERGIES UP TO 3.5 MEV). IT TURNS OUT THAT SUCH BEAMS DO NOT AFFECT THE DETECTORS STEADY STATE RESPONSE FUNCTION UP TO THE MAXIMUM INVESTIGATED FLUENCES, I.E. 4.3X1E14 P/CM2 AND 4.5X1E13 N/CM2, RESPECTIVELY. A CORRELATION BETWEEN NEUTRON IRRADIATION EFFECTS AND AVERAGE ENERGIES OF THE IMPINGING NEUTRONS IS IN PROGRESS.

WORK SUPPORTED BY REGIONE PIEMONTE UNDER THE PROJECT SECONADECH. THE AUTHORS THANK THE INFN FOR THE ACCESS TO THE IRRADIATION FACILITIES AND THE INFN-LNL STAFF FOR HIS SUPPORT IN THE IRRADIATION RUNS

5EPF-01

RESONANT ACTIVATION OF CURRENT-BIASED JOSEPHSON JUNCTIONS NEAR THE CLASSICAL QUANTUM CROSSOVER ***Z. THRAILKILL****, J. LAMBERT, S. CARABELLO, R. RAMOS;* DREXEL UNIVERSITY. — WE EXAMINE THE MICROWAVE ACTIVATION OF A CURRENT-BIASED JOSEPHSON JUNCTION NEAR THE CROSSOVER TEMPERATURE. WE REPORT ON EXPERIMENTS THAT DEMONSTRATE HOW THE DEVICE TRANSITIONS FROM THE QUANTUM REGIME BEHAVIOR TO THAT OF A CLASSICAL NONLINEAR OSCILLATOR. WE USE MICROWAVES TO PROBE THE QUANTUM ENERGY STATES THAT EXIST IN THE POTENTIAL WELL. THE QUANTUM FEATURES ARE VISIBLE UNTIL THE JUNCTION IS HEATED UP TO THE CROSSOVER TEMPERATURE, AT WHICH POINT THE LINE WIDTHS OF THE ENERGY LEVELS OVERLAP AND BECOME INDISTINGUISHABLE FROM ONE ANOTHER. WHEN WELL ABOVE THIS TEMPERATURE, THE JUNCTION BEHAVES CLASSICALLY WHEN RESONANTLY ACTIVATED WITH MICROWAVES.

5EPF-02

RFSQUID-MEDIATED COHERENT TUNABLE COUPLING BETWEEN A SUPERCONDUCTING PHASE QUBIT AND A LUMPED ELEMENT RESONATOR ***M. S. ALLMAN****, F. ALTOMARE, J. WHITTAKER;* NIST. — WE DEMONSTRATE COHERENT TUNABLE COUPLING BETWEEN A SUPERCONDUCTING PHASE QUBIT AND A LUMPED ELEMENT RESONATOR. THE COUPLING STRENGTH IS MEDIATED BY A FLUX-BIASED RF SQUID OPERATED IN THE NON-HYSTERETIC REGIME. BY TUNING THE APPLIED FLUX BIAS TO THE RF SQUID WE CHANGE THE EFFECTIVE MUTUAL INDUCTANCE, AND THUS THE COUPLING ENERGY, BETWEEN THE PHASE QUBIT AND RESONATOR . WE VERIFY THE MODULATION OF COUPLING STRENGTH FROM 0 TO $100\;MHZ$ BY OBSERVING MODULATION IN THE SIZE OF THE SPLITTING IN THE PHASE QUBIT'S SPECTROSCOPY, AS WELL AS COHERENTLY BY OBSERVING MODULATION IN THE VACUUM RABI OSCILLATION FREQUENCY WHEN ON RESONANCE. THE MEASURED SPECTROSCOPIC SPLITTINGS AND VACUUM RABI OSCILLATIONS AGREE WELL WITH THEORETICAL PREDICTIONS.

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5EPF-03

EVALUATION OF TWO LEVEL SYSTEMS IN SUPERCONDUCTING RESONATORS USING POWER AND TEMPERATURE DEPENDENCE OF Q AND F ***D. P. PAPPAS****, D. S. WISBEY, F. C. S. S. DA SILVA, J. S. KLINE, J. GAO, M. VISSERS;* NIST. — HIGH QUALITY FACTOR, I.E. LOW LOSS, RESONATORS ARE IMPORTANT FOR QUANTUM INFORMATION STORAGE AND ADDRESSING. IN THIS WORK WE STUDY THE RESONANCE FREQUENCY AND LOSS IN SUPERCONDUCTING 1/4 WAVE, COPLANAR WAVEGUIDE RESONATORS AS A FUNCTION OF TEMPERATURE AND POWER. WE FIND THAT THERE IS ENHANCES LOSS AT LOW POWER AND LOW TEMPERATURE. THE INCREASED LOSS IS ATTRIBUTED TO THE EXISTENCE OF TWO-LEVEL SYSTEMS AT THE SURFACES, INTERFACES, AND IN THE BULK OF INSULATORS DEPOSITED ON THE STRUCTURES. WE SHOW HOW THE POWER DEPENDENCE OF THE QUALITY FACTOR AND THE TEMPERATURE DEPENDENCE OF THE RESONANT FREQUENCY CAN BOTH BE USED TO FIND THE ZERO TEMPERATURE CONTRIBUTION TO THE LOSS FROM TLS. A WIDE RANGE OF SUPERCONDUCTORS, SUBSTRATES, AND INSULATORS ARE TESTED AND THE CORRESPONDENCE OF THESE TWO INDEPENDENT MEASUREMENTS OF TLS LOSS IS EVALUATED.

IARPA, BBN, AND NIST

5EPF-04

MEASURING ENERGY DISSIPATION IN JOSEPHSON JUNCTIONS USED IN SUPERCONDUCTING QUANTUM BITS ***J. A. STRONG****[1], M. S. ALLMAN[2], F. ALTOMARE[2], K. CICAK[2], A. J. SIROIS[2], J. TEUFEL[2], J. D. WHITTAKER[2], R. W. SIMMONDS[2];* [1]NORTHROP GRUMMAN, [2]NIST. — JOSEPHSON JUNCTIONS WITH LOW ENERGY DISSIPATION ARE ESSENTIAL TO SUPERCONDUCTING QUANTUM COMPUTATION. WE HAVE MADE TUNABLE RESONATORS WHICH INCORPORATE JUNCTIONS SIMILAR TO THOSE USED IN OUR PHASE QUBITS. MEASUREMENT OF THE Q OF THESE RESONATORS ALLOWS A DIRECT MEASUREMENT OF THE ENERGY DISSIPATED IN THE JOSEPHSON JUNCTION. WE EXAMINE RESULT FROM MULTIPLE DEVICES.

THANKS TO IARPA FOR FUNDING

5EPF-05

DESIGN OF SUPERCONDUCTING MICROWAVE RESONATORS FOR QUBIT READ-OUT ***B. SURI****[1], S. NOVIKOV[1], Z. KIM[1], V. ZARETSKEY[1], F. C. WELLSTOOD[2], B. S. PALMER[3];* [1]DEPARTMENT OF PHYSICS, UNIVERSITY OF MARYLAND, [2]DEPARTMENT OF PHYSICS, UNIVERSITY OF MARYLAND, JOINT QUANTUM INSTITUTE, CENTER FOR NANOPHYSICS AND ADVANCED MATERIALS, [3]LABORATORY FOR THE PHYSICAL

SCIENCES,COLLEGE PARK, MARYLAND. — WE HAVE DESIGNED, FABRICATED, AND MEASURED A VARIETY OF THIN FILM, SUPERCONDUCTING NB "LUMPED-ELEMENT" RESONATORS WITH RESONANCE FREQUENCIES AROUND 5.5GHZ. THE RESONATORS ARE BUILT ON C-AXIS SAPPHIRE WAFERS WITH A MEANDER LINE INDUCTOR AND INTER-DIGITATED CAPACITOR AND ARE COUPLED TO A MICROWAVE TRANSMISSION LINE, THAT IS USED TO DRIVE THE SYSTEM. WE MEASURE THE TRANSMITTED AMPLITUDE AND PHASE AS A FUNCTION OF TEMPERATURE BETWEEN 400 MK AND THE SUPERCONDUCTING TRANSITION TEMPERATURE OF NB, TC ~9.2K AND FOR INPUT POWERS RANGING FROM 1MICROWATT TO 1 FEMTOWATT. FROM MEASUREMENTS OF THE ABSORPTIVE POWER AND THE CHANGE IN THE PHASE AS A FUNCTION OF FREQUENCY WE HAVE FOUND THAT THE LOADED QUALITY FACTOR CAN VARY FROM 500 UP TO 30,000 AND THE INTERNAL QUALITY FACTOR CAN VARY FROM 10,000 UP TO 250,000 AT 400 MK, DEPENDING ON THE GEOMETRY OF THE RESONATOR AND ITS COUPLING TO THE TRANSMISSION LINE. WE COMPARE THESE RESULTS TO QUARTER-WAVE COPLANAR WAVEGUIDE RESONATORS AND DISCUSS THE USE OF THE DIFFERENT RESONATOR GEOMETRIES FOR CHARGE QUBIT READ-OUT.

5EPF-06

SUPERPOSITION OF INDUCTIVE AND CAPACITIVE COUPLING IN SUPERCONDUCTING LC RESONATORS ***S. GLADCHENKO****, M. KHALIL, K. OSBORN;* LABORATORY FOR PHYSICAL SCIENCES,UNIVERSITY OF MARYLAND. — LOW LOSS MICROWAVE RESONATORS ARE USED IN MANY SUPERCONDUCTING CIRCUITS FROM MULTIPLEXED READOUTS OF LOW TEMPERATURE DETECTORS TO QUANTUM BITS. THIS WORK PRESENTS AN EXPERIMENTAL INVESTIGATION OF LUMPED-ELEMENT SUPERCONDUCTING LC RESONATORS ON SAPPHIRE DESIGNED TO PROVIDE DIFFERENT TYPES OF COUPLING TO A TRANSMISSION LINE. WE HAVE DESIGNED FOUR RESONATOR GEOMETRIES INCLUDING DIPOLE OR QUADRUPOLE SHAPED INDUCTORS CONNECTED IN PARALLEL WITH SILICON NITRIDE FILLED PARALLEL PLATE CAPACITORS. THEORETICALLY, THE SYMMETRY OF THE INDUCTOR AND THE METHOD OF CAPACITANCE GROUNDING WOULD ALLOW US TO CREATE EITHER INDUCTIVE OR CAPACITIVE COUPLING, OR SUPERPOSE THE TWO. THE MEASUREMENTS HAVE BEEN CARRIED OUT AT TEMPERATURES FROM 30-300MK AND AT VARIABLE POWER, TO DESCRIBE THE DATA INCLUDING THE POWER DEPENDENT LOSS FROM THE INTERLAYER DIELECTRIC. WE FIND THAT BOTH CAPACITIVE AND INDUCTIVE COUPLING CAN BE CREATED OR SUPERPOSED WITH ONLY A MINOR CHANGE IN THE CIRCUIT DESIGN.

5EPF-07

LOSS DEPENDENCE ON GEOMETRY AND APPLIED POWER IN SUPERCONDUCTING COPLANAR RESONATORS ***M. KHALIL****[1], S. GLADCHENKO[1], M. STOUTIMORE[1], F. WELLSTOOD[1], K. OSBORN[2];* [1]UNIVERSITY OF MARYLAND-COLLEGE PARK, [2]LABORATORY FOR PHYSICAL SCIENCES. — THE LOSS IN COPLANAR SUPERCONDUCTING RESONATORS AT LOW-PHOTON NUMBER HAS IMPLICATIONS ON THE ACHIEVABLE COHERENCE OF SUPERCONDUCTING QUBITS, BUT IS NOT YET UNDERSTOOD. WE HAVE FABRICATED AND MEASURED HIGH QUALITY FACTOR SUPERCONDUCTING ALUMINUM COPLANAR RESONATORS ON SAPPHIRE, WITH FUNDAMENTAL RESONANCE FREQUENCIES OF APPROXIMATELY 6GHZ, TO FACILITATE THE STUDY OF LOSS MECHANISMS INCLUDING LOSS CAUSED BY TWO-LEVEL SYSTEM DEFECTS. WE HAVE STUDIED FOUR RESONATOR GEOMETRIES THAT INCLUDE A QUASI-LUMPED-ELEMENT RESONATOR, A COPLANAR STRIP WAVEGUIDE RESONATOR, AND TWO HYBRID DESIGNS THAT CONTAIN BOTH COPLANAR STRIP AND COMPACT ELEMENTS. THE MEASUREMENTS ARE TAKEN AT 30MK WITH A PROBE FREQUENCY THAT IS VARIED IN POWER. WE FIND THAT THE INTERNAL QUALITY FACTOR OF THE RESONATORS INCREASES WITH PHOTON NUMBER IN A MANNER THAT IS NOT MERELY EXPLAINED BY AN ORDINARY SPATIAL DISTRIBUTION OF INDEPENDENT ELECTRICALLY DRIVEN TWO-LEVEL SYSTEMS.

5EPF-08

MEASURING EXCESS NOISE IN SUPERCONDUCTING MICRO-RESONATORS WITH A JOSEPHSON PARAMETRIC AMPLIFIER ***J. GAO****[1], G. C. HILTON[1], K. D. IRWIN[1], L. R. VALE[1], B. A. MATES[1], D. R. SCHMIDT[1], F. MALLET[2], K. W. LEHNERT[2], H. G. LEDUC[3], J. ZMUIDZINAS[3];* [1]NATIONAL INSTITUTE OF STANDARD AND TECHNOLOGY, [2]UNIVERSITY OF COLORADO AT BOULDER, [3]CALIFORNIA INSTITUTE OF TECHNOLOGY. — SUPERCONDUCTING MICRO-RESONATORS ARE USED IN MICROWAVE KINETIC INDUCTANCE DETECTORS (MKIDS) AND OTHER SENSITIVE MEASUREMENTS. IT IS FOUND THAT SIGNAL TRANSMITTED THROUGH A RESONATOR SHOWS EXCESS NOISE IN THE "FREQUENCY QUADRATURE" (ASSOCIATED WITH SHIFTS IN RESONANCE FREQUENCY), WHICH IS CAUSED BY SURFACE TWO-LEVEL SYSTEMS (TLS). HOWEVER, NO EXCESS NOISE ABOVE THE NOISE FLOOR OF A HIGH ELECTRON MOBILITY TRANSISTOR AMPLIFIER (HEMT) IS OBSERVED IN THE "DISSIPATION QUADRATURE" (ASSOCIATED WITH DISSIPATION IN THE RESONATOR). A HEMT AMPLIFIER HAS A NOISE TEMPERATURE OF ~4 K, WHICH IS 30 TIMES THE QUANTUM NOISE AT 6 GHZ, SO IT HAS SO FAR BEEN UNCLEAR WHAT THE ACTUAL LEVEL OF NOISE IS IN THE DISSIPATION QUADRATURE. TO EXPLORE THE RESONATOR NOISE BELOW HEMT NOISE FLOOR, WE HAVE BUILT JOSEPHSON PARAMETRIC AMPLIFIERS WHICH ARE NEARLY QUANTUM-LIMITED. THESE JPAS, WHICH ARE ESSENTIALLY NB QUARTER-WAVE COPLANAR WAVE GUIDE (CPW) RESONATORS TERMINATED BY SERIES OF SQUIDS, AMPLIFY ONLY ONE QUADRATURE AND SQUEEZE THE OTHER. WHEN WE USE A JPA TO AMPLIFY THE DISSIPATION QUADRATURE AND SQUEEZE THE FREQUENCY QUADRATURE, WE FIND THAT NO EXCESS NOISE IS OBSERVED ABOVE JPAS NOISE FLOOR AND THE NOISE IN THE DISSIPATION QUADRATURE IS MORE THAN A FACTOR OF 10 BELOW HEMT NOISE FLOOR. THIS SUGGESTS THAT THE SENSITIVITY OF MKIDS CAN BE IMPROVED BY USING A QUANTUM-LIMITED AMPLIFIER SUCH AS JPA IN A DISSIPATION READOUT MODE.

5EPG-01

DYNAMIC RANGE STUDIES OF HIGH SENSITIVE MAGNETIC FIELD SQUID ARRAYS SENSORS OF PATTERN $YBA_2CU_3O_{7-\Delta}$ BI-CRYSTALS. ***M. C. DE ANDRADE***[1]*, A. M. LEESE DE ESCOBAR*[1]*, S. B. RICE*[1]*, E. H. WONG*[1]*, S. BERKOWITZ*[2]*;* [1]SPAWAR SYSTEMS CENTER, [2]OUT OF THE FOG RESEARCH. — HIGH QUALITY SQUID ARRAYS WITH VARYING TOTAL AREA HAVE BEEN FABRICATED FROM $YBA_2CU_3O_{7-\Delta}$ BI-CRYSTALS GRAIN BOUNDARY JOSEPHSON JUNCTIONS. THE SOURCE OF RF RADIATION WAS SYSTEMATICALLY CONTROLLED UTILIZING A TEM CELL DESIGNED TO OPERATE IN THE FREQUENCY RANGE DC ≤ *F* ≤ 1 GHZ. THE VOLTAGE TRANSDUCED FROM THE SENSORS WAS MEASURED AS A FUNCTION OF THE INCIDENT RF RADIATION. THE ABILITY TO LINEARIZE THE VOLTAGE RESPONSE TO THE INCIDENT MAGNETIC FIELD IS DISCUSSED IN TERMS OF ITS DEPENDENCY IN FREQUENCY AND ARRAY'S UNIFORMITY. MODELS COMPARING THE RESULTS IN TERMS OF COUPLING INDUCTANCE, NUMBER OF ELEMENTS IN THE ARRAY, AND ARRAY'S UNIFORMITY WERE APPLIED TO EXPLAIN THE OBSERVED EXPERIMENTAL DATA. PERFORMANCE ENHANCEMENT IN TERMS OF LINEARITY AND DYNAMIC RANGE ARE THEN EXPLORED.

5EPG-02

ARRAY OF NON-LOCALLY COUPLED DC SQUIDS ***P. LONGHINI***[1]*, S. GUYLER*[2]*, A. PALACIOS*[2]*, V. IN*[1]*, A. LEESE DE ESCOBAR*[1]*;* [1]SSC PACIFIC, SPAWAR, [2]SAN DIEGO STATE UNIVERSITY. — IN THIS PAPER WE EXPLORE AN ARRAY OF NON-LOCALLY COUPLED DC SQUIDS THAT IS COUPLED THROUGH THE MAGNETIC FIELD CREATED BY THE CIRCULATING CURRENT. THE MOTIVATION IS BASED ON WORK USING AN ARRAY OF NON-IDENTICAL SQUID LOOPS OR SQIFS TO PRODUCE A NON-PERIODIC VOLTAGE RESPONSE WITH A UNIQUE ANTI-PEAK CENTERED AROUND THE ZERO APPLIED FLUX. OUR APPROACH DIFFERS BY USING AN ARRAY OF IDENTICAL SQUID LOOPS, HOWEVER, VARYING THE SPACING BETWEEN EACH OF THESE LOOPS. CERTAIN DISTRIBUTIONS OF SPACING PRODUCES THE ANTI-PEAK RESPONSE AS SEEN IN THE SQIF.

5EPG-03

DESIGN AND EXPERIMENTAL EVALUATION OF SQIF ARRAYS WITH LINEAR VOLTAGE RESPONSE ***V. KORNEV***[1]*, I. SOLOVIEV*[1]*, N. KLENOV*[1]*, O. MUKHANOV*[2]*;* [1]MOSCOW STATE UNIVERSITY, [2]HYPRES, 175 CLEARBROOK ROAD, ELMSFORD, NY 10523, USA. — WE PRESENT EXPERIMENTAL RESULTS AND THEIR COMPARISON WITH THEORETICAL CALCULATIONS OF SQIF ARRAYS DESIGNED TO ACHIEVE HIGHLY LINEAR VOLTAGE RESPONSE. A DIFFERENTIAL CIRCUIT OF TWO IDENTICAL PARALLEL SQIFS FRUSTRATED OPPOSITELY BY MAGNETIC FLUX HAS BEEN ESTABLISHED AS THE MOST PROMISING CIRCUIT ARCHITECTURE. WE HAVE FOUND THAT AS LONG AS THE SQIF RESPONSE SHAPE OF EACH SQIF IS CLOSE TO A PARABOLIC FORM, THE RESULTANT DIFFERENTIAL RESPONSE IS PERFECTLY LINEAR REGARDLESS OF IMPOSED MAGNETIC FRUSTRATION. THE OPTIMALLY LINEARIZED DIFFERENTIAL ARRAY CIRCUITS BASED ON 10 JOSEPHSON JUNCTION PARALLEL SQIFS WERE DESIGNED, LAYED OUT, AND FABRICATED USING STANDARD HYPRES NB PROCESS. EXPERIMENTAL STUDIES OF THE FABRICATED CIRCUITS HAVE CONFIRMED OUR PARABOLIC RESPONSE APPROACH FOR MAXIMIZING LINEARITY. LINEAR DIFFERENTIAL RESPONSE WITH AMPLITUDE OF ABOUT 25 MV HAS BEEN OBSERVED FOR SERIAL ARRAYS OF 108 DIFFERENTIAL SQIF CIRCUITS.

THIS WORK WAS SUPPORTED BY CRDF GRANT RUP1-1493-MO-05.

5EPG-04

MICROWAVE PARAMETRIC OSCILLATIONS IN OPTICALLY-ILLUMINATED SUPERCONDUCTING MESOSCOPIC STRUCTURES ***B. G. GHAMSARI****, A. MAJEDI;* UNIVERSITY OF WATERLOO. — THE SENSITIVITY OF SUPERCONDUCTING STRUCTURES TO OPTICAL RADIATION ENABLES MANY MICROWAVE-PHOTONIC DEVICE APPLICATIONS SUCH AS PHOTODETECTORS AND OPTOELECTRONIC MIXERS. BECAUSE OF THE COOPER PAIR BREAKING PROCESS, WHERE EXCESS QUASIPARTICLES ARE PRODUCED BY ENERGETIC PHOTONS, THE PAIRING POTENTIAL FIELD MAY BE CONTROLLED THROUGH EXTERNAL OPTICAL ILLUMINATION. THE PARAMETRIC PROCESS WILL BE POSSIBLE UNDER THE MODULATION OF THE PAIRING POTENTIAL IN A SUPERCONDUCTING MICRO-STRUCTURE. AS A PROMINENT EXAMPLE, AN RF DRIVEN SUPERCONDUCTING MICROSTRUCTURE (AS A LOCAL SIGNAL) UNDER THE OPTICAL IRRADIATION (AS A PUMP SIGNAL) CAN BE USED TO REALIZE PARAMETRIC OSCILLATION AND AMPLIFICATION.THIS WORK EMPLOYS THE BOGOLIUBOV-DE GENNES METHOD TO INVESTIGATE THE POSSIBILITY AND CONDITIONS OF PARAMETRIC EXCITATIONS, SUCH AS OSCILLATION AND AMPLIFICATION, IN OPTICALLY ILLUMINATED AND RF DRIVEN SUPERCONDUCTING MICRO-STRUCTURES. ANALYTICAL FORMULATION AND NUMERICAL SIMULATION WILL BE PRESENTED TO STUDY BOTH THE TRANSIENT AND STEADY-STATE RESPONSES. THE APPLICATION OF THE PARAMETRIC EXCITATIONS WILL BE, THEN, EXAMINED FOR ACTIVE AND TUNEABLE MICROWAVE DEVICES, AND SOME NOVEL DEVICE DESIGNS ARE PROPOSED.

5EPG-05

SUPERCONDUCTING METAMATERIALS FOR CLOAKING DC MAGNETIC FIELDS ***C. NAVAU***[1]*, D. CHEN*[2]*, N. DEL-VALLE*[1]*, A. SANCHEZ*[1]*;* [1]UNIVERSITAT AUTONOMA DE BARCELONA, [2]ICREA AND UNIVERSITAT AUTONOMA DE BARCELONA. — A THREE-DIMENSIONAL ARRAY OF SUPERCONDUCTING PLATES HAS BEEN PROPOSED AS A CLOAKING SYSTEM FOR DC MAGNETIC FIELDS. THE VALUES OF EFFECTIVE PERMEABILITY OF THE SYSTEM CAN RANGE FROM SMALL VALUES TO ONE, DEPENDING ON THE ARRANGEMENT OF THE ARRAY, IF ONE CONSIDERS PERFECTLY SHIELDED SUPERCONDUCTORS. HOWEVER, WHEN CONSIDERING PENETRATION OF THE FIELD INSIDE THE SUPERCONDUCTORS THE RANGE OF VARIATION OF THE EFFECTIVE PERMEABILITY IS REDUCED. IN THIS WORK WE MAKE ACCURATE CALCULATIONS TO SHOW, DEPENDING ON THE ARRANGEMENT AND ON THE PROPERTIES OF THE SUPERCONDUCTING PLATES, THE RANGE OF EFFECTIVE PERMEABILITY THAT ONE CAN ACHIEVE AND THE LIMITATIONS OF THE DC SUPERCONDUCTING CLOAKING SYSTEM.

5EPG-07

TWO-STAGE DIRECTLY-COUPLED SUPERCONDUCTING QUANTUM INTERFERENCE DEVICE ARRAY MAGNETOMETER ***J. T. JENG***[1]*, M. J. WANG*[2]*, C. H. WU*[3]*, C. C. LU*[4]*;* [1]DEPARTMENT OF MECHANICAL ENGINEERING, NATIONAL KAOHSIUNG UNIVERSITY OF APPLIED SCIENCES, KAOHSIUNG 80778, TAIWAN., [2]ACADEMIA SINICA INSTITUTE OF ASTRONOMY AND ASTROPHYSICS (ASIAA), TAIPEI 10617, TAIWAN, [3]INSTITUTE OF NANOSCIENCE, NATIONAL CHUNG HSING UNIVERSITY, TAICHUNG 40227, TAIWAN., [4]INSTITUTE OF MECHATRONIC ENGINEERING, NATIONAL TAIPEI UNIVERSITY OF TECHNOLOGY, TAIPEI 10608, TAIWAN.. — THE CHARACTERISTICS OF THE VOLTAGE-BIASED SUPERCONDUCTING QUANTUM INTERFERENCE DEVICE (SQUID) WERE INVESTIGATED. BY SOLVING THE COUPLED DIFFERENTIAL EQUATIONS OF THE RESISTIVELY-AND-CAPACITIVELY SHUNTED JUNCTION CIRCUIT MODEL, IT IS FOUND THAT THE FLUX-TO-CURRENT TRANSFER COEFFICIENT IS MAXIMIZED WITH PROPER BIAS IMPEDANCE. TO ENHANCE THE TRANSFER COEFFICIENT, WE PROPOSED THE DESIGN OF TWO-STAGE SQUID ARRAY CONNECTED BY WIRE BONDING. THE ENHANCEMENT OF FLUX-TO-CURRENT TRANSFER COEFFICIENT OF THE PARALLEL SQUID ARRAY IN THE FIRST STAGE WAS VERIFIED EXPERIMENTALLY. WITH THE EXISTENCE OF CRITICAL CURRENT SPREAD, THE PROBABILITY OF FINDING TWO SQUIDS IN THE SECOND STAGE WITH SIMILAR CRITICAL CURRENTS IS ALSO CALCULATED. ACCORDING TO THE THEORETICAL ANALYSIS, THE FIELD NOISE OF THE TWO-STAGE MAGNETOMETER CAN BE MINIMIZED WITH A PROPER NUMBER OF ELEMENTS IN PARALLEL. THE PROPOSED DESIGN CAN BE IMPLEMENTED BY USING THE SINGLE-LAYERED HIGH-T_C SUPERCONDUCTING FILM AND THE GRAIN-BOUNDARY JOSEPHSON JUNCTIONS.

* THIS WORK IS FINANCIALLY SUPPORTED BY THE NATIONAL SCIENCE COUNCIL OF TAIWAN UNDER GRANT NO. NSC98-2112-M-151-002-MY3.

5EPG-08

RF MEASUREMENTS OF WIDEBAND VHF-UHF SQIF AMPLIFIER ***G. V. PROKOPENKO***[1]*, O. A. MUKHANOV*[1]*, A. L. DE ESCOBAR*[2]*;* [1]HYPRES, 175 CLEARBROOK RD., ELMSFORD, NY 10523, USA, [2]SPAWAR, SAN DIEGO, CA, USA. — WE PRESENT RESULTS OF RF MEASUREMENTS OF THE VHF-UHF WIDEBAND AMPLIFIER BASED ON SUPERCONDUCTING QUANTUM INTERFERENCE FILTER (SQIF) WITH HIGH SENSITIVITY, LINEARITY AND DYNAMIC RANGE. THE AMPLIFIER WAS DESIGNED AS PAIR OF 2D SQIF ARRAYS MOUNTED IN A COPLANAR WAVEGUIDE (CPW) AND SYMMETRICALLY GROUNDED TO CORRESPONDING SIDES OF CPW. THE AMPLIFIER SQIF ARRAYS WITH DIFFERENT PARAMETER DISTRIBUTIONS ARE USED FOR COMPARISON. THE RF OUTPUT COMES OUT FROM THE CENTRAL COMMON LINE, WHICH IS ALSO USED FOR DC BIASING AND FORMS A SYMMETRICAL BALANCED OUTPUT. THE SIGNAL FEEDBACK IS DESIGNED AS A MEANDER LINE WITH INTEGRATED NEGATIVE PHASE SHIFT PASSED THROUGH EACH CELL OF THE SQIF ARRAY. THE MEASURED LINEARITY, DYNAMIC RANGE, POWER GAIN, AND NOISE TEMPERATURE WILL BE PRESENTED. THE MEASURED RESULTS WILL BE COMPARED TO SIMULATION RESULTS OBTAINED USING MICROWAVE OFFICE SOFTWARE ADAPTED FOR JOSEPHSON TECHNOLOGY. ALL SQIF AMPLIFIER SAMPLES WERE FABRICATED ON 5 MM X 5 MM CHIPS USING STANDARD HYPRES NIOBIUM 4.5 KA/CM2 FABRICATION PROCESS. WE WILL DISCUSS A DESIGN APPROACH FOR THE ELECTRICALLY SMALL MAGNETIC FIELD ANTENNA WITH HIGH BANDWIDTH BASED ON THIS SQIF AMPLIFIER.

THE WORK IS SUPPORTED IN PART BY THE SPAWAR CONTRACT N00039-08-C-0024.

5EPH-01

HIGH-TEMPERATURE SUPERCONDUCTING GRADIOMETER COUPLED WITH LARGE PICKUP COIL MADE OF GDBCO COATED CONDUCTOR ***A. TSUKAMOTO***[1]*, S. ADACHI*[1]*, Y. OSHIKUBO*[1]*, T. HATO*[1]*, K. TANABE*[1]*, K. ENPUKU*[2]*;* [1]ISTEC-SRL, [2]KYUSHU UNIVERSITY. — WE HAVE FABRICATED A LARGE HIGH-TEMPERATURE SUPERCONDUCTING GRADIOMETER FOR GEOPHYSICAL APPLICATION SUCH AS A TRANSIENT ELECTRO-MAGNETIC (TEM) METHOD. THE GRADIOMETRIC PICKUP COIL (FLUX TRANSFORMER) WAS MADE OF A COMMERCIALLY AVAILABLE GDBCO COATED CONDUCTOR FORMED ON A HASTELLOY TAPE BY AN IBAD-PLD METHOD. TWO PICKUP LOOPS WITH A DIAMETER OF 100MM AND AN INPUT COIL WERE CONNECTED IN SERIES WITH LOW RESISTANCE CONTACTS. THE INPUT COIL WAS MAGNETICALLY COUPLED WITH A RE-123 BASED DIRECTLY-COUPLED GRADIOMETER WHICH WAS MADE ON A MGO SUBSTRATE BY USING THE OXIDE THIN FILM MULTILAYER AND RAMP-EDGE JOSEPHSON JUNCTION TECHNOLOGIES. THE BESELINE LENGTH DEFINED AS THE DISTANCE OF TWO PICKUP LOOPS IS ABOUT 130 MM.THE PERFORMANCES OF THE GRADIOMETER SUCH AS FLUX NOISE, GRADIOMETER BALANCE AND FREQUENCY DEPENDENCE OF SENSITIVITY WERE INVESTIGATED BY APPLYING A HOMOGENEOUS MAGNETIC FIELD GENERATED BY A HELMHOLTZ COIL. THE GRADIOMETER BALANCE OF 1/133 WAS OBTAINED FOR THE DIRECTION NORMAL TO THE PICKUP COIL PLANE. A CUTOFF FREQUENCY OF THE GRADIOMETER SENSITIVITY OF 100 HZ WAS OBTAINED.

THIS WORK IS A PART OF MINERAL EXPLORATION RENOVATING PROGRAM CONDUCTED BY JAPAN OIL, GAS AND METALS NATIONAL CORPORATION (JOGMEC) AND IS FULLY FUNDED BY MINISTRY OF ECONOMY, TRADE AND INDUSTRY, JAPAN.

5EPH-02

FABRICATION OF INTEGRATED TWO AXIS HIGH-TC PLANAR GRADIOMETER ***A. TSUKAMOTO****, S. ADACHI, Y. OSHIKUBO, J. KAWANO, T. HATO, K. TANABE;* ISTEC-SRL. — -WE HAVE FABRICATED A TWO-AXIS HIGH-TC PLANAR GRADIOMETER INTEGRATED ON A SUBSTRATE. THE DIRECTIONS OF THE TWO PAIRS OF GRADIOMETRIC PICKUP COILS ARE ORTHOGONAL, AND. MAGNETIC FIELD GRADIENTS DBZ/DX AND DBZ/DY AT THE SAME POSITION CAN BE MEASURED SIMULTANEOUSLY BY USING THIS DEVICE, WHERE Z IS DEFINED AS THE DIRECTION

NORMAL TO THE PICKUP COILS.-THE TWO-AXIS GRADIOMETER WAS FABRICATED ON A 15X15 MM MGO(100) SUBSTRATE USING AN HTS MULTILAYER PROCESS INCLUDING CROSSOVERS, SUPERCONDUCTIVE CONTACTS AND RAMP-EDGE JUNCTIONS. THE WIDTH OF THE PICKUP COIL AND THE BASELINE LENGTH ARE 6 MM AND 8.5 MM, RESPECTIVELY. THE CENTER OF THE TWO GRADIOMETRIC PICKUP COILS CROSSES EACH OTHER NEAR THE CENTER OF THE SUBSTRATE. FOUR SQUIDS WERE DIRECTLY COUPLED TO EACH PICKUP COIL.-VOLTAGE MODULATIONS IN V-FAI CHARACTERISTICS MORE THAN 20 UV AT 77 K WERE OBTAINED IN BOTH THE GRADIOMETERS. PARASITIC EFFECTIVE AREAS MEASURED BY APPLYING A UNIFORM MAGNETIC FIELD WERE 0.00085-0.00109 MM2. FROM THIS RESULT, THE GRADIOMETER BALANCE WAS ESTIMATED TO BE 1/175-1/137. DIRECT SENSING OF THE BARE SQUID MAINLY CONTRIBUTED THE PARASITIC EFFECTIVE AREA.

THIS WORK WAS SUPPORTED BY NEW ENERGY AND INDUSTRIAL TECHNOLOGY DEVELOPMENT ORGANIZATION (NEDO).

5EPH-03

FABRICATION OF LOW-NOISE HTS-SQUID GRADIOMETERS AND MAGNETOMETERS WITH RAMP-EDGE JOSEPHSON JUNCTIONS ***S. ADACHI***, *A. TSUKAMOTO, Y. OSHIKUBO, T. HATO, Y. ISHIMARU, K. TANABE;* SRL-ISTEC. — WE HAVE STUDIED THE FABRICATION PROCESS OF HTS-SQUIDS WITH RAMP-EDGE JOSEPHSON JUNCTIONS (JJS). SMBA2CU3OY (SMBCO) AND ER0.95LA0.1BA1.95CU3OY (L1ERBCO) WERE USED FOR BASE- AND COUNTER-ELECTRODES HAVING TC'S AROUND 90 K, RESPECTIVELY. SRSNO3 (SSO) WAS USED FOR INSULATING LAYERS. THE SUPERCONDUCTING ELECTRODES WERE DEPOSITED ONTO SSO LAYERS EXCEPT POSITIONS OF JJ AND SUPERCONDUCTING CONTACTS. MGO (100) SINGLE CRYSTALS WERE USED FOR SUBSTRATES. A BLACK-COLORED PR1.4BA1.6CU2.6GA0.4OY LAYER WAS UNDERLAID AT THE LOWEST. IT WAS EXPECTED TO WORK AS A TEMPERATURE HOMOGENIZER OVER A WHOLE SUBSTRATE AREA DURING DEPOSITION OF THE UPPER LAYERS. WE FABRICATED PLANAR GRADIOMETERS WITH THE PICKUP COILS WITH SIZES OF 0.5 X 1.0, 1.0 X 1.0 AND 3.0 X 3.0 MM2. THE BASELINES ARE 1.0, 1.0 AND 3.0 MM, RESPECTIVELY. THE FEEDBACK COILS ARE PLACED ON THE PICKUP COILS. THE GRADIOMETERS EXHIBITED FLUX NOISE LEVELS AT 77 K AS LOW AS 3.3 ~ 4.5 UΦ0/RTHZ AT 1 KHZ. DIRECTLY AND INDUCTIVELY COUPLED MAGNETOMETERS HAVING A PICKUP COIL WITH 12 MM SQUARE WERE ALSO FABRICATED. THE LATTER HAS AN INTEGRATED 20-TURN INPUT COIL. THEY SHOWED FIELD NOISE LEVELS AT 77 K OF 45 AND 20 FT/RTHZ AT 1 KHZ, RESPECTIVELY.

THIS WORK WAS SUPPORTED BY JST FOR STRATEGIC PROMOTION OF INNOVATIVE R&D.

5EPH-04

YBCO STEP-EDGE JUNCTIONS E.E. MITCHELL AND C.P. FOLEY *CSIRO MATERIALS SCIENCE AND ENGINEERING, PO BOX 218, LINDFIELD, NSW, 2070, AUSTRALIA* WE INVESTIGATE THE STEP-EDGE MORPHOLOGY AND FILM STRUCTURE OF YBCO-BASED STEP-EDGE JUNCTIONS ON MGO [001] SUBSTRATES. THE DEPENDENCE OF THE TRANSPORT PROPERTIES ON THE MGO STEP-EDGE AND JUNCTION MORPHOLOGY IS EXAMINED AT 4.2 K TO ENABLE A DIRECT COMPARISON WITH RESULTS FOR THE BULK OF JUNCTION STUDIES PREVIOUSLY PUBLISHED ON [001]-TILT AND [100]-TILT JUNCTIONS. MGO STEP-EDGE JUNCTIONS SHOW A SLOWER REDUCTION IN CRITICAL CURRENT DENSITY WITH STEP ANGLE COMPARED WITH [001]-TILT JUNCTIONS, SUGGESTING THERE MAY BE LESS STRAIN AT THE GRAIN BOUNDARY OF STEP-EDGE JUNCTIONS. HIGH-RESOLUTION ELECTRON MICROSCOPY REVEALS A CLEAN GBJ INTERFACE OF WIDTH ~1 NM AND A SINGLE JUNCTION AT THE TOP EDGE, WHICH STRUCTURALLY RESEMBLE [100]-TILT JUNCTIONS. FOR OPTIMIZED STEP PARAMETERS, TRANSPORT MEASUREMENTS REVEALED LARGE CRITICAL CURRENT AND NORMAL RESISTANCE (I_CR_N) PRODUCTS (~3–5 MV), COMPARABLE WITH THE BEST RESULTS OBTAINED IN OTHER KINDS OF [100]-TILT GBJS IN YBCO AT 4.2 K. JUNCTION-BASED DEVICES SUCH AS SQUIDS (SUPERCONDUCTING QUANTUM INTERFERENCE DEVICES) AND THZ IMAGERS SHOW EXCELLENT PERFORMANCE WHEN MGO-BASED STEP-EDGE JUNCTIONS ARE USED.

5EPH-05

FABRICATION AND PROPERTIES OF HIGH-TC YBCO SQUID WITH VARIABLE THICKNESS BRIDGES BY FOCUSED ION BEAM ***C. H. WU***[1], *J. T. JENG*[2], *J. H. CHEN*[3], *H. C. YANG*[4], *F. J. JHAN*[1]; [1]DEPARTMENT OF PHYSICS, NATIONAL CHUNG HSING UNIVERSITY, TAICHUNG 402, TAIWAN, [2]DEPARTMENT OF MECHANICAL ENGINEERING, NATIONAL KAOHSIUNG UNIVERSITY OF APPLIED SCIENCES, KAOHSIUNG 80778, TAIWAN.,, [3]DEPARTMENT OF ELECTRICAL ENGINEERING, DA-YEH UNIVERSITY, CHANGHWA 515, TAIWAN, [4]DEPARTMENT OF PHYSICS, NATIONAL TAIWAN UNIVERSITY, TAIPEI 402, TAIWAN. — WE HAVE SUCCESSFULLY FABRICATED YBCO JOSEPHSON JUNCTIONS AND SQUIDS WITH VARIABLE THICKNESS BRIDGES. THE VARIABLE-THICKNESS BRIDGES OF YBCO THIN FILM WERE FABRICATED BY PHOTOLITHOGRAPHY AND FIB. WE MEASURED THE VOLTAGE VS CURRENT CHARACTERISTICS OF HIGH-TC YBA2CU3OY JOSEPHSON JUNCTIONS UNDER MICROWAVES. THE SHAPIRO STEPS WERE OBSERVED IN SINGLE JUNCTION. THE VOLTAGE VS CURRENT AND VOLTAGE VS MAGNETIC FIELD CHARACTERISTICS WERE MEASURED IN SQUID MAGNETOMETER. THE PROPERTIES OF SINGLE JUNCTION AND SQUID MAGNETOMETER HAVE BEEN INVESTIGATED.

THE AUTHORS WOULD LIKE TO THANK THE NATIONAL SCIENCE COUNCIL OF THE REPUBLIC OF CHINA, TAIWAN, FOR FINANCIALLY SUPPORTING THIS RESEARCH UNDER CONTRACT NO. NSC98-2112-M-005-006-MY3

5EPH-06

FABRICATION OF BI2SR2CACU2O8 INTRINSIC DC-SQUID WITH A SHUNT RESISTOR ***T. KATO***[1], *A. MIWA*[1], *H. SUEMATSU*[1], *A.*

KAWAKAMI[2], K. HAMSAKI[1]; [1]NAGAOKA UNIVERSITY OF TECHNOLOGY, [2]NATIONAL INSTITUTE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY. — WE SUCCESSFULLY FABRICATED A $BI_2SR_2CACU_2O_X$ (BI-2212) INTRINSIC DC-SQUIDS WITH A EXTERNAL SHUNT RESISTOR. THE TWO STACKS CONNECTED WITH THE SQUID LOOP WERE SINGLED OUT FROM INSIDE A BI-2212 SINGLE CRYSTAL PLATELET BY DIPPING INTO A DILUTE HYDROCHLORIC ACID (PH >1.4). THE SHUNT RESISTOR LAYER WAS FORMED BY AG THIN FILM. THE CURRENT-VOLTAGE CHARACTERISTIC (I-V) HAD A PARABOLIC SHAPE WITHOUT BRANCH STRUCTURES FOR THE BI-2212 INTRINSIC JOSEPHSON JUNCTIONS. THE SQUID OUTPUT VOLTAGE AT 77 K WAS MODULATED BY A DC-MAGNETIC FIELD UP TO ABOUT 10~20 G. SUCH MODULATION WAS NOT OBSERVED ABOVE THE LOWER CRITICAL FIELD (B_{C1}) OF THE SINGLE BI-2212 CRYSTAL.

5EPH-07

FABRICATION OF HTS MULTILAYER STRUCTURES USING CHEMICAL-MECHANICAL POLISHING ***M. L. CHUKHARKIN[1]**, A. KALABUKHOV[1], J. SCHNEIDERMAN[1], F. OISJOEN[1], O. V. SNIGIREV[2], D. WINKLER[1];* [1]DEPARTMENT OF MICROTECHNOLOGY AND NANOSCIENCE - MC2, CHALMERS UNIVERSITY OF TECHNOLOGY, [2]DEPARTMENT OF PHYSICS, MOSCOW STATE UNIVERSITY. — MAGNETO-ENCEPHALOGRAPHY AND IN LOW-FIELD MAGNETO-RESONANT IMAGING SYSTEMS REQUIRE VERY HIGH MAGNETIC FIELD SENSITIVITY ABOUT 10 FT AT 10 HZ. A TYPICAL NOISE OF THE HTS SQUID-MAGNETOMETERS WITH SINGLE-LAYER PICK UP LOOP COIL IS ABOUT 30 FT. THE SENSITIVITY CAN BE INCREASED TO 5 FT BY USING ADDITIONAL FLUX TRANSFORMER, BUT IT REQUIRES RATHER COMPLICATED MULTILAYER FABRICATION TECHNOLOGY IN HTS FILMS WHICH IS NOT WELL ESTABLISHED SO FAR. WE HAVE DEVELOPED A NEW FABRICATION PROCESS BASED ON THE YBCO FILM PLANARIZATION USING CHEMICAL-MECHANICAL POLISHING (CMP). CMP ALLOWS TO CREATE VERY SHALLOW (LESS THAN 5°) SLOPE EDGES IN THE BOTTOM ELECTRODE, THAT MAKES IT POSSIBLE TO FABRICATE YBCO CROSSOVERS WITHOUT GRAIN BOUNDARIES AND WITH VERY HIGH CRITICAL CURRENT DENSITIES ABOUT 2•106 A/CM2. WE ALSO DEVELOPED OPTIMIZED PLANARIZATION PROCESS IN ORDER TO CREATE INTERCONNECTIONS BETWEEN TOP AND BOTTOM SUPERCONDUCTING ELECTRODES. THE CONTACTS BETWEEN YBCO LAYERS WERE MADE THROUGH THE HOLES IN INSULATING STO/PBCO/STO TRILAYER. WE OBSERVED THAT CRITICAL PARAMETERS OF THE BOTTOM ELECTRODE (TC, JC) DID NOT DEGRADE AFTER THE DEPOSITION AND PATTERNING OF THE INSULATING AND TOP YBCO ELECTRODES. OPERATION OF FABRICATED FLIP-CHIP AND INTEGRATED FLUX TRANSFORMERS TOGETHER WITH BICRYSTAL DC SQUIDS WILL BE PRESENTED.

THE WORK IS SUPPORTED BY EUROPEAN FP7 PROJECT "MEGMRI", CONTRACT NUMBER 200859.

5EPH-08

LONG BASELINE PLANAR SQUID GRADIOMETER FOR OPERATION IN A SOFT SHIELDED ENVIRONMENT ***C. GRANATA**, A. VETTOLIERE, S. ROMBETTO, M. RUSSO;* ISTITUTO DI CIBERNETICA. — A FIRST ORDER PLANAR SQUID GRADIOMETER WITH A LONG BASELINE IN VIEW OF ITS APPLICATION IN BIOMAGNETISM IS PRESENTED. IN PARTICULAR WE REPORT THE SENSOR DESIGN CRITERIA, AN EXTENSIVE ANALYSIS CONCERNING THE DEVICE RESPONSE TO THE CURRENT DIPOLE COMPARING THE RESULTS WITH THOSE OF AN AXIAL GRADIOMETER, THE FABRICATION PROCESS AND THE SENSOR EXPERIMENTAL PERFORMANCES. THE SENSOR DESIGN HAS BEEN AIMED TO OBTAIN BOTH A HIGH INTRINSIC BALANCE AND A HIGH INTRINSIC RESPONSIVITY IN ORDER TO USE A SIMPLE ELECTRONIC READOUT SCHEME. THE STUDY OF THE SENSOR PERFORMANCE IN VIEW OF BIOMAGNETIC APPLICATIONS HAS CONSISTED IN THE COMPUTATION OF THE MAGNETIC RESPONSES TO A CURRENT DIPOLE WHICH IS THE MOST FUNDAMENTAL MODEL USED IN BIOMAGNETISM. IN PARTICULAR, THE MAGNETIC FLUX MEASURED BY THE SENSORS IN THE PRESENCE OF A SETTING CURRENT DIPOLE AND THE MINIMUM DETECTABLE DIPOLE AS FUNCTION OF OFF-AXIS DISTANCE FROM THE GRADIOMETER HAVE BEEN COMPUTED. THE RESULTS HAVE BEEN COMPARED WITH THOSE OF FIRST ORDER AXIAL GRADIOMETER HAVING SAME BASELINE, PICKUP COIL'S SIZE, AND THE SAME SQUID DESIGN PARAMETERS. AT T=4.2 K, THE SENSORS HAVE SHOWN, A HIGH INTRINSIC RESPONSIVITY OF ABOUT 500 MV/Φ_0 AND A WHITE MAGNETIC FLUX NOISE SPECTRAL DENSITY AS LOW AS 3.0 $M\Phi_0/HZ^{1/2}$ CORRESPONDING TO A FIELD GRADIENT NOISE OF 0.6 $FT/(CM\cdot HZ^{1/2})$, MEASURED IN THE FLUX LOCKED LOOP CONFIGURATION, USING A SIMPLE DIRECT-COUPLED READOUT ELECTRONICS.

THIS WORK WAS PARTIALLY SUPPORTED BY ITALIAN MIUR UNDER THE PROJECT

5EPH-09

CLARIFYING FLUX-TO-VOLTAGE TRANSFER FUNCTION AND EFFECTIVE AREA IN SUPERCONDUCTING-QUANTUM-INTERFERENCE-DEVICE SERIES ARRAYS ***J. CHEN[1]**, C. WU[2], K. CHEN[3], U. SOU[3];* [1]DA-YEH UNIVERSITY, [2]NATIONAL CHUNG HSING UNIVERSITY, [3]NATIONAL TAIWAN UNIVERSITY. — MAGNETOMETERS BASE ON SUPERCONDUCTING QUANTUM INTERFERENCE DEVICES (SQUIDS) ARE THE MOST SENSITIVE DEVICES TO MEASURE LOW FREQUENCY MAGNETIC FIELDS, HOWEVER, THE OUTPUT VOLTAGE OF A SINGLE SQUID IS RELATIVELY SMALL. OCCASIONALLY, A SERIES-CONNECTED ARRAY OF SQUIDS IS USED TO MULTIPLY THE OUTPUT VOLTAGE, AND THEN THE MAGNETIC FIELD NOISE POWER SPECTRAL DENSITY SCALES INVERSELY WITH THE NUMBER OF SERIES-CONNECTED SQUIDS. THE REDUCTION OF MAGNETIC FIELD NOISE IS OFTEN ATTRIBUTED TO THE LARGER FLUX-TO-VOLTAGE TRANSFER FUNCTION OF THE SQUID SERIES ARRAYS. AS A MATTER OF FACT, THE REDUCTION OF MAGNETIC FIELD NOISE SHOULD BE ASCRIBED TO THE INCREASE OF EFFECTIVE AREA OF THE SQUID SERIES ARRAYS, NOT THE TRANSFER COEFFICIENT. THE REASON IS THAT THE TRANSFER COEFFICIENT OF IDEAL SQUID SERIES ARRAYS SHOULD BE THE SAME AS A SINGLE SQUID. A CLEAR INTERPRETATION BASES

ON THE GRAPH OF MODULATION VOLTAGE *VERSUS* MAGNETIC FLUX IS PRESENTED.

5EPH-10

DIGITAL DROS WITH SFQ UP/DOWN COUNTER FOR WIDE DYNAMIC OPERATION RANGE ***H. MYOREN****, Y. KIMIMOTO, K. TERUI, T. TAINO;* SAITAMA UNIVERSITY. — WE DESIGNED AND FABRICATED A DIGITAL DOUBLE RELAXATION OSCILLATION SQUID (DROS) WITH AN SFQ UP/DOWN COUNTER. THE DROS IS CONNECTED TO A FEEDBACK SQUID LOOP AND SIGNAL MAGNETIC FLUX IS INPUT TO THE FEEDBACK SQUID LOOP. THE DROS GENERATES UP AND DOWN VOLTAGE PULSES CORRESPONDING TO THE TOTAL MAGNETIC FLUX IN THE FEEDBACK SQUID LOOP. THE VOLTAGE PULSES ARE CONVERTED TO SFQ PULSES AND INPUT TO THE FEEDBACK SQUID LOOP TO KEEP MAGNETIC FLUX IN THE SQUID LOOP CONSTANT. GENERATED SFQ PULSES ARE ALSO COUNTED USING THE SFQ UP/DOWN COUNTER. THUS, COUNTING NUMBER IS CORRESPONDING TO THE INPUT MAGNETIC FLUX. BECAUSE THE SFQ UP/DOWN COUNTER IS OPERATED IN THE PULSE DRIVEN MODE, THE DIGITAL DROS NEEDS ONLY DC BIAS CURRENT FOR OPERATION. WE DESIGNED THE DROS WITH A RELAXATION OSCILLATION FREQUENCY OF 3 GHZ AND THE SFQ UP/DOWN COUNTER WITH AN UPPER OPERATION FREQUENCY OF 30 GHZ AND A BIAS MARGIN OF +-30% AT 10GHZ. WE CONFIRMED THE DESIGNED DIGITAL DROS HAS DYNAMIC RANGE EXCEEDED +-100 Φ_0 AND MAGNETIC THROUGH RATE OF $3X10^9$ Φ_0/S BY SIMULATIONS. WE FABRICATED THE DESIGNED DIGITAL DROS USING ISTEC SRL 2.5 KA/CM^2 NB STANDARD PROCESS II AND CONFIRMED CORRECT OPERATION THE DROS AND THE SFQ 8-BIT UP/DOWN COUNTER. DETAIL OF DIGITAL DROS OPERATIONS WILL BE PRESENTED AT THE CONFERENCE.

THIS WORK WAS PARTIALLY SUPPORTED BY A GRANT-IN-AID FOR SCIENTIFIC RESEARCH ON PRIORITY AREAS ``SINGLE-FLUX-QUANTUM INTEGRATED CIRCUITS BASED ON LOCALIZED ELECTROMAGNETIC WAVE'' (NO. 18080002) FROM THE MEXT, JAPAN.

5EPJ-01

LOW FIELD MRI DETECTION WITH TUNED HTS SQUID MAGNETOMETER ***H. DONG***[1]*, Y. ZHANG*[1]*, H. KRAUSE*[1]*, X. XIE*[2]*, A. I. BRAGINSKI*[1]*, A. OFFENHÄUSSER*[1]*;* [1]INSTITUTE OF BIO- AND NANOSYSTEMS, FORSCHUNGSZENTRUM JUELICH, GERMANY, [2]SHANGHAI INSTITUTE OF MICROSYSTEM AND INFORMATION TECHNOLOGY, CHINESE ACADEMY OF SCIENCES, P. R. CHINA. — **LOW FIELD MRI DETECTION WITH TUNED HTS SQUID MAGNETOMETER**WE SET UP A LOW FIELD (LF) MAGNETIC RESONANCE IMAGING (MRI) SYSTEM WITH A TUNED HIGH-T_C (HTS) SUPERCONDUCTING QUANTUM INTERFERENCE DEVICE (SQUID) CONSISTING OF A SQUID MAGNETOMETER AND A LIQUID-NITROGEN-COOLED *LC* RESONANT PICKUP CIRCUIT. THIS CIRCUIT INCLUDES A CAPACITOR AND A COPPER COIL INDUCTIVELY COUPLED TO THE SQUID. AROUND 9 KHZ, IT ENHANCES THE SENSITIVITY OF THE SYSTEM TO 7 ~ 8 FT/√HZ. THE RELATIVELY LARGE DIAMETER OF THE COIL COMPENSATES THE MAGNETOMETER'S DRAWBACK OF A SMALL PICKUP AREA. WE PERFORMED OUR EXPERIMENTS WITHIN A MAGNETICALLY SHIELDED ROOM; THE MEASUREMENT FIELD WAS 212 MT, THE LARMOR FREQUENCY ≈ 9 KHZ. TWO-DIMENSIONAL MRI IMAGES OF CARROTS (CYLINDERS WITH DIAMETER OF 27 MM AND HEIGHT OF 10 MM) WERE ACQUIRED WITH A POLARIZING FIELD OF 10 MT AND A GRADIENT FIELD OF 9 HZ/CM. THE SIGNAL-TO-NOISE RATIO WAS ABOUT 10 WITH 20 AVERAGES. AN IMAGING RESOLUTION OF ABOUT 3 × 3 MM^2 WAS ACHIEVED, MUCH HIGHER THAN THAT ATTAINED BY THE BARE SQUID MAGNETOMETER. A RELATIVELY INEXPENSIVE PORTABLE HTS SYSTEM FOR BIOLOGICAL LF MRI DETECTION BY A TUNED SQUID IS FEASIBLE.

5EPJ-02

HTS SQUID MAGNETOMETER USING RESONANT COUPLING OF COOLED CU PICKUP COIL ***K. ENPUKU****, S. HIRAKAWA, Y. TSUJI, R. MOMOTOMI, M. MATSUO, T. YOSHIDA;* KYUSHU UNIVERSITY. — WE HAVE BEEN DEVELOPING A MAGNETOMETER MADE OF HTS SQUID AND CU PICKUP COIL COOLED AT *T*=77 K. FOR THE APPLICATION TO LOW FIELD NMR, WE CONSIDER THE CASE WHEN RELATIVELY LARGE PICKUP COIL WAS RESONANTLY COUPLED TO THE SQUID. FIRST, WE STUDIED THE DEPENDENCE OF THE SENSITIVITY ON THE PARAMETERS OF THE PICKUP COIL, SUCH AS THE DIAMETER D, NUMBER OF TURNS N AND CROSS-SECTIONAL AREA A OF THE COPPER WIRE. IN THE EXPERIMENT, WE USED THE PICKUP COIL WITH D=50 MM AND N=60, WHERE THE COPPER WIRE WITH CROSS SECTIONAL AREA OF A=0.5 MM2 WAS USED TO FORM THE PICKUP COIL. THE PICKUP COIL WITH INDUCTANCE L=212 MH WAS CONNECTED TO AN INPUT COIL THROUGH A RESONANT CAPACITANCE C=1 MF, AND THE SQUID WAS MAGNETICALLY COUPLED TO THE INPUT COIL WITH MUTUAL INDUCTANCE *M*=1 NH. THE Q VALUE AND THE RESISTANCE R OF THE PICKUP COIL AT THE RESONANT FREQUENCY F=10.9 KHZ WERE Q=107.4 AND R=0.12 Ω, RESPECTIVELY. THE MEASURED VALUE OF THE RESISTANCE WAS ABOUT 35 % HIGHER THAN THE DC RESISTANCE, INDICATING THE EFFECT OF EDDY-CURRENT LOSS OF THE COPPER WIRE. THE ESTIMATED MAGNETIC FIELD NOISE OF THE MAGNETOMETER WAS 4 FT/$HZ^{1/2}$ AT F=10.9 KHZ. THIS HIGH SENSITIVITY WILL BE USEFUL FOR THE APPLICATION TO LOW FIELD NMR.

5EPJ-03

AN EXPERIMENTAL STUDY OF ULTRA-LOW FIELD NMR USING A HIGH-T_C DC-SQUID *Y. JIN, N. WANG, S. LI, Y. TIAN, Y. REN, Y. WU, H. DENG, Y. CHEN, J. LI, H. TIAN, G. CHEN,* ***D. ZHENG****;* INSTITUTE OF PHYSICS AND BEIJING NATIONAL LABORATORY FOR CONDENSED MATTER PHYSICS, CHINESE ACADEMY OF SCIENCES, BEIJING 100190, CHINA. — WE HAVE CARRIED OUT NMR EXPERIMENTS IN MICROTESLA RANGE USING A HIGH-T_C DC-SQUID SENSOR. THE MEASUREMENTS WERE CARRIED OUT IN A HOME-MADE MAGNETICALLY SHIELDED ROOM. RESONANCE SPECTRA OF ^1H FROM TAP WATER AND OTHER SUBSTANCE SAMPLES WERE OBTAINED IN THE FIELD RANGE FROM 7-70MT, CORRESPONDING TO RESONANCE FREQUENCY 300-3KHZ. THE SIGNAL TO NOISE RATIO IN A SINGLE-SHOT

MEASUREMENT IS AROUND 4 FOR ABOUT 15 ML WATER, WHICH WOULD BE INCREASED TO ABOUT 40 AFTER 100 TIMES AVERAGING. THE EFFECT OF RESIDUAL MAGNETIC FIELD IN THE MAGNETICALLY SHIELDED ROOM, PRE-POLARIZATION TIME AND DATA ACQUISITION TIME WAS INVESTIGATED. IN PARTICULAR, WE HAVE INVESTIGATED THE EFFECT OF LOW FREQUENCY FIELD DISTURBANCE ON THE NMR SPECTRA BY APPLYING A SINUSOID WAVEFORM FIELD WITH A VARIETY OF DIFFERENT FREQUENCIES, AMPLITUDES AND INITIAL PHASE ANGLES. THE DISTURBANCE FIELD WAS APPLIED IN DIRECTIONS BOTH PARALLEL AND PERPENDICULAR TO THE MEASUREMENT FIELD. THE RESULTS WERE COMPARED WITH THE NUMERICAL CALCULATIONS BASED ON THE BLOCH EQUATION.

5EPJ-04

NUCLEAR MAGNETIC RESONANCE AND MAGNETIC RESONANCE IMAGING USING HIGH-T_C SUPERCONDUCTING QUANTUM INTERFERENCE DEVICES IN MICROTESLA MAGNETIC FIELDS ***S. H. LIAO***[1]*, H. C. YANG*[1]*, H. H. CHEN*[2]*, H. E. HORNG*[2]*, S. Y. YANG*[3]*, L. M. WANG*[1]*;* [1]DEPARTMENT OF PHYSICS, NATIONAL TAIWAN UNIVERSITY, [2]INSTITUTE OF ELECTRO-OPTICAL SCIENCE AND TECHNOLOGY, NATIONAL TAIWAN NORMAL UNIVERSITY, [3]MAGQU CO., LTD.. — IN THIS WORK, NUCLEAR MAGNETIC RESONANCE AND MAGNETIC RESONANCE IMAGING (NMR/MRI) IN MICROTESLA BY USING HIGH-T_C SQUID MAGNETOMETER IS PRESENTED. IN THE PROPOSED NMR/MRI DETECTION SCHEME, THE NUCLEUS SPIN PROCESSION WAS INDUCTIVELY COUPLED TO THE SQUID MAGNETOMETER VIA A FLUX TRANSFORMER. ACCORDING TO THIS SCHEME, BOTH THE SQUID AND THE INPUT COUPLING COIL WERE PLACED INSIDE A HIGH-T_C SUPERCONDUCTING VESSEL WHICH SHIELDED ENVIRONMENTAL NOISES AND SET THE SQUID IN A STABLE OPERATION CONDITION. IN MICROTESLA FIELDS WHERE THE CHEMICAL SHIFTS ARE ABSENT, THE PROTON-FLUORINE COUPLINGS IN TRIFLUOROETHANOL WITH J-COUPLING J[H,F] = [9.0 ± 0.4] HZ WAS DETECTED. APPLYING A PRE-MAGNETIZED FIELD, A GRADIENT FIELD OF 24.6 MT/M AND A UNIFORM MEASUREMENT FIELD OF 101 MT, A PROTON MRI WITH A SPATIAL RESOLUTION GIVEN BY $\Delta X = 2\Pi\Delta F/\Gamma G$ = 1 MM IN PROTON MRI, WHERE Γ = 42.58 KHZ/MT, WAS DEMONSTRATED. THE NMR/MRI SYSTEM OF HIGH SPECTRAL RESOLUTION AND SENSITIVITY WILL BE OF GREAT INTEREST FOR A STUDY OF THE STRUCTURES OF CHEMICALS AND BIOLOGICAL IMAGING.

5EPJ-05

LIQUID-STATE NUCLEAR MAGNETIC RESONANCE MEASUREMENTS FOR IMAGING USING HTS-RF-SQUID IN ULTRA-LOW FIELD ***S. FUKUMOTO***[1]*, M. HAYASHI*[1]*, Y. KATSHU*[1]*, Y. HATSUKADE*[1]*, S. TANAKA*[1]*, O. SNIGIREV*[2]*;* [1]TOYOHASHI UNIVERSITY OF TECHNOLOGY, [2]MOSCOW STATE UNIVERSITY. — SINCE NMR/MRI MEASURED IN ULTRA-LOW FIELD (ULF) USING SQUID HAVE UNIQUE FEATURES, THEY CAN BE SUPPLEMENTS TO THE CONVENTIONAL NMR/MRI IN HIGH FIELD. IN THIS STUDY, WE CONSTRUCTED A ULF-NMR/MRI SYSTEM EMPLOYING HTS-RF-SQUID AND EVALUATED THE SYSTEM PERFORMANCE BY MEASURING LIQUID-STATE NMR. IN THE SYSTEM, WE EMPLOYED THE PULSED PRE-POLARIZING FIELD B_P PERPENDICULAR TO THE MEASUREMENT FIELD B_M UTILIZING A HIGH-SPEED SWITCHING CIRCUIT WITH MOSFET TO TURN OFF B_P OF ABOUT 30 MT WITHIN 10 MS. IN CASE THAT THE ORTHOGONAL FIELD GRADIENTS DB_Z/DX, DB_Z/DY AND DB_Z/DZ WERE USED TO COMPENSATE THE UNIFORMITY OF B_M OF 45 MT, A FREE INDUCTION DECAY SIGNAL OF ^{1}H-NMR AT 1970 HZ, WHICH LAST MORE THAN 3.3 S, WAS MEASURED FROM TAP WATER. IN CASE THAT THE FIELD GRADIENT DB_Z/DY OR DB_Z/DZ OF ABOUT 1 MT/M WAS APPLIED TO A SAMPLE, IN WHICH WATER WAS DIVIDED INTO TWO PARTS, ^{1}H-NMR SPECTRUM WITH TWO PEAKS WITH THE IDENTICAL PEAK AMPLITUDES AND DIFFERENT PEAK FREQUENCIES WAS MEASURED. THE FREQUENCY DIFFERENCE BETWEEN THE PEAKS 0.68 HZ CORRESPONDED TO THE DISTANCE OF 13.3 MM, WHICH ROUGHLY AGREED WITH THE DISTANCE BETWEEN THE GRAVITY POINTS OF THE TWO-DIVIDED WATER. IN CASE THAT THE SAME FIELD GRADIENT WAS APPLIED TO A SAMPLE DIVIDED INTO WATER AND MINERAL OIL, WE MEASURED THE TWO PEAKS WITH THE SAME FREQUENCY DIFFERENCE AS THE WATER SAMPLE, BUT DIFFERENT PEAK AMPLITUDES BECAUSE OF THE DIFFERENT MOLECULAR COMPOSITIONS.

5EPJ-06

SQUID-BASED LOW FIELD MRI USING A MEG SYSTEM FOR SMALL ANIMALS ***J. HATTA****, M. MIYAMOTO, J. KAWAI, G. UEHARA, H. KADO;* KANAZAWA INSTITUTE OF TECHNOLOGY. — LOW FIELD MRI AND MEG ARE BASED ON THE ABILITY OF SQUID SENSORS TO DETECT FEMTOTESLA MAGNETIC FIELDS. MEG SYSTEMS TO OBTAIN SMALL ANIMAL BIOMAGNETIC SIGNALS HAVE BEEN DEVELOPED BY OUR GROUP. WE ARE NOW WORKING TOWARDS COMBINATION OF TWO METHODS. OUR MRI TECHNIQUE INVOLVES PRE-POLARIZING THE SAMPLE AT UP TO 35MT AND DETECTING THE NMR SIGNAL AT 80UT (3.5 KHZ). THE SNR OF THE MRI SIGNAL IS DETERMINED BY THE AMPLITUDE AND TIME OF POLARIZING FIELD AND THE MAGNETIC FIELD NOISE OF THE SYSTEM. THE FAST SWITCHING OF THE POLARIZING FIELD INHERENTLY INDUCES LARGE TRANSIENT SIGNALS ORIGINATING FROM THE CURRENTS INDUCED IN COILS FOR THE MRI MEASUREMENT AND SURROUNDING CONDUCTIVE PLATES. WE HAVE OPTIMIZED OUR SYSTEM TO MINIMIZE THESE TRANSIENTS, BY REDUCING THE BACK ELECTROMOTIVE FORCE OF THE POLARIZING COIL AND MODIFYING A SQUID SENSOR AND FLL CIRCUIT. THE MAGNETIC FIELD NOISE SPECTRAL DENSITY IS 9FT/RTHZ. WE DESIGNED FOUR SETS OF PLANAR COILS TO GENERATE THE MEASUREMENT FIELD AND THREE GRADIENT FIELDS. THE MAJOR PROBLEM IN USE OF SWITCHED COILS, FOR MULTIPLE-ECHO 3D IMAGING SEQUENCE, IS THE INTERACTION OF THE RAPIDLY SWITCHED FIELDS WITH SURROUNDING CONDUCTIVE PLATES. THE FIELD HOMOGENEITY CAN BE DEGRADED AND THE RISE AND DECAY TIMES OF THE SWITCHED FIELD CAN BE INCREASED. EMPLOYING THE "TARGET FIELD METHOD" FOR THE DESIGN OF THE SHIELDED PLANAR COILS, WE ACHIEVED MEASUREMENT FIELD HOMOGENEITY OF 0.5% OVER 40MM DSV.

5EPJ-07

PROGRESS ON DETECTION OF LIQUID EXPLOSIVES USING SQUID-BASED ULF MRI ***M. A. ESPY****, R. H. KRAUS, A. N. MATLASHOV, T. OWENS, I. SAVUKOV, L. J. SCHULTZ, A. URBAITIS, P. L. VOLEGOV;* LANL. — NUCLEAR MAGNETIC RESONANCE (NMR) METHODS ARE WIDELY USED IN MEDICINE, CHEMISTRY AND INDUSTRY. ONE APPLICATION AREA IS MAGNETIC RESONANCE IMAGING OR MRI. OVER THE PAST SEVERAL YEARS THERE HAS BEEN INCREASING INTEREST IN PERFORMING NMR AND MRI IN ULTRA-LOW FIELD (ULF) REGIME, WITH MEASUREMENT FIELD STRENGTHS OF 10 - 100 MICROTESLA AND PRE-POLARIZATION FIELDS OF 30 - 50 MTESLA. THE REAL-TIME SIGNAL-TO-NOISE RATIO FOR SUCH MEASUREMENTS IS ABOUT 100. OUR GROUP AT LANL HAS BUILT AND DEMONSTRATED THE PERFORMANCE OF SQUID-BASED ULF NMR/MRI INSTRUMENTATION FOR CLASSIFICATION OF MATERIALS AND DETECTION OF LIQUID EXPLOSIVES VIA THEIR RELAXATION PROPERTIES MEASURED AT ULF, USING T1, T2, AND T1 FREQUENCY DISPERSION. HERE WE PRESENT RECENT PROGRESS ON THE APPLICATIONS OF SQUID-BASED ULF MR TO THE DETECTION OF LIQUID EXPLOSIVES, IN IMAGING AND RELAXOMETRY.

THIS WORK WAS SUPPORTED BY THE U.S. DEPARTMENT OF HOMELAND SECURITY

5EPJ-08

STEP-EDGE HIGH-T_C SUPERCONDUCTING-QUANTUM-INTERFERENCE-DEVICE MAGNETOMETER FOR LOW-FIELD NUCLEAR MAGNETIC RESONANCE ***S. YANG****[1], H. HORNG[2], H. YANG[3], S. LIAO[3], C. HONG[4];* [1]MAGQU CO., LTD., [2]NATIONAL TAIWAN NORMAL UNIVERSITY, [3]NATIONAL TAIWAN UNIVERSITY, [4]NATIONAL CHUNG-HSING UNIVERSITY. — THE FABRICATION PROCESSES OF STEP-EDGE HIGH-T_C SUPERCONDUCTING-QUANTUM- INTERFERENCE-DEVICE (SQUID) MAGNETOMETER ARE DEVELOPED. A MAGNETOMETER IS CONSISTED THREE SQUIDS, WHICH CAN BE ACTIVATED INDIVIDUALLY OR IN SERIES. THUS, THE TRANSFER FUNCTION CAN BE MANIPULATED BY ACTING SINGLE SQUID OR SQUIDS IN SERIES. FURTHERMORE, SUCH SQUID MAGNETOMETER IS BENEFITED WITH THE FACT THAT ONCE ONE OF THE THREE SQUIDS IS BROKEN, THE OTHER TWO SQUIDS WOULD BE STILL WORKABLE. IN ADDITION TO CHARACTERING THE SQUID MAGNETOMETER, THE APPLICATION OF THE SQUID MAGNETOMETER IN LOW-FIELD NUCLEAR MAGNETIC RESONANCE (NMR) IS INVESTIGATED. THE RESULTS SHOW A CLEAR NMR SIGNAL AT 4230 HZ FOR WATER UNDER 99.3 MT. IT IS WORTHY NOTING THAT THE FLUX-COUPLING TECHNOLOGY IS UTLIZED FOR THE SQUID-BASED LOW-FIELD NMR SYSTEM TO GUIDE THE NMR SIGNAL GENERATED FROM THE SAMPLE TO THE SQUID MAGNETOMETER FAR FROM THE SAMPLE. THUS, THE SQUID CAN BE OPERATED STABLY DUIRNG APPLYING RF FIELDS OF PREPOLARIZATION FIELDS TO THE SAMPLE FOR DETECTING NMR SIGNAL.

5EX-01

(INVITED) **AVALANCHE-MODE SINGLE PHOTON DETECTOR BASED ON 30 NM-WIDE SUPERCONDUCTING NANOWIRES** ***F. MARSILI****[1], F. NAJAFI[1], X. HU[1], C. HERDER[1], J. YANG[1], E. DAULER[2], R. MOLNAR[2], K. BERGGREN[1];* [1]DEPARTMENT OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, 77 MASSACHUSETTS AVENUE, CAMBRIDGE, MASSACHUSETTS 02139, USA, [2]LINCOLN LABORATORY, MASSACHUSETTS INSTITUTE OF TECHNOLOGY,244 WOOD ST., LEXINGTON, MASSACHUSETTS 02420, USA. — IN ORDER TO IMPROVE THE SENSITIVITY OF SUPERCONDUCTING NANOWIRE SINGLE PHOTON DETECTORS (SNSPDS) AT TELECOM WAVELENGTHS, WE FABRICATED SNSPDS BASED ON 30 NM-WIDE NANOWIRES.TO MAKE THE PHOTODETECTION PULSE DETECTABLE WITH STANDARD ROOM-TEMPERATURE ELECTRONICS, N NANOWIRES WERE ARRANGED IN A PARALLEL ARCHITECTURE SUCH THAT WHEN ONE SECTION FIRED, THE CURRENT FLOWING THROUGH THE WHOLE DEVICE WAS REDIRECTED TO THE READ-OUT CIRCUITRY (AVALANCHE OPERATION MODE). THE SIGNAL TO NOISE RATIO WAS THEN N TIMES HIGHER THAN WITH A SERIES DESIGN.THE SINGLE-PHOTON DETECTION EFFICIENCY (DE) OF NARROW SNSPDS WITH 3, 4 OR 5 PARALLEL SECTIONS WAS MEASURED FOR 1550 NM WAVELENGTH AT A TEMPERATURE OF 2.8 K. THE DE EXHIBITED A REDUCE DEPENDENCE ON THE BIAS CURRENT (IB) THAN WITH 100 NM-WIDE SNSPDS. THIS ALLOWED OPERATING NARROW SNSPDS AT AN IB (~ 75 % OF THE CRITICAL CURRENT IC) FAR LOWER THAN WITH WIDE SNSPDS (TYPICALLY ~ 95 % OF IC) FOR THE SAME DE. THIS REDUCTION IN THE OPERATING BIAS CURRENT WOULD IN PRINCIPLE IMPROVE THE DETECTOR SENSITIVITY, AS THE DARK COUNT RATE (DK) OF SNSPDS DECREASES EXPONENTIALLY WITH IB. HOWEVER, THE HIGHEST DE MEASURED AT 0.75IC WAS 2% FOR A DK = 500 HZ, WHICH DOES NOT REPRESENT AN IMPROVEMENT TO THE PERFORMANCE OF WIDE SNSPDS. THIS PERFORMANCE WAS IN PART DUE TO THE LOW FILL FACTOR (F = 30 %) OF THE DEVICE ACTIVE AREA AND THE BACKGROUND-RADIATION-INDUCED DARK COUNTS.

THIS WORK WAS SPONSORED BY THE UNITED STATES AIR FORCE UNDER AIR FORCE CONTRACT #FA8721-05-C-0002. OPINIONS, INTERPRETATIONS, RECOMMENDATIONS AND CONCLUSIONS ARE THOSE OF THE AUTHORS AND ARE NOT NECESSARILY ENDORSED BY THE UNITED STATES GOVERNMENT.

5EX-02

(INVITED) **OPTICAL-ANTENNA INTEGRATED SUPERCONDUCTING NANOWIRE SINGLE-PHOTON DETECTORS** ***X. HU****[1], E. A. DAULER[2], F. NAJAFI[1], F. MARSILI[1], R. J. MOLNAR[2], K. K. BERGGREN[1];* [1]MASSACHUSETTS INSTITUTE OF TECHNOLOGY, [2]LINCOLN LABORATORY, MASSACHUSETTS INSTITUTE OF TECHNOLOGY. — WE DESIGNED AND FABRICATED SUPERCONDUCTING NANOWIRE SINGLE-PHOTON DETECTORS (SNSPDS) WITH NANO-OPTICAL ANTENNAE TO REDUCE THE LENGTH OF THE NANOWIRE NEEDED FOR EFFICIENT OPTICAL COUPLING. IN OUR DESIGN, WE INCREASED THE PITCH OF THE MEANDER AND ADDED A GOLD

NANO-OPTICAL ANTENNA STRUCTURE TOGETHER WITH A TOP REFLECTOR TO ENHANCE THE ABSORPTANCE OF THE NIOBIUM NITRIDE (NBN) NANOWIRE FOR TRANSVERSE-MAGNETICALLY (TM) POLARIZED INCIDENT LIGHT. WE EXPERIMENTALLY DEMONSTRATED 47% DEVICE EFFICIENCY FOR A 9 MM × 9 MM, 600-NM PITCH SNSPD FOR THE TM-POLARIZATION AND 4% FOR THE TE-POLARIZATION, CONSISTENT WITH THEORETICAL PREDICTION. THE REDUCTION OF THE LENGTH OF THE NANOWIRE SHORTENED THE DETECTION EFFICIENCY RECOVERY TIME FOR THE DETECTOR AFTER PULSING. THE TOTAL LENGTH OF THE ANTENNA-COUPLED NANOWIRE WAS 145 MM. COMPARED WITH A TYPICAL (NON-ANTENNA COUPLED), 200-NM PITCH SNSPD WITH THE SAME AREA, THE LENGTH OF THE NANOWIRE WAS REDUCED BY 2/3, AND THEREFORE THE SPEED IS EXPECTED TO HAVE BEEN INCREASED BY A FACTOR OF 3.THIS WORK WAS SPONSORED IN PART BY THE UNITED STATES AIR FORCE UNDER AIR FORCE CONTRACT #FA8721-05-C-0002. OPINIONS, INTERPRETATIONS, RECOMMENDATIONS AND CONCLUSIONS ARE THOSE OF THE AUTHORS AND ARE NOT NECESSARILY ENDORSED BY THE UNITED STATES GOVERNMENT.

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5EX-03

(INVITED) **SUPERCONDUCTING NANOWIRE SINGLE ELECTRON DETECTOR** ***M. ROSTICHER***[1]*, F. LADAN*[1]*, J. MANEVAL*[1]*, T. ZIJLSTRA*[2]*, T. M. KLAPWIJK*[2]*, S. N. DORENBOS*[3]*, V. ZWILLER*[3]*, A. LUPASCU*[4]*, G. NOGUES*[5]*;* [1]LABORATOIRE PIERRE AIGRAIN, ENS, [2]PHYSICS OF NANOELECTRONICS, KAVLI INSTITUTE OF NANOSCIENCE, TU DELFT, [3]QUANTUM TRANSPORT, KAVLI INSTITUTE OF NANOSCIENCE, TU DELFT, [4]INSTITUTE FOR QUANTUM COMPUTING, UNIVERSITY OF WATERLOO, [5]CEA-CNRS JOINT TEAM "NANOPHYSIQUE DES SEMICONDUCTEURS, INSTITUT NÉEL & LABORATOIRE KASTLER BROSSEL ENS. — WE REPORT THE DETECTION OF SINGLE ELECTRONS USING A 6 NM-THICK, 100 NM-WIDE, NB0.7TI0.3N SUPERCONDUCTING STRIP DEPOSITED ON A SIOX/SI SUBSTRATE. WHEN BIASED SLIGHTLY BELOW THE CRITICAL CURRENT, A MEANDER-SHAPED DEVICE, NOT ONLY DETECTS SINGLE PHOTONS, BUT ALSO COUNTS THE SINGLE KEV ELECTRONS ISSUED FROM A SCANNING ELECTRON MICROSCOPE (SEM) WITH AN EFFICIENCY APPROACHING UNITY. THE RESPONSE TIME IS SHORT ENOUGH TO DISCRIMINATE THE INCIDENT ELECTRONS FROM THOSE BACKSCATTERED FROM THE UNDERLYING MATERIAL. IT IS THEREFORE POSSIBLE TO MAP THE ELECTRON DETECTIVITY AS WELL AS THE PHOTON DETECTIVITY ON THE SAME DEVICE. A CLEAR CORRELATION BETWEEN THE TWO MEASUREMENTS IS OBSERVED, WITH A SUPERIOR SPATIAL RESOLUTION THOUGH (AROUND 100 NM) FOR THE SEM MAPPING. IT ILLUSTRATES THE POTENTIAL USE OF THIS SINGLE ELECTRON MAPPING BY THE SEM METHOD TO CHARACTERIZE THE DETECTION HOMOGENEITY OF SSPDS

5EX-04

SUPERCONDUCTING SINGLE PHOTON DETECTORS FOR QUANTUM OPTICS AND QUANTUM PLASMONICS ***S. N. DORENBOS****, R. W. HEERES, T. A. BAART, E. BERMUDEZ UREÑA, L. P. KOUWENHOVEN, T. ZIJLSTRA, T. M. KLAPWIJK, V. ZWILLER;* DELFT UNIVERSITY OF TECHNOLOGY. — WE WILL REPORT ON THE CHARACTERIZATION OF SUPERCONDUCTING SINGLE PHOTON DETECTORS (SSPDS) FABRICATED WITH NBTIN ON A SILICON SUBSTRATE. THIS TYPE OF SSPDS SHOWS AN UNPRECEDENTED SIGNAL TO NOISE RATIO, MAKING THEM THE DETECTOR OF CHOICE FOR QUANTUM OPTICS EXPERIMENTS.WE HAVE PERFORMED CORRELATION AND LIFETIME MEASUREMENTS WITH DIFFERENT TYPES OF SINGLE PHOTON EMITTERS. WE WILL SHOW THAT LIFETIME MEASUREMENTS CAN BE SIMPLIFIED, BECAUSE ONLY A SINGLE SSPD IS REQUIRED, WHILE FOR THIS TYPE OF MEASUREMENTS USUALLY TWO DETECTORS ARE NEEDED.WE WILL ALSO DEMONSTRATE THAT SSPDS CAN BE USED TO DIRECTLY DETECT SURFACE PLASMON POLARITONS (PLASMONS). PLASMONS ARE ELECTROMAGNETIC WAVES PROPAGATING ON THE SURFACE OF A METAL WITH APPEALING CHARACTERISTICS OF SHORTENED WAVELENGTHS, ENHANCED FIELD STRENGTHS AND EASY ON-CHIP WAVEGUIDING. WE DETECT PLASMONS BY POSITIONING AN SSPD IN THE NEAR FIELD OF THE PROPAGATING PLASMON. WE WILL PROVE THE QUANTUM NATURE OF PLASMONS BY PERFORMING AN ANTIBUNCHING EXPERIMENT. THIS OPENS THE DOOR FOR (QUANTUM-) OPTICS-ON-A-CHIP EXPERIMENTS.

5EX-05

QUANTUM WAVEGUIDE CIRCUITS CHARACTERIZED WITH SUPERCONDUCTING SINGLE PHOTON DETECTORS ***R. H. HADFIELD***[1]*, C. NATARAJAN*[1]*, A. PERUZZO*[2]*, S. MIKI*[3]*, Z. WANG*[3]*, B. BAEK*[4]*, S. NAM*[4]*, J. L. O'BRIEN*[2]*;* [1]HERIOT-WATT UNIVERSITY, UK, [2]UNIVERSITY OF BRISTOL, UK, [3]NICT, JAPAN, [4]NIST, USA. — SUPERCONDUCTING NANOWIRE SINGLE PHOTON DETECTORS (SNSPDS) BASED ON NIOBIUM NITRIDE NANOWIRES ARE AN IMPORTANT ENABLING TECHNOLOGY FOR PHOTONIC QUANTUM INFORMATION SCIENCE AND TECHNOLOGY (QIST). ADVANCED QIST APPLICATIONS PLACE HIGH DEMANDS ON DETECTOR PERFORMANCE. SNSPDS OFFER SENSITIVITY FROM VISIBLE TO MID INFRARED WAVELENGTHS, COMBINED WITH LOW DARK COUNTS AND LOW TIMING JITTER. TO DATE FIBER-COUPLED SNSPDS IMPLEMENTED INTO PRACTICAL CLOSED CYCLE SYSTEMS HAVE BEEN EMPLOYED IN GROUNDBREAKING QUANTUM KEY DISTRIBUTION EXPERIMENTS. WE REPORT ON THE FIRST USE OF SNSPDS IN THE CHARACTERIZATION OF QUANTUM WAVEGUIDE CIRCUITS - A SCALABLE ROUTE FOR OPTICAL QIST. OWING TO IMPROVED SIGNAL TO NOISE, SNSPDS OFFER IMPROVED VISIBILITY (92.3 ± 1.0%) OVER CONVENTIONAL SI DETECTORS (89.9 ± 0.3%) IN A HONG OU MANDEL TWO-PHOTON INTERFERENCE EXPERIMENT AT Λ = 805 NM USING A QUANTUM WAVEGUIDE 50:50 COUPLER. WE FURTHER DEMONSTRATE THE CAPABILITY OF SNSPDS IN QUANTUM METROLOGY AND CNOT QUANTUM LOGIC GATE EXPERIMENTS ON QUANTUM WAVEGUIDE CIRCUITS. THIS STUDY OPENS THE PATHWAY TO QUANTUM WAVEGUIDE CIRCUITS AT 1550 NM, ALLOWING THE FULL RANGE OF TELECOMMUNICATIONS TECHNOLOGIES TO BE EXPLOITED.

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5EY-01

RECENT PROGRESS ON RESEARCH AND APPLICATIONS OF HTS FILTER SUBSYSTEMS FOR MOBILE COMMUNICATION IN BEIJING ***B. CAO****, X. ZHANG, B. WEI, X. GUO;* TSINGHUA UNIVERSITY. — WE DEVELOPED HTS FILTER SUBSYSTEMS (HTSFSS) WITH EXCELLENT PERFORMANCE FOR THE RECEIVER FRONTENDS OF CDMA MOBILE COMMUNICATION BASE STATIONS (BTS). EVERY HTSFS HAS SIX CHANNELS WITH EACH CHANNEL CONSISTING OF AN HTS FILTER AND A CRYOGENIC LOW NOISE AMPLIFIER (LNA). THE HTSFSS HAVE THE SAME CENTER FREQUENCY OF 830 MHZ AND BANDWIDTH OF 12 MHZ. THE NOISE FIGURE, INCLUDING THE CONNECTORS AND CABLES, IS 0.48 DB, AND THE BAND-EDGE STEEPNESS IS 31.4 DB/MHZ. AS A COMPARISON, A TYPICAL CONVENTIONAL FILTER SYSTEM USED IN THE CDMA BTSS HAS A NOISE FIGURE OF ABOUT 4 DB AND BAND-EDGE STEEPNESS OF 5 DB/MHZ. WE INSTALLED HTSFSS IN FIVE CDMA BTSS IN URBAN AREA OF BEIJING IN DECEMBER 2005 AND IN THREE ADDITIONAL BTSS IN APRIL 2008. DRIVE TESTS SHOW THAT, AFTER THE CONVENTIONAL FILTER SYSTEMS WERE REPLACED BY HTSFSS, THE AVERAGE TRANSMITTING POWER OF THE HANDSETS DECREASES 4.2 DB, CLEARLY EXHIBITING THE ADVANTAGES OF THE SUPERCONDUCTING RECEIVER FRONTENDS. THE COVERAGE AREA,THE CAPACITY, AND THE QUALITY OF SERVICE OF THE CDMA BTSS ARE ALSO IMPROVED. UP TO NOW, THE HTSFSS HAVE BEEN RUNNING STEADILY IN THE BTSS FOR MORE THAN 3 YEARS AND SERVING MORE THAN 200 THOUSANDS OF RESIDENTS 24 HOURS A DAY. THIS RESULT DEMONSTRATES THE HIGH RELIABILITY AND STABILITY OF OUR HTS FILTER SUBSYSTEMS.

5EY-02

REALIZATION OF A HIGHLY MINIATURIZED WIDEBAND BANDPASS FILTER AT THE UHF BAND ***S. SETOODEH***[1]*, P. D. LAFORGE*[2]*, R. R. MANSOUR*[1]*;* [1]UNIVERSITY OF WATERLOO, [2]UNIVERSITY OF REGINA. — A LOW TEMPERATURE SUPERCONDUCTING 7-POLE LUMPED ELEMENT BANDPASS FILTER WITH A BANDWIDTH OF 80% IS DESIGNED AND TESTED. THE FILTER DESIGN MAKES USE OF THE THIN DIELECTRIC LAYERS AND THE SMALL FEATURE SIZES OF THE STANDARD NIOBIUM PROCESS OFFERED BY HYPRES TO CREATE A HIGHLY MINIATURIZED FILTER. THIS FILTER DESIGN CAN THUS BE INTEGRATED WITH DIGITAL RECEIVERS REALIZED WITH SUPERCONDUCTING MICROELECTRONICS (SME) TECHNOLOGY ON A SINGLE CHIP. THE FILTER TOPOLOGY IS THAT OF THE BANDPASS TRANSFORMED LOWPASS PROTOTYPE FILTER WITH ALTERNATING SHUNT AND SERIES LUMPED ELEMENT RESONATORS. THIS LUMPED ELEMENT TOPOLOGY ALLOWS FOR THE DESIGN OF VERY WIDEBAND FILTERS BY ELIMINATING THE NEED TO USE FREQUENCY-DEPENDENT IMPEDANCE INVERTERS WHICH TYPICALLY LIMIT THE FILTER BANDWIDTH TO NARROWBAND OPERATION. THE 7-POLE FILTER HAS A CENTER FREQUENCY OF 375 MHZ, A BANDWIDTH OF 300MHZ AND A TOTAL SIZE OF 3MMX1MM. EACH RESONATOR HAS DIMENSION OF 0.5MMX1MM WHICH IS MORE THAN 800 TIMES SMALLER THAN THE FREE SPACE WAVELENGTH AT THE CENTER FREQUENCY OF THE FILTER. DUE TO THE RESONATORS BEING REALIZED IN LUMPED ELEMENT FORM, THE FILTER HAS A WIDE SPURIOUS FREE STOPBAND UP TO 4GHZ. THE MEASURED RETURN LOSS IS BETTER THAN 17 DB ACROSS THE PASSBAND WITHOUT ANY POST-FABRICATION TUNING. THE FILTER WAS DESIGNED AND OPTIMIZED USING ELECTROMAGNETIC-BASED DESIGN TOOLS. THE MEASURED AND SIMULATED RESULTS ARE IN GOOD AGREEMENT.

5EY-03

A HIGH POWER HANDLING HTS FILTER AND ITS APPLICATION IN TD-SCDMA MOBILE COMMUNICATION NETWORK ***Y. HE****, X. ZHANG, H. LI, Q. ZHANG, C. LI;* INSTITTUTE OF PHYSICS, CHINESE ACADEMY OF SCIEMCES. — A DUAL MODE HTS FILTER WAS CONSTRUCTED FOR APPLICATIONS WITH HIGH POWER HANDLING REQUIREMENTS, E.G., TD-SCDMA SYSTEM, ONE OF THE INTERNATIONAL STANDARDS FOR THE THIRD GENERATION (3G) MOBILE COMMUNICATIONS. THIS SYSTEM WORKS IN TDD MODE AND HENCE REQUIRES HIGH POWER HANDLING ABILITY FOR THE FILTER IN THE FRONT-END OF THE TRANSCEIVER. THE MAIN PROBLEMS, HOWEVER, IN DESIGNING DUAL MODE FILTER ARE ADJUSTING THE RESONATING FREQUENCY OF EACH MODE AND THE COUPLINGS BETWEEN PATCHES. A NOVEL STRUCTURE HAS BEEN DEVELOPED TO SOLVE THESE PROBLEMS AND A 4 POLE DUAL MODE PATCH FILTER WITH SATISFACTORY PERFORMANCE WAS CONSTRUCTED. NO OBVIOUS DETERIORATIONS CAN BE FOUND WITH INPUT POWER UP TO11.7W. BASED ON THIS FILTER A HTS TRANSCEIVER SUBSYSTEM WAS CONSTRUCTED, OF WHICH A TEST IN COMMERCIAL 3G MOBILE BASE STATION NETWORK WAS CARRIED OUT IN BEIJING. THE HTS SYSTEM SHOWED VERY GOOD IMPROVEMENT IN REDUCING BIT ERROR RATE FOR WEAK SIGNALS (80% AT -111DBM) AND STRONG ENHANCEMENT IN ANTI-INTERFERENCE (10DBM). THE IMPROVEMENT IN RESTRICTING SPURIOUS POWER IN EMITTING SIGNALS IS ALSO REMARKABLE (26DBM), SHOWING GREAT ADVANTAGE IN EM COMPATIBILITY. THE MOST INTERESTING AND ATTRACTIVE DEMONSTRATION IS IN THE VIDEO COMMUNICATIONS. WHILE THE PICTURES IN THE SCREEN OF THE HANDSET CONNECTED WITH CONVENTIONAL SYSTEM WAS DISTORTED AND BECAME MOSAIC PATTERNS DUE TO INTERFERENCE, THE ONE WITH HTS SYSTEM WORKS PERFECTLY.

THIS WORK WAS SUPPORTED IN PART BY THE EXTERNAL COOPERATION PROGRAM OF THE CHINESE ACADEMY OF SCIENCES (GRANT NO. GJHZ1007) AND THE CHINESE ACADEMY OF SCIENCES（GRANT NO. KJCX2-YW-W16）

5EY-04

SUPERCONDUCTING MULTIPLEXER FILTER BANK FOR A FREQUENCY SELECTIVE POWER LIMITER *E. ROCAS*[1]*,* ***J. MATEU***[2]*, A. PADILLA*[2]*, N. D. ORLOFF*[1]*, J. M. O'CALLAGHAN*[2]*, C. COLLADO*[1]*, J. C. BOOTH*[1]*;* [1]NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY, [2]UNIVERSITAT POLITECNICA

DE CATALUNYA. — PREVIOUS WORK HAS SHOWN THE APPLICATION OF SUPERCONDUCTING TRANSMISSION-LINE LIMITERS FOR PROTECTING DOWNSTREAM ELECTRONICS FROM HIGH-POWER TRANSIENTS, WITH TURN-ON TIMES OF A NANOSECOND OR LESS[1,2]. HOWEVER, SUCH BROADBAND LIMITERS PROVIDE ATTENUATION OVER THE ENTIRE FREQUENCY BAND OF INTEREST WHENEVER A HIGH-POWER SIGNAL IS PRESENT. A MORE DESIRABLE APPROACH IS TO RESTRICT THE LIMITER RESPONSE TO A NARROW FREQUENCY BAND AROUND THE HIGH-POWER SIGNAL, WITHOUT DEGRADING DEVICE PERFORMANCE IN THE REMAINDER OF THE FREQUENCY BAND. TO ACCOMPLISH THIS, A MULTIPLEXED SUPERCONDUCTING LIMITER FILTER BANK CAN BE IMPLEMENTED. IN THIS WORK WE USE THE MEASURED RESPONSE OF TRANSMISSION-LINE LIMITERS AS THE BASIS FOR THE DESIGN OF NARROWBAND SIGNAL-LIMITING FILTERS AT MICROWAVE FREQUENCIES. WE CALCULATE THE CURRENT DENSITY DISTRIBUTION OF THE INDIVIDUAL RESONATORS FORMING THE FILTER FROM THE INCIDENT POWER, AS A FUNCTION OF THE FILTER TOPOLOGY, BANDWIDTH, QUALITY FACTOR, AND DIMENSIONS, AND SUBSEQUENTLY DETERMINE THE FILTER RESPONSE AS A FUNCTION OF INCIDENT POWER. THE DETUNING OF THE FILTER PRODUCED BY A HIGH POWER SIGNAL AND ITS EFFECT ON THE OVERALL MULTIPLEXER RESPONSE ARE ALSO STUDIED.

[1]-J.C. BOOTH ET AL., IEEE TRANS. APPL. SUPERCONDUCTIVITY 13, 305 (2003).[2]-J.C. BOOTH ET AL., 2004 IEEE MTT-S INTERNATIONAL MICROWAVE SYMPOSIUM DIGEST 1, 139 (2004). CARLOS COLLADO THANKS GENERALITAT DE CATALUNYA FOR GRANT BE2-00196

5EY-05

DESCRIPTION OF SELF-HEATING MECHANISMS IN HIGH TEMPERATURE SUPERCONDUCTOR MICROWAVE DEVICES ***J. C. BOOTH***[1]*, E. ROCAS*[1]*, C. COLLADO*[1]*, N. ORLOFF*[1]*, K. DUSTAKAR*[2]*, S. BERKOWITZ*[2]*;* [1]NIST, [2]OUT OF THE FOG RESEARCH. — DESPITE THE LOW DISSIPATION OF SUPERCONDUCTOR DEVICES, UNDER SOME CONDITIONS THERMAL EFFECTS CAN PLAY A SIGNIFICANT ROLE IN DEVICE RESPONSE AT MICROWAVE FREQUENCIES. FOR EXAMPLE,THE DISSIPATION OF THE HEAT GENERATED IN A SUPERCONDUCTING LIMITER DIRECTLY AFFECTS ITS PERFORMANCE. THE HEAT GENERATION AND SUBSEQUENT PROPAGATION GENERATES A TEMPERATURE PROFILE AT EACH POINT OF THE CROSS-SECTION OF THE TRANSMISSION LINE, WHICH HAS AN AFFECT ON THE LOCAL DESCRIPTION OF THE SUPERCONDUCTOR NONLINEARITIES. TO MODEL THESE SELF-HEATING EFFECTS AND HOW THEY INFLUENCE THE NONLINEAR DISTRIBUTED PARAMETERS USED TO MODEL THE LIMITER PERFORMANCE, WE HAVE DEVELOPED AN ITERATIVE METHOD THAT COMBINES THE WEEKS METHOD[1] TO CALCULATE THE CURRENT DENSITY DISTRIBUTION OF PLANAR STRUCTURES WITH A FINITE ELEMENT METHOD TO CALCULATE THE TEMPERATURE AT EACH POINT OF THE PLANAR TRANSMISSION LINE. SIMULATIONS AND MEASUREMENTS OF HIGH TEMPERATURE SUPERCONDUCTOR LIMITERS BASED ON MICROSTRIP AND COPLANAR GEOMETRIES WILL BE EXAMINE, AND THE ROLE OF THE THERMAL CONDUCTIVITY OF THE SUBSTRATE WILL BE DIRECTLY ADDRESSED.

1. D.M. SHEEN ET AL., IEEE TRANS. APPL. SUPERCOND. 1, 108 (1991).

5EY-07

EXPERIMENTAL CHARACTERIZATION OF OPTICALLY TUNABLE YBCO MICROWAVE RESONATORS AND DELAY LINES ***H. ATIKIAN****, B. GHAMSARI, A. H. MAJEDI;* UNIVERSITY OF WATERLOO. — THE MICROWAVE TRANSMISSION CHARACTERISTICS OF OPTICALLY TUNABLE SUPERCONDUCTING RESONATORS AND DELAY LINES HAVE BEEN INVESTIGATED AS A FUNCTION OF INCIDENT OPTICAL POWER AND TEMPERATURE. THE DEVICES INCORPORATE A SUPERCONDUCTING COPLANAR WAVEGUIDE (CPW) TRANSMISSION LINE FABRICATED FROM 100NM YBCO THIN FILMS, INTERRUPTED BY 3 AND 5 MICRON MEANDER LINES ON AN LAO SUBSTRATE. MICROWAVE MEASUREMENTS ARE PERFORMED ON WAFER IN A CRYOGENIC MICROWAVE PROBE STATION, WHERE ALL THE CALIBRATIONS ARE PERFORMED AT CRYOGENIC TEMPERATURES. FIRST THE CPW IS MEASURED AT 77K UP TO A FREQUENCY OF 50GHZ WHERE IT EXHIBITS AN INSERTION LOSS OF 0.12DB/MM. IT HAS BEEN OBSERVED THAT THE RESONANCE FREQUENCY OF THE SUPERCONDUCTING MEANDER LINES CAN BE SHIFTED BY MORE THAN 2GHZ WITH INCIDENT OPTICAL ILLUMINATION AT A WAVELENGTH OF 1550NM. THE DELAY LINES ALSO EXHIBIT A PHASE RETARDATION OF UP TO 90 DEGREES AT THE SAME OPERATING CONDITIONS.

5EY-08

HTS JOSEPHSON JUNCTION CANTILEVER WITH INTEGRATED NEAR FIELD THZ-ANTENNA ***M. SCHILLING****, C. BRENDEL, J. M. SCHOLTYSSEK;* TU BRAUNSCHWEIG. — JOSEPHSON JUNCTIONS FROM THE HIGH-TEMPERATURE SUPERCONDUCTOR $YBA_2CU_3O_7$ ARE USED ON A CANTILEVER TO DETECT MICROWAVE EMISSION UP TO 762 GHZ FROM ROOM TEMPERATURE MICROWAVE DEVICES WITH SPECTRAL AND SPATIAL RESOLUTION. THE JOSEPHSON JUNCTIONS ON THE CANTILEVER ARE OPERATED IN A TEMPERATURE RANGE BETWEEN 40 K TO 80 K COOLED BY A CRYOCOOLER. WITH THIS MEASUREMENT SETUP AND A 3-AXIS TABLE WE ARE ABLE TO SCAN THE 3D HALF-SPACE IN THE NEAR AND FAR FIELD OVER THE MICROWAVE DEVICES. TO MEASURE THE NEAR FIELD OF A MICROWAVE SOURCE THE ANTENNA ON THE JOSEPHSON JUNCTION HAS TO BE SMALLER THAN THE WAVELENGHT TO ACHIEVE HIGH SPATIAL RESOLUTION BUT LARGE ENOUGH TO BE ABLE TO DETECT SUFFICIENT POWER. ALSO THE CHARACTERISTIC FREQUENCY, ANTENNA IMPEDANCE, BANDWIDTH UP TO 1 THZ AND CONNECTION FILTERS HAVE TO BE OPTIMIZED ON $LAALO_3$-BICRYSTAL SUBSTRATE SUITABLE FOR PREPARATION OF THE JOSEPHSON CANTILEVER. WE REPORT THE NEW INTEGRATED DESIGN OF THE JOSEPHSON CANTILEVER AND ITS APPLICATION FOR THE NEAR-FIELD CHARACTERIZATION OF THZ-DEVICES.

WE WISH TO ACKNOWLEDGE THE FINANCIAL SUPPORT OF CHRISTIAN BRENDEL BY THE BRAUNSCHWEIG INTERNATIONAL GRADUATE SCHOOL OF METROLOGY.

5LPA-01

DESIGN AND FABRICATION OF THE MU2E CABLE TEST SOLENOID ***A. V. MAKAROV***[1]*, N. ANDREEV*[1]*, V. S. KASHIKHIN*[1]*, M. LAMM*[1]*, G. V. VELEV*[1]*, A. YAMAMOTO*[2]*, T. OGITSU*[2]*;* [1]FERMILAB, [2]KEK. — DESIGN AND FABRICATION OF THE MU2E CABLE TEST SOLENOIDA. MAKAROV#, N. ANDREEV, V.S. KASHIKHIN, M. LAMM, G.V. VELEV, FERMILAB, BATAVIA, IL, US,A. YAMAMOTO, T. OGITSU, KEK, TSUKUBA, JAPAN*ABSTRACT*THE MU2E EXPERIMENT ASSUMES USING OF SUPERCONDUCTOR SOLENOIDS, WHICH REQUIRES THE EXTENDED R&D ON THE DIFFERENT SUPERCONDUCTOR CABLES PERFORMANCE, WORKING IN STRONG FIELD IN THE CRITICAL CURRENTS RANGE. TO TEST THESE CABLES, THE MU2E CABLE TEST SOLENOID WAS DESIGNED AND FABRICATED AT FERMILAB. THE SOLENOID CONTAINS THREE COILS (TWO MAIN COILS, AND ONE TESTED COIL), CONNECTED IN SERIAL. THE MAIN COILS ARE WOUND OF THE WELL KNOWN SSC NBTI CABLE. THEY ARE PERMANENTLY ATTACHED TO THE SOLENOID TOP AND BOTTOM CARBON STEEL FLANGES. THE TESTED COIL IS REPLACEABLE, AND MEANT TO BE INSTALLED BETWEEN TWO MAIN COILS. THIS COIL CAN BE WOUND OF ANY SUPERCONDUCTOR CABLE WHICH NEEDS TO BE TESTED (THE FIRST TESTED COIL WAS WOUND OF RIKEN HEAVY ALUMINUM STABILIZED NBTI CABLE). THE CABLES CROSS SECTION RATIO IN THE MAIN COILS AND THE TESTED COIL ENSURE OPERATING OF MAIN COILS IN THE CURRENT RANGES FARAWAY FROM THE CRITICAL VALUE FOR THEIR CABLE, WHILE THE TESTED COIL ALWAYS WORKS NEAR ITS CRITICAL CURRENT RANGE. THE SOLENOID DESIGN AND SOME CABLE SPLICING ISSUES ARE PRESENTED.

5LPA-02

EFFECT OF BARREL MATERIAL ON CRITICAL CURRENT MEASUREMENTS OF RRP® NB3SN WIRES* ***A. K. GHOSH****;* BROOKHAVEN NATIONAL LABORATORY. — NB3SN STRANDS EXTRACTED FROM A 20-STRAND RECTANGULAR CABLE WERE REACTED ON EITHER STAINLESS STEEL OR TI-ALLOY BARRELS AND THE CRITICAL CURRENT, IC, IN THE FIELD RANGE OF 8 - 11.5 T WAS MEASURED ON ITER-TYPE BARRELS MADE FROM TI-6AL-4V ALLOY, 304 STAINLESS STEEL AND G-10. MEASUREMENTS ON THE "STANDARD" TI-ALLOY BARREL USING THE TEST PROCEDURE EMPLOYED AT BNL IS SHOWN TO REPRODUCE IC FOR EXTRACTED STRANDS TO ± 2%. THE IC DATA FOR THE SAMPLE MOUNTED ON THE "STANDARD" TI-ALLOY ARE FIT TO THE DEVIATORIC STRAIN MODEL DEVELOPED FOR NB3SN BY THE UNIVERSITY OF TWENTE GROUP USING AN ARBITRARY PRE-STRAIN. USING THE PARAMETERS FOR THIS FIT, THE IC DATA FOR THE OTHER BARRELS ARE FITTED BY ONLY ADJUSTING THE STRAIN. USING THIS PROCEDURE, THE STRAIN DIFFERENCE DUE TO THE BARREL MATERIAL IS DETERMINED. ASSUMING A THERMAL PRE-STRAIN OF -0.2% FOR THE SAMPLE MEASURED ON THE TI-ALLOY BARREL, THE USE OF STAINLESS STEEL BARREL INCREASES THE COMPRESSIVE STRAIN BY -0.07%, THAT OF G-10 BY -0.10%. WITH THE WIRE SOLDERED TO THE STAINLESS STEEL BARREL, THE STRAIN INCREASES TO -0.15%. DETAILS OF THIS STUDY ARE PRESENTED

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5LPA-03

FABRICATION, QUALIFICATION AND TEST OF HIGH J_C ROEBEL $YBA_2CU_3O_{7-\Delta}$COATED CONDUCTOR CABLE FOR HEP MAGNETS *E. BARZI*[1]*, M. LAMM*[1]*,* ***V. LOMBARDO***[1]*, D. TURRIONI*[1]*, A. V. ZLOBIN*[1]*, N. LONG*[2]*;* [1]FERMILAB, [2]INDUSTRIAL RESEARCH LTD. — THE ROEBEL CABLE CONCEPT ALLOWS FOR A HIGH CRITICAL CURRENT CABLE ASSEMBLED USING COMMERCIALLY AVAILABLE $YBA_2CU_3O_{7-\Delta}$ COATED CONDUCTORS. THIS APPROACH TO CABLE DESIGN LEADS TO SEVERAL TECHNOLOGICAL IMPROVEMENTS IF APPLIED TO THE MANUFACTURE PROCESS OF NEXT GENERATION LOW INDUCTANCE, HIGH CURRENT DENSITY HTS COILS. A REDUCTION IN INDUCTANCE PROVES TO BE EXTREMELY IMPORTANT WHEN IT COMES TO PROTECTION OF COILS CAPABLE OF GENERATING FIELDS IN THE RANGE OF 40-50T, SUCH AS THE ONES NEEDED IN THE LAST STAGE OF THE COOLING CHANNEL OF A MUON COLLIDER. IN THIS WORK SEVERAL ASPECTS ARE PRESENTED INCLUDING THE QUALIFICATION AND MINIMUM REQUIREMENTS FOR $YBA_2CU_3O_{7-\Delta}$ COATED CONDUCTOR IN TERMS OF 2D CURRENT DENSITY UNIFORMITY AND THE MANUFACTURING PROCESS OF ROEBEL CABLES. TEST RESULTS ACHIEVED USING A SUPERCONDUCTING TRANSFORMER FOR CRITICAL CURRENT MEASUREMENTS IN LIQUID HELIUM ARE SHOWN, DISCUSSED AND COMPARED TO THE PERFORMANCE OF A SINGLE $YBA_2CU_3O_{7-\Delta}$ COATED CONDUCTOR TAPE.

5LPA-04

BSCCO-2212 WIRE AND CABLE STUDIES ***E. BARZI****, V. LOMBARDO, D. TURRIONI;* FERMILAB. — BSCCO-2212 ROUND WIRES AND CABLES ARE BEING STUDIED FOR POSSIBLE USE IN VERY HIGH FIELD MAGNETS WITHIN THE VERY HIGH FIELD SUPERCONDUCTING MAGNET COLLABORATION (VHFSMC). A NUMBER OF BILLETS PRODUCED BY OST WITH DIFFERENT INTERNAL DESIGNS AND POWDERS WERE USED TO MAKE RUTHERFORD-TYPE CABLES OF VARIOUS GEOMETRIES. THE EFFECT OF THESE PARAMETERS WAS MEASURED ON THE EXTRACTED STRAND PERFORMANCE AND DEFORMATION. HIGH (14 T) AND LOW FIELD TRANSPORT PROPERTIES WERE MEASURED AT 4.2 K FOR THE EXTRACTED STRANDS ACROSS THE EDGES, AND COMPARED WITH VIRGIN SAMPLES. TO CORRELATE DAMAGE WITH PERFORMANCE, FOR SEVERAL CABLES AND CONDITIONS STRAND DEFORMATION WAS MEASURED AS A FUNCTION OF STRAND LOCATION IN THE CABLE CROSS SECTION. FINALLY CABLES WERE TESTED USING A SUPERCONDUCTING TRANSFORMER AND RESULTS COMPARED TO THOSE OF THE EXTRACTED STRANDS. THE RESULTS OBTAINED IN THE PRESENT STUDY WERE FED BACK TO INDUSTRY FOR BILLET UPGRADES.

5LPA-06

CABLING AND JOINT METHODS OF HIGH CURRENT CABLES MADE FROM HTS TAPES ***M. TAKAYASU***[1]*, L. CHIESA*[2]*, L. BROMBERG*[1]*, J. MINERVINI*[1]*;* [1]MIT, [2]TUFTS UNIVERSITY. — NEW ELECTRIC POWER AND MAGNET APPLICATIONS REQUIRE DEVELOPMENT OF HTS CABLES CAPABLE OF CARRYING HIGH CURRENT, OFTEN AT HIGH MAGNETIC FIELDS. THE PRESENT FLAT SHAPE OF BOTH 1G AND 2G TAPES ARE NOT IDEAL FOR BUNDLING TOGETHER TO CARRY HIGH CURRENTS. CABLES CARRYING ORDER OF 1-3 KA HAVE ALREADY BEEN DEMONSTRATED BY HELICALLY WINDING THE TAPES ON A TUBE SURFACE. THIS APPROACH IS NOT ADEQUATE TO EXTEND TO MUCH HIGHER CURRENT CABLES. OTHER METHODS ARE ALSO UNDER DEVELOPMENT SUCH AS ROEBEL ASSEMBLED COATED CONDUCTOR. THIS GEOMETRY REDUCES AC LOSSES, BUT IT ALSO IS NOT EASILY SCALABLE TO VERY HIGH CURRENTS. RECENTLY WE HAVE STARTED DEVELOPMENT OF A TWISTED, STACKED-TAPE GEOMETRY TO PROVIDE A MORE SIMPLE AND SCALABLE CABLING METHOD. TYPICALLY 2G YBCO TAPE IS FORMED ON A BASE NI ALLOY SUBSTRATE WITH ADDITIONAL INSULATING BUFFER LAYERS AND A THIN SILVER LAYER ABOVE THE YBCO LAYER. THIN COPPER MAY BE DEPOSITED OVER THE ASSEMBLY. THE SILVER SIDE OF THE TAPE THUS HAS BETTER ELECTRICAL TRANSVERSE CONDUCTIVITY THAN THE SUBSTRATE SIDE. THIS ASYMMETRIC CONDUCTIVITY IS UNIQUE COMPARED WITH OTHER SUPERCONDUCTORS, AND REQUIRES SPECIAL TECHNOLOGIES FOR JOINTS AND TERMINATIONS. IN THIS PAPER WE PRESENT OUR CONCEPT FOR MAKING TWISTED STACKED-TAPE CONDUCTORS AND THEIR JOINTS, TAKING INTO ACCOUNT THE ASYMMETRIC ELECTRIC CONDUCTIVITY AND THE EFFECT ON NON-UNIFORM CURRENT SHARING AND AC LOSSES.

THIS WORK SUPPORTED BY THE U. S. DEPARTMENT OF ENERGY, OFFICE OF FUSION ENERGY SCIENCE UNDER GRANT NUMBER: DE-FC02-93ER54186.

5LPA-07

EXPERIMENTALLY DETERMINED AC LOSSES OF SMALL CC CABLE MODELS WITH IN-PHASE ALTERNATING CURRENT AND APPLIED FIELD ***J. ŠOUC****, M. VOJENČIAK, F. GÖMÖRY;* IEE, SLOVAK ACADEMY OF SCIENCES. — SHORT CABLE MODEL WAS MANUFACTURED FROM THREE COATED CONDUCTOR (CC) YBCO TAPES HELICALLY WOUND IN ONE LAYER ON FIBERGLASS FORMER OF DIAMETER 5 MM, WITH TWIST PITCH OF 2.5 CM. THE TAPES FORMED PARALLEL PATHS TO THE AC CURRENT THANKS TO THE GALVANIC CONNECTION AT THE TERMINATIONS. THE LOSS ORIGINATED DUE TO TRANSPORT AC CURRENT FLOWING IN THE MODEL AS WELL AS THE MAGNETIZATION LOSS CAUSED BY THE APPLIED AC MAGNETIC FIELD WERE MEASURED SEPARATELY. CONSIDERING OUR MODEL AS A PROTOTYPE OF CABLED CONDUCTOR FROM COATED TAPES, THE MOST SIGNIFICANT CIRCUMSTANCE FOR THE LOSS DETERMINATION IS WHEN IN-PHASE AC CURRENT AND AC MAGNETIC FIELD ARE APPLIED SIMULTANEOUSLY. WE PRESENT THE RESULTS OF EXPERIMENTS PERFORMED AT LN2 AND DIFFERENT FREQUENCIES AND DISCUSS THE POTENTIAL OF THIS CABLING CONCEPT.

5LPA-08

ESTIMATION OF THE CRITICAL CURRENT DENSITY FROM THE MEASURED VALUES OF PERPENDICULAR MAGNETIZATION LOSSES IN HTS COATED CONDUCTORS ***J. LEE***[1]*, Y. KIM*[2]*, S. LEE*[2]*, W. KIM*[3]*, C. PARK*[4]*, K. CHOI*[2]*;* [1]WOOSUK UNIVERSITY, [2]KOREA POLYTECHNIC UNIVERSITY, [3]KOREA ELECTRIC POWER RESEARCH INSTITUTE, [4]SEOUL NATIONAL UNIVERSITY. — STACKING WITH STRIATION IS ONE OF THE POSSIBLE METHODS FOR LARGE SCALE POWER APPLICATIONS OF HTS CONDUCTORS. BUT IT IS NOT EASY TO MEASURE AN EFFECTIVE CRITICAL CURRENT OF SUCH STACKED HTS COATED CONDUCTORS (CC) WITH STRIATION. INSTEAD OF DIRECT MEASUREMENT OF ITS CRITICAL CURRENT, AN INDIRECT ESTIMATION COULD BE USEFUL FOR PRACTICAL USE OF CC. IN THIS PAPER, WE SUGGESTED AND VERIFIED THE INDIRECT ESTIMATION USING THE MAGNETIZATION LOSS OF STACKED CC. THE MAGNETIZATION LOSS OF A SUPERCONDUCTOR IS SUPPOSED TO BE AFFECTED BY A FULL PENETRATING MAGNETIC FIELD, AND IT TENDS TO SHOW AN INFLECTION POINT AT THE FULL PENETRATING MAGNETIC FIELD WHEN WE GENERATE THE GRAPH OF MAGNETIZATION LOSS VS. EXTERNAL MAGNETIC FIELD. THE FULL PENETRATING MAGNETIC FIELD DEPENDS ON THE SHAPE OF THE CONDUCTOR AND ITS CRITICAL CURRENT DENSITY, SO WE CAN ESTIMATE THE EFFECTIVE CRITICAL CURRENT DENSITY FROM MEASURING THE MAGNETIZATION LOSS. TO PROVE THE EFFECTIVENESS OF THIS INDIRECT ESTIMATION OF THE CRITICAL CURRENT, WE MEASURED THE PERPENDICULAR MAGNETIZATION LOSSES IN SHORT SAMPLES OF SEVERAL KINDS OF STACKED HTS CC WITH STRIATION AND ESTIMATED THE CRITICAL CURRENT DENSITIES OF THE SAMPLES.

THIS RESEARCH WAS SUPPORTED BY A GRANT FROM CENTER FOR APPLIED SUPERCONDUCTIVITY TECHNOLOGY OF THE 21ST CENTURY FRONTIER R&D PROGRAM FUNDED BY THE MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY, REPUBLIC OF KOREA.

5LPA-09

AN OPTIMIZATION OF A NBTI SUPERCONDUCTOR HAVING LOW AC-LOSS AND HIGH STABILITY AND CURRENT DENSITY ***M. LYLY****, A. STENVALL, R. MIKKONEN;* TAMPERE UNIVERSITY OF TECHNOLOGY. — REMOVING THE AC LOSSES IN LARGE SCALE SUPERCONDUCTING APPLICATIONS HAS HIGH COSTS. THIS IS ALSO THE CASE IN SEMI-DC MAGNETS SUCH AS ONES OF HUGE PARTICLE ACCELERATORS WHERE MAGNETS ARE RAMPED SYNCHRONOUSLY WITH THE BEAM ENERGY. ALSO, THESE MAGNETS REQUIRE LARGE CABLES MADE OF SEVERAL INDIVIDUAL STRANDS. THIS MAKES EVEN THE AC LOSS ANALYSIS OF SUCH MAGNETS VERY DIFFICULT. HOWEVER, ONE WANTS THE WIRE TO BE DESIGNED IN A WAY THAT THE AC LOSS OF THE FULL SIZE MAGNET IS MINIMIZED WHILE REQUIRED STABILITY IS MAINTAINED. THE OPTIMIZATION OF INDIVIDUAL WIRE INCLUDES AT LEAST DETERMINATION OF FILAMENT SIZE AND ZONES AND SELECTION OF MATRIX MATERIAL AND TOPOLOGY. AT THE SAME TIME THE HIGH CRITICAL CURRENT AND GOOD WORKABILITY MUST BE ENSURED. WITH NUMERICAL ANALYSIS IT IS POSSIBLE TO CONSIDER THESE FACTORS AND DESIGN NEW KIND OF LOW AC LOSS STRANDS, AND CABLES, FOR SPECIFIC APPLICATIONS.

IN THIS PAPER WE CONSIDER OPTIMIZATION OF NBTI CONDUCTOR TO ACHIEVE LOW AC LOSS AND ADEQUATE STABILITY WHILE INCLUDING ALSO VIEWPOINTS FROM THE MANUFACTURING SIDE.

5LPA-10

DEVELOPMENT OF NB_3SN RUTHERFORD CABLES WITH CORES FOR LARP QUADRUPOLE MODELS ***D. DIETDERICH***[1], *A. GODEKE*[1], *A. K. GHOSH*[2]; [1]LAWRENCE BERKELEY NATIONAL LABORATORY, [2]BROOKHAVEN NATIONAL LABORATORY. — LBNL HAS BEEN FABRICATING RUTHERFORD CABLES FOR THE LHC-US ACCELERATOR RESEARCH PROGRAM (LARP) SINCE ITS INCEPTION. UP TO NOW ALL OF THE CABLES USED IN LARP MAGNETS HAVE NOT HAD A CORE TO REDUCE ELECTRICAL COUPLING BETWEEN STRANDS ACROSS THE CABLE. IT HAS BEEN KNOW FOR MANY YEARS THAT A THIN STAINLESS STEEL CORE, ADDED TO MIDDLE OF A CABLE, WOULD SIGNIFICANTLY REDUCE THIS COUPLING. ADDING A STAINLESS STEEL CORE WITH THE PRESENT LARP CABLE FABRICATION PROCEDURE; FABRICATION OF THE OVERSIZE CABLE, ANNEALING THE CABLE, FOLLOWED BY RE-ROLLING OF THE CABLE TO FINAL SIZE, IS NOT A SIMPLE TASK. DUE TO THE DIMENSIONAL CHANGES OF THE CABLE DURING THE ANNEALING HEAT TREATMENT, AND THE MECHANICAL PROPERTY DIFFERENCES OF THE STAINLESS STEEL CORE AND STRAND, RE-ROLLING IS NEXT TO IMPOSSIBLE. LARP IS PURSUING TWO PATHS. ONE IS TO ADD CORES WITH VERY LITTLE MECHANICAL STRENGTH AND THE SECOND IS THE CHANGE THE CABLING PROCESS TO ONE ROLLING STEP, AND THUS USE A STAINLESS STEEL CORE. THE FIRST METHOD WILL UTILIZE CORES OF S-2 GLASS AND MGO PAPER WHILE THE SECOND REQUIRES THAT THE NB_3SN WIRE BE ANNEALED PRIOR TO CABLING TO REMOVE MOST OF THE RESIDUAL STRESS IN THE STRAND. THE MOST PROMISING OPTIONS WILL BE DISCUSSED AND PRACTICAL EXPERIENCE AND MEASUREMENTS IN HQ QUADRUPOLE COILS WILL BE PRESENTED.

THIS WORK WAS SUPPORTED BY THE DIRECTOR, OFFICE OF SCIENCE, HIGH ENERGY PHYSICS, U.S. DEPARTMENT OF ENERGY UNDER CONTRACT NO. DE-AC02-05CH11231.

5LPA-11

STRAND AND CABLE R&D FOR FAST CYCLED MAGNETS AT CERN ***L. BOTTURA***[1], *A. BONASIA*[1], *W. GAERTNER*[2], *S. LE NAOUR*[1], *L. R. OBERLI*[1], *D. RICHTER*[1], *T. SALMI*[1], *G. SIKLER*[2], *G. WILLERING*[1]; [1]CERN, [2]BNG. — FAST CYCLED SUPERCONDUCTING MAGNETS (FCM'S) ARE AN OPTION OF INTEREST FOR THE LONG-TERM CONSOLIDATION AND UPGRADE PLAN OF THE LHC ACCELERATOR COMPLEX. IN THE PAST TWO YEARS WE HAVE CONDUCTED AN R&D OF LIMITED SCOPE, TARGETED AT INVESTIGATING THE FEASIBILITY, OPERATIONAL ISSUES AND ECONOMICAL ADVANTAGE OF FCM'S IN THE RANGE OF 2 T BORE FIELD, CONTINUOUSLY CYCLED AT 1 HZ. IN THIS PAPER WE REPORT THE MAIN RESULTS ON THE DEVELOPMENT OF STRANDS AND CABLES SUITABLE FOR THIS APPLICATION, PROVIDING DETAILS ON THE STRANDS TESTED (CRITICAL CURRENT AND AC LOSS), THE CABLE MANUFACTURING (PROCEDURE, DIMENSIONS) AND PERFORMANCE (DC AND AC CRITICAL CURRENT, QUENCH), AND THE JOINING TECHNIQUE AND PERFORMANCE (JOINT RESISTANCE).

5LPB-01

DEVELOPMENT OF A CRYOGENIC HELIUM-NEON GAS MIXTURE COOLING SYSTEM FOR USE IN A GD-BULK HTS SYNCHRONOUS MOTOR ***B. FELDER***[1], *M. MIKI*[1], *Z. DENG*[1], *K. TSUZUKI*[1], *N. SHINOHARA*[1], *H. HAYAKAWA*[2], *M. IZUMI*[1]; [1]TOKYO UNIVERSITY OF MARINE SCIENCE AND TECHNOLOGY, [2]KITANO SEIKI CO. LTD.. — IN THE DOMAIN OF HTS BULKS APPLIED TO SYNCHRONOUS MOTORS, AN EFFICIENT COOLING SYSTEM IS NECESSARY TO INCREASE THE MAXIMUM TRAPPED FIELD DENSITY, DECREASE THE OVERALL COOLING TIME AND ALLOW A GOOD PROTECTION AGAINST UNDESIRABLE HEAT INVASION. THERMOSYPHONS ARE A PRIVILEGED WAY OF TRANSFERRING THE HEAT FROM THE ROTOR PLATE TO THE CRYOCOOLER, AS THEY COMBINE COOLING EFFICIENCY AND EASINESS OF USE, THOUGH SINGLE-PHASE CONDENSATION OFTEN MEANS THE CHOICE OF VERY LOW TEMPERATURE IS MADE AT THE EXPEND OF THE PRESSURE AND THUS OF THE HEAT TRANSFER. BASED ON A CONDENSED-NEON CLOSED-CYCLE THERMOSYPHON SUCCESSFULLY DEVELOPED RECENTLY, A GASEOUS HELIUM PHASE HAS BEEN ADDED TO THE SYSTEM FOLLOWING THE PREVIOUS THERMODYNAMIC CONSIDERATIONS. THAT WAY, THE LATENT HEAT OF NEON-FILM COOLING IS COMBINED WITH HELIUM'S HIGH THERMAL CONDUCTIVITY AND THE MIXTURE STATE OF TWO GASES HAVING QUITE DIFFERENT BOILING POINTS OPENS A NEW RANGE OF POSSIBLE TEMPERATURES. IN THIS PAPER, DIFFERENT MIXTURE PROPORTIONS AND QUANTITIES ARE EVALUATED IN TERMS OF COOLING TIME AND RESISTANCE TO VARIABLE HEAT LOADS. THE COMBINATION CONSIDERED THE MOST EFFICIENT WAS THEN USED IN A REAL-SCALE TEST TO COOL DOWN A 30 KW-GRADE GD-BULK HTS SYNCHRONOUS MOTOR. LESS THAN FIVE HOURS WERE REQUIRED FOR THE EIGHT 60-MM DIAMETER BULKS TO REACH TEMPERATURES LOWER THAN 40 K. THE APPLICATION TO HIGHER-GRADE ROTATING MACHINES IS ALSO ENVISAGED.

5LPB-02

TEST RESULTS OF A COOLING SYSTEM USING MIXED CRYOGEN FOR HTS SUPERCONDUCTING MAGNETIC ENERGY STORAGE (SMES) SYSTEM ***K. KIM***[1], *J. SONG*[1], *K. KIM*[1], *J. LEE*[1], *J. CHOI*[2], *S. KIM*[2], *D. KOH*[3], *K. SEONG*[4], *H. LEE*[1]; [1]KOREA UNIVERSITY, KOREA, [2]GYEONGSANG NATIONAL UNIVERSITY AND ERI, KOREA, [3]KOREA INSTITUTE OF MACHINERY & MATERIALS, KOREA, [4]KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE, KOREA. — FOR AN HTS SUPERCONDUCTING MAGNETIC ENERGY STORAGE (SMES) MAGNET, A COOLING SYSTEM USING SOLID NITROGEN (SN2) HAS BEEN INTRODUCED AS AN EFFECTIVE HEAT CAPACITY ENHANCER IN RECENT STUDIES. ONE IMPORTANT FEATURE OF THIS SYSTEM IS THE LARGE AMOUNT OF ENTHALPY WITH A MINIMAL WEIGHT OF SN2; THIS ENABLES A PORTABLE SYSTEM BY INCREASING THE RECOOLING TO RECOOLING TIME PERIOD (RRTP) VALUE. HOWEVER, THE COOLING SYSTEM USING SN2 ALONE POTENTIALLY HAS A THERMAL CONTACT PROBLEM (THERMAL "DRY-OUT" PHENOMENA) BETWEEN THE SN2 AND

HTS SMES MAGNET. USING A MIXTURE OF SN2 AND A SMALL AMOUNT OF LIQUID CRYOGEN IS VERY EFFECTIVE IN SUPPRESSING THIS THERMAL DRY-OUT. IN THIS STUDY, WE DISCUSS THE COOLING PERFORMANCE OF A MIXTURE OF SN2 AND LIQUID NEON (LNE) ON AN HTS SMES MAGNET.

THIS WORK WAS SUPPORTED BY THE ELECTRIC POWER INDUSTRY TECHNOLOGY EVALUATION & PLANNING.

5LPB-03

EXPERIMENT STUDY ON COOLING SYSTEM OF HTS SYNCHRONOUS MACHINES ***C. BIAO****, G. GUOBIAO, Z. GUOQIANG;* THE INSTITUTE OF ELECTRICAL ENGINEERING (IEE), CHINESE ACADEMY OF SCIENCES (CAS). — AN INTEGRATED ROTOR COOLING PLATFORM WAS DESIGNED, MANUFACTURED AND TESTED TO INVESTIGATE CHARACTERISTICS OF DIFFERENT COOLING METHODS. THESE COOLING METHODS WERE INCLUDED SATURATED BOILING COOLING(SBC), THERMOSYPHON COOLING(TC), DISTRIBUTED THERMOSYPHON COOLING(DTC), LAYERED EVAPORATIVE COOLING(LEC), AND PIPING EVAPORATIVE COOLING(PEC), WHICH ARE ALL PHASE CHANGE COOLING BASED ON BOILING THEORY AND CLOSED SELF-CIRCULATION LOOPS. THE DESIGN CONCEPT, COMPONENTS AND MEASURE APPARATUSES OF THE PLATFORM WERE PRESENTED RESPECTIVELY. THE EXPERIMENTAL DATA SHOWED THAT SBC EXHIBITED THE BEST HEAT TRANNSFER PERFORMANCE AND LEC, DTC, TC WERE GRADUALLY BECOME PLAY DOWN. AND PEC MADE THE SIMILAR CHARATERISTIC LIKE LEC. THE STUDIED RESULTS OF PRESSURE DROP OF PEC IMPLIED THAT THE METHOD FOR STATIONARY TWO-PHASE FLOW: L-M-N EQUATION COULD BE EXTENDED TO THE ROTARY SITUATION WHEN THE FLOW DIRECTION WAS PARALLEL WITH THE REVOLVING AXIS. A DETAILED COOLING METHODS SUGGESTION MATCHED DIFFERENT SITUATIONS WAS OBTAINED ACCORDING TO THE EXPERIMENTAL RESULTS. THESE COOLING METHODS CAN BE EXTENDED TO CONVENTIONAL GENERATORS AND MOTORS, ESPECIALLY HIGH POWER DENSITY MOTORS AND LARGE CAPACITY TURBINE GENERATOR.

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5LPB-04

HTS (HIGH TEMPERATURE SUPERCONDUCTOR) MOTOR COOLED BY ON-BOARD CRYOCOOLER. ***Y. KIM****[1], H. KIM[1], J. KIM[1], S. JEONG[1], Y. KWON[2], S. KIM[2];* [1]KOREA ADVANCED INSTITUTE OF SCIENCE AND TECHNOLOGY, [2]KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE. — HTS MOTOR THAT UTILIZES SUPERCONDUCTOR AS THE FIELD WINDING HAS ADVANTAGE OF COMPACTNESS, LIGHT WEIGHT AND HIGH EFFICIENCY, BUT IT HAS AN INHERENT DISADVANTAGE THAT THE ROTOR MUST BE COOLED DOWN AT CRYOGENIC TEMPERATURE. CONVENTIONALLY, HTS ROTOR WAS COOLED BY CIRCULATION OF CRYOGENIC FLUID AND THE COOLING SYSTEM WAS INSTALLED OUTSIDE OF THE MOTOR TO PREVENT IT FROM BEING ROTATED. IN THIS PAPER, THE PROTOTYPE OF THE HTS MOTOR USING THE NOVEL CONCEPT OF COOLING SYSTEM, SO CALLED AN ON-BOARD CRYOCOOLER, IS FABRICATED AND TESTED. THE SYSTEM IS COMPOSED OF THE STATOR, THE ROTOR WITH SUPERCONDUCTOR, AND THE CRYOCOOLER. THE ROTOR IS FABRICATED AS THE RACE-TRACK COIL WITH 2G, YBCO TAPE AND SITUATED IN THE 110 MM DIAMETER CRYOSTAT. IT IS DESIGNED TO MINIMIZE HEAT INVASION FROM ENVIRONMENT AND BE COMPATIBLE WITH THE COAXIAL STRUCTURE OF THE CRYOCOOLER. THE CRYOCOOLER IS IN PHYSICALLY AND THERMALLY CONTACT WITH THE HTS ROTOR. TWO KINDS OF REFRIGERATOR, AN INLINE-TYPE STIRLING REFRIGERATOR AND A PTR (PULSE TUBE REFRIGERATOR) WITH LINEAR COMPRESSOR, ARE USED INDIVIDUALLY AS THE ON-BOARD CRYOCOOLER. SEVERAL TEMPERATURE SENSORS AND VOLTAGE TAPS ARE INSTALLED TO MONITOR THE CONDITION OF THE HTS ROTOR AND CRYOCOOLER. THE HTS MOTOR IS SUCCESSFULLY OPERATED WITH 90 RPM OF ROTATING SPEED. IN ROTATING TEST, 50 A CURRENT IS SUPPLIED TO THE SUPERCONDUCTING ROTOR.

5LPB-06

STRUCTURAL DESIGN OF TOROIDAL CONFIGURATION OF HTS SMES COOLING SYSTEM ***H. YEOM****[1], J. KO[1], D. KOH[1], Y. HONG[1], S. KIM[2], K. SUNG[2];* [1]KIMM, [2]KERI. — THE SUPERCONDUCTING MAGNETIC ENERGY STORAGE (SMES) SYSTEM IS CHARGED ENERGY BY (1/2)LI^2.TO DO A ROLL OF STORAGE ENERGY, THE SUPERCONDUCTING COIL MUST BE COOLED BELOW THE CRITICAL TEMPERATURE BY THE CRYOGENIC COOLING SYSTEM. IN GENERAL, WORKING TEMPERATURE OF THE HTS SMES SYSTEM IS MAINTAINED AROUND 30 K BY HELIUM GAS OF LIQUID NEON OF FOR INCREASING CRITICAL CURRENT.THERE ARE SOME APPLIED EXAMPLES OF CONDUCTION COOLING SYSTEM IN SUB MJ CLASS HTS SMES, BUT CONDUCTION COOLING SYSTEM HAS SOME PROBLEMS TO ADAPT IN BIG HTS SMES SYSTEM.A TOROIDAL TYPE HTS SMES HAS SOME MERITS, SO IT IS VERY SMALL MAGNETIC FIELD LEAKAGE, AND MAGNETIC FIELD APPLIED PERPENDICULAR TO THE TAPE SURFACE CAN BE REDUCED.SO, WE HAVE DESIGNED THE CRYOGENIC COOLING SYSTEM FOR TOROIDAL CONFIGURATION HTS SMES.THERE ARE 56 NUMBERS OF HTS SINGLE PANCAKE COILS AND THEY ARE ARRAYED TOROIDAL CONFIGURATION.THE TOROIDAL INNER DIAMETER IS 162 MM, AND OUTER DIAMETER IS 1197 MM, AND HEIGHT IS ABOUT 162 MM.BY THE WAY ELECTROMAGNETIC FORCE ACTS ON INNER DIRECTION IN TOROIDAL CONFIGURATION.SO STRUCTURE OF THE INNER PART OF THE TOROID MUST BE ABLE TO WITHSTAND THE ELECTROMAGNETIC FORCE.IN THIS STUDY, WE HAVE DESIGNED THE COOLING STRUCTURE AND ANALYZED STRESS AND STRAIN OF THE STRUCTURE.

THIS WORK WAS CARRIED OUT UNDER THE SUPPORT OF THE MINISTRY OF COMMERCE, INDUSTRY AND ENERGY, KOREA.

5LPB-09

AN INNOVATIVE CONCEPT OF STORING COLD ENERGY FOR SFES (SUPERCONDUCTOR FLYWHEEL ENERGY STORAGE) SYSTEM ***J. LEE****[1], S. JEONG[1], Y. HAN[2], B. PARK[2];* [1]KOREA

ADVANCED INSTITUTE OF SCIENCE AND TECHNOLOGY, [2]KOREA ELECTRIC POWER RESEARCH INSTITUTE. — A SUPERCONDUCTOR FLYWHEEL ENERGY STORAGE (SFES) SYSTEM IS AN ENERGY STORAGE DEVICE WITH UNPRECEDENTED SMALL KINETIC ENERGY LOSS BY UTILIZING LEVITATION PROPERTY OF SUPERCONDUCTOR. THE SYSTEM, THEREFORE, IS EXPECTED TO BE ONE OF THE MOST PROMISING CANDIDATES IN THE APPLICATION OF RENEWABLE ENERGY FIELD SUCH AS PV (PHOTOVOLTAIC) OR WIND ENERGY DEVELOPMENT WHERE THE POWER GENERATION IS INTERMITTENT. THE INHERENT CHARACTERISTIC OF SFES, HOWEVER, IS THE FACT THAT IT REQUIRES COSTLY CRYOGENIC COOLING. THIS CRYOGENIC HARDWARE NOT ONLY INCREASES THE TOTAL CAPITAL COST OF SFES BUT ALSO LOWERS THE OVERALL ENERGY STORAGE EFFICIENCY. NON-NEGLIGIBLE AMOUNT OF ELECTRICITY IS ALWAYS NECESSARY DURING THE ENERGY STORAGE PERIOD TO MAINTAIN CRYOGENIC ENVIRONMENT SO THAT HTS BULK REMAINS STABLY. AN INNOVATIVE CONCEPT TO STORE COLD ENERGY AS WELL AS KINETIC ENERGY IN THE SFES SYSTEM IS INTRODUCED TO IMPROVE THE OVERALL ENERGY STORAGE EFFICIENCY. THE RECENT EXPERIMENTAL RESULT IS PRESENTED IN THIS PAPER. A CRYOGENIC THERMOSIPHON IS DESIGNED TO OPERATE AT FREEZING TEMPERATURE OF NITROGEN WHILE SOLID NITROGEN CAN CHANGE ITS PHASE TO LIQUID. THE EVAPORATOR TEMPERATURE IS SUCCESSFULLY MAINTAINED NEAR 64 K EVEN THOUGH THE IMPLEMENTED CRYOCOOLER IS TURNED OFF. THE INCREASED OVERALL ENERGY STORAGE EFFICIENCY IS QUANTITATIVELY DISCUSSED, AND THE PRACTICAL DESIGN METHOD IS PRESENTED IN THIS PAPER.

THIS WORK WAS SUPPORTED IN PART BY KOREA ELECTRIC POWER RESEARCH INSTITUTE FROM THE ELECTRIC POWER TECHNOLOGY EVALUATION & PLANNING CENTER OF THE REPUBLIC OF KOREA.

5LPB-10

HELIUM BASED PULSATING HEAT PIPE FOR SUPERCONDUCTING MAGNETS ***J. M. PFOTENHAUER***[1]*, D. M. GRANT*[1]*, E. W. STAUTNER*[2]*;* [1]UNIVERSITY OF WISCONSIN - MADISON, [2]GE GLOBAL RESEARCH, NISKAYANA ,NY. — THE ADVANTAGES OF PULSATING HEAT PIPES (PHP) FOR TRANSFERRING HEAT AND SMOOTHING TEMPERATURE PROFILES IN VARIOUS ROOM TEMPERATURE APPLICATIONS HAVE BEEN EXPLORED FOR THE PAST 20 YEARS. THIS STUDY EXTENDS THE EXPLORATION TO LOW TEMPERATURE APPLICATIONS, IN PARTICULAR SUPERCONDUCTING MAGNETS. AN EXPERIMENTAL APPARATUS TO INVESTIGATE THE HEAT TRANSFER PROPERTIES OF A HELIUM-BASED PULSATING HEAT PIPE HAS BEEN DESIGNED, FABRICATED AND OPERATED. THE EVAPORATOR END OF THE PHP IS COMPRISED OF A COPPER WINDING IN WHICH HEAT LOADS UP TO 10 WATTS ARE GENERATED, WHILE THE ISOTHERMAL CONDENSER END IS TEMPERATURE CONTROLLED VIA A SUMITOMO RDK408A2 GM CRYOCOOLER. VARIOUS EXPERIMENTAL DESIGN FEATURES ARE HIGHLIGHTED. ADDITIONALLY, PERFORMANCE RESULTS IN THE FORM OF HEAT TRANSFER AND TEMPERATURE CHARACTERISTICS ARE PROVIDED AS A FUNCTION OF AVERAGE CONDENSER TEMPERATURE, PHP FILL RATIO, AND EVAPORATOR HEAT LOAD. RESULTS ARE SUMMARIZED IN THE FORM OF A DIMENSIONLESS CORRELATION AND COMPARED TO ROOM TEMPERATURE SYSTEMS. IMPLICATIONS FOR SUPERCONDUCTING MAGNET STABILITY ARE HIGHLIGHTED.

SUPPORT FOR THIS WORK FROM GE GLOBAL RESEARCH IS GRATEFULLY ACKNOWLEDGED

5LPC-01

PROPERTIES OF AN HTS MAGNET HAVING OPTIMIZED AIR GAP BETWEEN PANCAKE WINDINGS ***Y. KIM***[1]*, M. KU*[1]*, G. CHA*[1]*, S. PARK*[2]*;* [1]SOONCHUNHYANG UNIV., [2]KOREA LIFT COLLEGE.. — RECENT PAPER SHOWED THAT AN AIR GAP BETWEEN PANCAKE WINDINGS INCREASED THE STRENGTH AND THE UNIFORMITY OF THE CENTRAL MAGNETIC FIELD IN AN HTS MAGNET CONSISTING OF PANCAKE WINDINGS. THE LENGTH OF ALL AIR GAPS WAS THE SAME AT THAT PAPER. IF THE LENGTH OF EACH AIR GAP IS OPTIMIZED, THE CENTRAL MAGNETIC FIELD CAN BE INCREASED FURTHER. THIS PAPER SHOWS THE STRENGTH AND THE UNIFORMITY OF THE CENTRAL MAGNETIC FIELD CAN BE SIMULTANEOUSLY INCREASED FURTHER BY MAKING THE LENGTH OF EACH AIR GAP OPTIMIZED. TO MAXIMIZE THE CENTRAL MAGNETIC FIELD BY ASSIGNING OPTIMIZED LENGTH TO EACH AIR GAP, THE OPTIMIZATION OF THE LENGTH OF AIR GAP WAS CARRIED OUT BY USING A BSCCO HTS MAGNET CONSISTING OF PANCAKE WINDINGS. E-J RELATION WAS USED TO ESTIMATE THE CRITICAL CURRENT OF THE HTS MAGNET AND EVOLUTION STRATEGY WAS USED AS AN OPTIMIZATION TECHNIQUE. WHEN THE NUMBER OF PANCAKE WINDINGS AND THE NUMBER OF TURNS OF THE HTS MAGNET WERE 8 AND 800 TURNS IN TOTAL, THE CENTRAL MAGNETIC FIELD OF THE HTS MAGNET WAS INCREASED BY 35.6% FROM 0.308 T (NO AIR GAP) TO 0.404 T (OPTIMIZED AIR GAP).

5LPC-02

EFFECT OF DIFFERENT INNER DIAMETER OF OUTSERT PANCAKE WINDINGS ON AN HTS MAGNET WITH AN INSERT AND AN OUTSERT WINDING ***M. KU***[1]*, M. KANG*[1]*, H. LEE*[1]*, G. CHA*[1]*, K. RYU*[2]*;* [1]SOONCHUNHYANG UNIV., [2]CHONNAN NATIONAL UNIV.. — HIGH FIELD MAGNETS CONSISTING OF PANCAKE WINDINGS HAVE AN INSERT WINDING AND AN OUTSERT WINDINGS. THE DIAMETER OF ALL PANCAKE WINDINGS OF THE OUTSERT WINDING HAS BEEN THE SAME. IF THE DIAMETER OF THE PANCAKE WINDINGS LOCATED ABOVE AND BELOW THE INSERT WINDING IS REDUCED, IT CAN REDUCE THE DISTANCE BETWEEN THE WINDING AND THE CENTER OF THE MAGNET AND IT CAN INCREASE THE CRITICAL CURRENT OF THE INSERT MAGNET BECAUSE THE PERPENDICULAR MAGNETIC FIELD COMPONENT APPLIED TO THE INSERT WINDING REDUCES. THE SHORTER DISTANCE AND REDUCED PERPENDICULAR COMPONENT WILL INCREASE THE CENTRAL MAGNETIC FIELD OF AN HTS MAGNET. THIS PAPER SHOWS THE CENTRAL MAGNETIC FIELD CAN BE INCREASE BY REDUCING THE INNER DIAMETER OF THE OUTSERT PANCAKE WINDINGS LOCATED ABOVE AND BELOW THE INNER WINDING. FOR THE HTS MAGNET CONSISTING OF 8 YBCO

PANCAKE WINDINGS FOR INSERT WINDING AND 12 BSCCO PANCAKE WINDINGS FOR OUTSERT WINDINGS, THE CENTRAL MAGNETIC FIELD INCREASED BY 15.1%. FIELD UNIFORMITY OF THE HTS MAGNET WAS ALSO INCREASED.

5LPC-03

MAGNETIC FIELD AND STORED ENERGY OF A BSCCO HTS MAGNET AT VARIOUS ASPECT RATIO ***M. KANG***[1], *Y. KIM*[1], *H. LEE*[1], *G. CHA*[1], *K. RYU*[2]; [1]SOONCHUNHYANG UNIVERSITY, [2]CHONNAM NATIONAL UNIVERSITY. — WHEN THE LENGTH OF WIRE USED TO MAKE AN HTS MAGNET IS FIXED, THE MAGNETIC PROPERTIES OF THE HTS MAGNET INCLUDING CENTRAL MAGNETIC FIELD AND STORED ENERGY MOSTLY DEPEND ON THE ASPECT RATIO OF THE HTS MAGNET. THIS PAPER CALCULATED THE MAGNETIC PROPERTIES OF A BSCCO HTS MAGNET AT VARIOUS ASPECT RATIO. THE HTS MAGNET WAS ASSUMED TO BE MADE BY PANCAKE WINDINGS. THE TOTAL LENGTH OF THE BSCCO WIRE WAS VARIED FROM 2 TO 10KM. FOR A SPECIFIC LENGTH OF THE BSCCO WIRE, THE NUMBER OF PANCAKE WINDINGS WAS VARIED UP TO 70. THE INNER DIAMETER AND THE OPERATING TEMPERATURE OF THE HTS MAGNET WERE FIXED TO BE 50 MM AND 77K. WHEN THE LENGTH OF BSCCO WIRE WAS 2KM, THE CENTRAL MAGNETIC FIELD WAS MAXIMUM AT 34 PANCAKE WINDINGS. THE MAXIMUM CENTRAL MAGNETIC FIELD AND THE CURRENT OF THE HTS MAGNET WERE 859.3 MT AND 21.8 A, RESPECTIVELY. THE NUMBER OF TURNS OF A SINGLE PANCAKE WINDING AND THE ASPECT RATIO OF THE HTS MAGNET WERE 171 TURNS AND 2.54, RESPECTIVELY.

5LPC-04

FUNDAMENTAL DESIGN SPECIFICATION FOR GJ CLASS SUPERCONDUCTING MAGNETIC ENERGY STORAGE ***S. H. HWANG***[1], *A. R. KIM*[1], *K. M. KIM*[1], *J. G. KIM*[1], *M. W. PARK*[1], *I. K. YU*[1], *S. H. KIM*[2], *K. D. SIM*[2], *K. C. SEONG*[2]; [1]CHANGWON NATIONAL UNIVERSITY, [2]KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE. — SUPERCONDUCTING MAGNETIC ENERGY STORAGE (SMES) IS A PROMISING DEVICE FOR FREQUENCY STABILIZATION AND LOAD LEVELING OF POWER GRID. BUT, NEITHER MAGNET TYPE NOR WIRE TYPE WHICH IS SUITABLE FOR GJ CLASS SMES HAVE BEEN STUDIED YET. THIS PAPER INVESTIGATES FUNDAMENTAL DESIGN SPECIFICATIONS FOR GJ CLASS SMES AND PRESENTS COMPARISON RESULTS OF PROPERTIES ACCORDING TO WIRE TYPE AND MAGNET TYPE IN ORDER TO DETERMINE PROPER DESIGN PARAMETERS FOR A GJ CLASS SMES.TWO DIFFERENT TYPES OF SUPERCONDUCTING WIRE (YBCO AND BSCCO) AND TWO TYPES OF SUPERCONDUCTING MAGNET (D-SHAPE AND TOROID) FOR 2 GJ CLASS SMES ARE CONSIDERED FOR THE COMPARISON STUDY. FOUR DESIGN MODELS OBTAINED BY COMBINATION OF EACH DESIGN PARAMETER ARE INVESTIGATED BY USING FINITE ELEMENT ANALYSIS METHOD (FEM). TOTAL LENGTH OF SUPERCONDUCTING WIRE, MAGNETIC FIELD STRENGTH, MAGNET VOLUME, AND CRITICAL CURRENT ARE ESTIMATED AND THE RESULTS ARE ANALYZED TO FIND OUT BEST SPECIFICATIONS. ESPECIALLY THE PROPER LENGTH OF SUPERCONDUCTING WIRE IS PREFERENTIALLY CONSIDERED FOR THE COST EFFECTIVE DESIGN OF 2 GJ CLASS SMES. AS A RESULT OF THE STUDY, WE PROVIDE NOT ONLY PROPER DESIGN PARAMETERS BUT ALSO BASIC MODEL OF 2 GJ CLASS SMES.

MINISTRY OF KNOWLEDGE ECONOMY

5LPC-05

DESIGN OF COIL BOBBIN STRUCTURE FOR 2.5 MJ HTS SMES THROUGH STRESS ANALYSIS ***K. KIM***[1], *S. LEE*[2], *S. KIM*[3], *M. PARK*[1], *I. YU*[1], *G. CHOI*[4], *K. SEONG*[3], *J. LEE*[5], *S. LEE*[4]; [1]CHANGWON NATIONAL UNIVERSITY, [2]UIDUK UNIVERSITY, [3]KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE, [4]KOREA POLYTECHNIC UNIVERSITY, [5]WOOSUK UNIVERSITY. — A 2.5 MJ HTS SMES SYSTEM ARE UNDER DEVELOPMENT TO COMPENSATE THE SAG OR INSTANTANEOUS BLACK OUT FOR A UTILITY SIDE. ACCORDING AS THE PERFORMANCE OF 2G HTS CONDUCTOR IS IMPROVED CONTINUOUSLY, THE 2G HTS CONDUCTOR IS CONSIDERED AS A MOST COMPETITIVE CONDUCTOR CONSIDERING PRICE AND COMPACTNESS. THE TOROID STRUCTURE IS ADAPTED TO REDUCE THE PERPENDICULAR MAGNETIC FIELD AND STRAY FIELD OUTSIDE THE SMES. IN THE TOROID COIL, IT SHOWS A SMALL PERPENDICULAR MAGNETIC FIELD, HOWEVER, THE PARALLEL MAGNETIC FIELD IS MUCH LARGER THAN THE PERPENDICULAR ONE. THEREFORE, LORENTZ FORCE IN THE CONDUCTOR IS VERY STRONG AND THE STRESS ANALYSIS SHOULD BE CARRIED OUT TO VERIFY THAT THE MAXIMUM HOOP STRESS AND NORMAL STRESS ARE IN APPROPRIATE RANGE. IN ADDITION, OVERALL INWARD FORCE IN THE TOROID IS VERY STRONG AND STRESS ANALYSIS FOR THE BOBBIN AND SUPPORTING STRUCTURE IS IMPORTANT TO DESIGN THE MECHANICALLY STABLE STRUCTURE.THIS PAPER DESCRIBES THE ANALYSIS AND DESIGN RESULT FOR THE TOROID TYPE HTS SMES COIL CONSIDERING ORTHOTROPIC MATERIAL PROPERTIES, LARGE MAGNETIC FIELD AND THE RESULTING LORENTZ FORCE.

THIS WORK WAS SUPPORTED BY ELECTRIC POWER INDUSTRY TECHNOLOGY EVALUATION & PLANNING

5LPC-06

AN OPTIMAL CONFIGURATION DESIGN OF SUPERCONDUCTING MAGNETS FOR DC REACTOR TAKING LOSS INTO ACCOUNT ***S. NOGUCHI***[1], *K. YOSHIZAWA*[1], *M. TSUDA*[2]; [1]HOKKAIDO UNIVERSITY, [2]TOHOKU UNIVERSITY. — LARGE-SCALE DC REACTORS (DCL) WITH LARGE INDUCTANCES ARE OFTEN REQUIRED IN PRACTICAL FACTORIES. SUPERCONDUCTING MAGNETS REPRESENT AN INTERESTING ALTERNATIVE FOR THE CONSTRUCTION OF SUCH DEVICES. FROM THE POINT OF VIEW OF FLUX LEAKAGE, THE TOROIDAL MAGNET IS AN IDEAL STRUCTURE. THEREFORE, THE OPTIMAL CONFIGURATION OF THE TOROIDAL SUPERCONDUCTING MAGNETS FOR DC REACTOR WAS PREVIOUSLY PROPOSED IN ORDER TO MINIMIZE THE WINDING VOLUME. HOWEVER, THE MINIMIZATION OF THE LOSS HAS TO BE ALSO TAKEN INTO ACCOUNT ON THE OPTIMAL DESIGN.THE OPTIMAL CONFIGURATION DESIGN METHODS FOR SMES HAVE BEEN PROPOSED. THE CONFIGURATIONS OF THE SMES COILS WERE WELL RESEARCHED. HOWEVER, IN THE CASE OF THE DCL DESIGN, A DIFFERENT APPROACH HAS TO BE USED. THAT IS, THE INDUCTANCE OF THE TOROIDAL SUPERCONDUCTING

MAGNET HAS TO BE INCREASED WITH THE LARGE OPERATING CURRENT AND THE LOW LOSS. THEREFORE, WE HAVE INVESTIGATED THE CONFIGURATION OF THE TOROIDAL SUPERCONDUCTING MAGNETS FOR DCL. USING THE PREVIOUSLY PROPOSED METHOD, THE MAGNET CONFIGURATION IS OPTIMIZED TO MINIMIZE THE LOSS WITH THE LARGE INDUCTANCE AND THE LARGE OPERATING CURRENT UNDER CRITICAL CURRENT.

5LPD-01

ANALYSIS OF FACTORS AFFECTING FIELD QUALITY AND HEAT RELEASES OF THE QUADRUPOLE MAGNET FOR THE SIS 300 ***L. M. TKACHENKO****, S. S. KOZUB, P. A. SHCHERBAKOV, V. V. SYTNIK, V. V. ZUBKO;* INSTITUTE FOR HIGH ENERGY PHYSICS (IHEP). — HEP HAS DEVELOPED A DESIGN OF A SUPERCONDUCTING QUADRUPOLE MAGNET FOR THE SIS 300, PROJECT FAIR. THE MAIN PARAMETERS OF THIS QUADRUPOLE ARE: 45-T/M CENTRAL GRADIENT WITH THE GRADIENT RAMP RATE OF 10 T/M/C IN THE USEFUL APERTURE OF 105 MM AND THE COIL ID OF 125 MM; THE GEOMETRIC LENGTH OF THE MAGNET IS 1 M. THIS WORK INCLUDES THE ANALYSIS OF THE FACTORS AFFECTING FIELD QUALITY AND HEAT RELEASES OF THE QUADRUPOLE MAGNET FOR THE SIS 300. PARTICULARLY, INFLUENCE OF THE WEAK MAGNETIC ELEMENTS OF THE DESIGN ON THE FIELD QUALITY IN THE MAGNET IS EXAMINED AS WELL AS THE EFFECT OF GENERATED HEAT RELEASES IN THE RESISTIVE PARTS ON THE TEMPERATURE MARGIN IN THE QUADRUPOLE. TOLERANCES FOR THE MANUFACTURING ACCURACY OF VARIOUS GEOMETRICAL PARAMETERS ARE PRESENTED. EXAMINATION OF THE PARAMETERS AFFECTING THE INTEGRAL FIELD QUALITY IS DESCRIBED. PRESENTED LAW OF DEPENDENCE OF LOW INTEGRAL FIELD MULTIPOLES ON BOTH THE THICKNESS OF THE SPACER AND ITS POSITION IN THE END PARTS ALLOWS ONE TO QUICKLY FIND OPTIMIZED GEOMETRY WITH A VIEWPOINT OF THE INTEGRAL FIELD QUALITY.

5LPD-02

DESIGN AND ANALYSIS OF A SELF-CENTERED COLD MASS SUPPORT FOR THE MICE COUPLING MAGNETS ***L. WANG****[1], H. WU[2], S. LI[3], M. GREEN[4], X. GUO[2], H. PAN[2], S. ZHENG[2];* [1]SHANGHAI INSTITUTE OF APPLIED PHYSICS,CAS,SHANGHAI 201204,CHINA, [2]INSTITUTE OF CRYOGENICS AND SUPERCONDUCTIVITY TECHNOLOGY, HIT, HARBIN150080, CHINA, [3]HILONG UNIVERSITY OF SCIENCE AND TECHNOLOGY, HARBIN 150027, CHINA, [4]LAWRENCE BERKELEY LABORATORY, BERKELEY CA 94720, USA. — THE MUON IONIZATION COOLING EXPERIMENT (MICE) CONSISTS OF EIGHTEEN SUPERCONDUCTING SOLENOIDS IN SEVEN MODULES, WHICH ARE MAGNETICALLY HOOKED TOGETHER SINCE THERE IS NO IRON TO SHIELD THE COILS AND THE RETURN FLUX. THE RF COUPLING COIL (RFCC) MODULE CONSISTS OF A SUPERCONDUCTING COUPLING SOLENOID MOUNTED AROUND FOUR CONVENTIONAL CONDUCTING 201.25 MHZ CLOSED RF CAVITIES. THE COUPLING COIL WILL PRODUCE UP TO A 2.2 T MAGNETIC FIELD ON THE CENTERLINE TO KEEP THE BEAM WITHIN THE RF CAVITIES DURING NORMAL OPERATION. THE PEAK MAGNETIC FORCE ON THE COUPLING MAGNET FROM THE OTHER MAGNETS IN MICE IS UP TO 500 KN IN LONGITUDINAL DIRECTION, WHICH WILL BE TRANSFERRED TO THE BASE OF THE RF COUPLING COIL (RFCC) MODULE THROUGH A COLD MASS SUPPORT SYSTEM. A SELF-CENTERED DOUBLE-BAND COLD MASS SUPPORT SYSTEM WITH INTERMEDIATE THERMAL INTERRUPTIONS IS APPLIED FOR THE COUPLING MAGNET, AND THE DESIGN IS INTRODUCED IN DETAIL IN THIS PAPER. THE THERMAL AND STRUCTURAL ANALYSES ABOUT THE COLD MASS SUPPORT ASSEMBLY AND ITS COLD BASE HAVE BEEN CARRIED OUT USING COMMERCIAL CODE. THE PRESENTED DESIGN OF THE COLD MASS SUPPORT CAN MEET WITH THE STRINGENT REQUIREMENTS FOR THE MAGNET CENTER AND AXIS AZIMUTHAL ANGLE WHEN FULLY CHARGED.

THIS WORK IS SUPPORTED BY FUNDS OF THE CRYOGENICS AND SUPERCONDUCTING TECHNOLOGY INNOVATION PROJECT UNDER THE “985-2” PLAN OF THE HIT. THIS WORK IS ALSO SUPPORTED BY THE OFFICE OF SCIENCE, US-DOE UNDER DOE CONTRACT DE-AC02-05CH11231.

5LPD-03

AN OPTIMAL DESIGN TECHNIQUE OF HTS COILS BY CHANGING OUTER DIAMETERS AND THE GAP DISTANCES BETWEEN PANCAKES ***M. AHN****[1], S. LEE[2], H. LEE[3], D. BAE[4], H. KANG[4], Y. CHUNG[5], Y. YOON[6], T. KO[7];* [1]KUNSAN NATIONAL UNIVERSITY, [2]UIDUK UNIVERSITY, [3]KOREA UNIVERSITY, [4]CHUNGJU NATIONAL UNIVERSITY, [5]UNIVERSITY OF SUWON, [6]ANSAN COLLEGE OF TECHNOLOGY, [7]YONSEI UNIVERSITY. — IN GENERAL, HIGH TEMPERATURE SUPERCONDUCTING (HTS) COILS COMPRISE PANCAKES. THE ENTIRE CRITICAL CURRENT OF THE PANCAKE-STACKED HTS COIL IS MAINLY GOVERNED BY THE PERPENDICULAR MAGNETIC FIELD TO THE HTS TAPE WOUND IN THE UPPERMOST AND LOWERMOST PANCAKE. IN THIS PAPER, AN OPTIMAL DESIGN TECHNIQUE OF HTS COILS HAS BEEN PROPOSED FOR HIGH CRITICAL CURRENT PURPOSE. MAIN VARIABLE FACTORS ARE OUTER DIAMETER OF EACH PANCAKE AND GAP DISTANCES BETWEEN PANCAKES. THE WIDTH AND CRITICAL CURRENT OF TAPE OF EACH PANCAKE ARE ALSO VARIABLE. A NUMERICAL CODE HAS BEEN DEVELOPED TO CALCULATE THE MAGNETIC FLUX DENSITY. AN OPTIMIZATION PROCESS HAS BEEN CONDUCTED BY EVOLUTION STRATEGY AND ITERATION. TO CONFIRM THE CODE AND OPTIMIZATION PROCESS, A FINITE ELEMENT ANALYSIS WAS ALSO CONDUCTED FOR DOUBLE-CHECKING. THIS OPTIMAL DESIGN METHOD COULD BE APPLIED TO CONCEPTIONAL DESIGN OF UNIVERSAL MAGNETS.

THIS STUDY WAS SUPPORTED BY THE KOREA SCIENCE AND ENGINEERING FOUNDATION (KOSEF) GRANT FUNDED BY THE KOREA GOVERNMENT (MEST 2009-0085369).

5LPD-04

STRESS ANALYSIS OF A 7T SUPERCONDUCTING MAGNET FOR ANIMAL MRI ***J. CHEN****, X. JIANG, G. CHAI;* TSINGHUA UNIVERSITY, BEIJING, CHINA. — **STRESS ANALYSIS OF A 7T SUPERCONDUCTING MAGNET FOR ANIMAL MRI**THIS PAPER PRESENTS A STRESS ANALYSIS OF A 7T SUPERCONDUCTING MAGNET FOR ANIMAL MRI. IN ORDER TO OBTAIN AN ACCURATE DISTRIBUTION OF THE STRESS IN THE WINDING

AND SUPPORTING/REINFORCEMENT STRUCTURE, AN ELECTROMAGNETIC-STRUCTURAL COUPLING CALCULATION IS PERFORMED BY THE FINITE ELEMENT METHOD. PRE-STRESS OF THE MAGNET WINDING, THE REINFORCEMENT, THE THERMAL STRESSES DUE TO DIFFERENTIAL THERMAL CONTRACTION CAUSED BY THE MAGNET COOLING AND THE ELECTROMAGNETIC FORCES BY THE MAGNET EXCITATION ARE ALL TAKEN INTO CONSIDERATION. ACCORDING TO THE RESULTS, THE FEASIBILITY AND RATIONALITY OF THE STRUCTURAL DESIGN ARE VALIDATED.

5LPD-05

MECHANICAL OPTIMIZATION OF A HIGH FIELD NB_3AL COMMON COIL MAGNET ***Q. XU****, K. SASAKI, T. NAKAMOTO, A. TERASHIMA, A. YAMAMOTO;* CRYOGENICS SCIENCES CENTER, HIGH ENERGY ACCELERATOR RESEARCH ORGANIZATION. — A 13.1T NB_3AL COMMON COIL MAGNET IS UNDER DEVELOPMENT. MAGNETIC SIMULATION SHOWS THAT OPPOSITE DIRECTION LORENZ FORCES ARE APPLIED TO THE TWO LAYERS OF THE MOST CENTER COIL (WHERE THE MAXIMUM MAGNETIC FIELD IS LOCATED) DURING EXCITATION, WHICH STRONGLY TENDS TO TEAR THE COIL INTO TWO PARTS. THERMAL CONTRACTION STRESS OF THE ALUMINIUM SHELL, TOGETHER WITH THE PRE-STRESS APPLIED AT THE ROOM TEMPERATURE, OVERCOMES THIS LORENZ FORCE. HOWEVER, IN A TRADITIONAL COMMON COIL APPROACH, MOST OF THE FORCE COMING FROM THE OUTER SHELL WILL BE INTERCEPTED BY THE RIGID ISLANDS AND HORSE-SHOES. IN OTHER WORDS, THE STRESS IS NOT EFFICIENTLY TRANSFERRED TO THE COILS. THIS CAUSES THE INCREASE OF THE SHELL THICKNESS OR APPLICATION PRESSURE OF THE BLADDER, AND RESULT IN A LARGER SIZE OF THE WHOLE MAGNET OR MORE DIFFICULT MAGNET ASSEMBLY. SEVERAL POSSIBLE SOLUTIONS WERE PRESENTED AND DISCUSSED FOR THIS PROBLEM, INCLUDING SHAPE MODIFICATION OF THE ISLANDS AND HORSE-SHOES, SLIDING BOUNDARY CONDITION OF THE SUPERCONDUCTING COILS AND ETC. MERITS AND DEFECTS OF EACH SOLUTION WERE COMPARED.

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5LPD-06

DESIGN STUDY ON DC SUPERCONDUCTING MAGNETS WITH CONDUCTIVE SHEETS BETWEEN TURNS ***S. IMAGAWA****;* NATIONAL INSTITUTE FOR FUSION SCIENCE. — QUENCH PROTECTION IS IMPORTANT FOR SUPERCONDUCTING MAGNETS, IN WHICH EXTERNAL DUMP RESISTORS ARE USUALLY ADOPTED. SINCE THE VOLTAGE AT SHUT-OFF IS THE HIGHER IN THE LARGER MAGNETS, THEY NEED HIGH-VOLTAGE SWITCH AND INSULATION SYSTEM. IN THE CASE OF DC MAGNETS, TURN-TO-TURN INSULATION CAN BE REPLACED BY CONDUCTIVE SHEETS OR SPACERS. JOULE LOSSES BY THE BYPASS CURRENTS IN CHARGING CAN BE REDUCED WITHIN ALLOWABLE LEVEL WITH THE SLOW CHARGING RATE. THIS CONCEPT CAN REALIZE QUENCH PROTECTION BY INTERNAL-DUMP, WHICH IS CALLED 'QUENCH BACK'. WHEN THE EXCITED MAGNET IS OPENED TO THE POWER SUPPLY, THE TRANSPORT CURRENT RETURNS THROUGH THE CONDUCTIVE SHEETS, AND THEIR JOULE LOSSES HEAT UP THE WHOLE MAGNET QUICKLY AND UNIFORMLY. MERITS OF THIS METHOD ARE HIGH RELIABILITY WITHOUT EXTERNAL PROTECTION CIRCUITS, LOW SHUT-OFF VOLTAGE, AND NEEDLESSNESS OF LARGE-CURRENT CONDUCTORS. IN ADDITION, THE LOW VOLTAGE ENABLES TO USE CERAMIC INSULATION BETWEEN THE LAYERS, WHICH CAN IMPROVE THE RADIATION-RESISTANCE OF THE MAGNET. THE SUITABLE RESISTIVITY OF THE CONDUCTIVE MATERIAL IS 1,000 TO 100,000 TIMES HIGHER THAN STAINLESS STEELS. AS THE RESULTS OF SURVEY OF COMMERCIAL MATERIALS, A FEW CONDUCTIVE CERAMICS AND CONDUCTIVE RESINS ARE SELECTED AS CANDIDATES. THEY ARE AL2O3 WITH TIC, SIC, AND EPOXY RESINS WITH CONDUCTIVE FILLER. A CONCEPTUAL DESIGN OF DC MAGNETS WITH THE CONDUCTIVE SHEETS BETWEEN TURNS IS PROPOSED.

5LPE-01

HIGH VOLTAGE DIELECTRIC CHARACTERISTICS OF EPOXY NANOCOMPOSITES IN LIQUID NITROGEN FOR SUPERCONDUCTING TRANSFORMER ***Y. J. LEE****[1], S. H. LEE[1], K. J. LIM[2], J. J. PARK[3], J. Y. KOO[1], B. W. LEE[1];* [1]HANYANG UNIVERSITY, [2]CHUNGBUK NATIONAL UNIVERSITY, [3]JOONGBU UNIVERSITY. — HIGH VOLTAGE INSULATION PLAYS A SIGNIFICANT ROLE IN THE DEVELOPMENT OF SUPERCONDUCTING ELECTRICAL DEVICES DETERMINING THEIR OPTIMUM DESIGN AND THE PERFORMANCES. NOWADAYS, NEWLY DEVELOPED NANOCOMPOSITES HAVE SHOWN ENHANCED ELECTRICAL, THERMAL, AND MECHANICAL PROPERTIES OF POLYMER MATERIALS. AND THE APPLICATION OF NANOCOMPOSITES IN HIGH VOLTAGE POWER SYSTEMS COULD BE IMPLEMENTED IN THE NEAR FUTURE. AMONG THE VARIOUS NANOCOMPOSITES, EPOXY NANOCOMPOSITES HAVE BEEN PAID MUCH ATTENTION AS A NEW INSULATING MATERIAL FOR HIGH VOLTAGE INSULATION. IN THIS PAPER, WE PRESENTED EXPERIMENTAL RESULTS OF EPOXY NANOCOMPOSITES IN LIQUID NITROGEN AND DETERMINED THE POSSIBLE APPLICATIONS OF NANOCOMPOSITES AS INSULATING MATERIAL FOR SUPERCONDUCTING TRANSFORMERS. IN ORDER TO DETERMINE THEIR DIELECTRIC BREAKDOWN PROPERTIES IN LIQUID NITROGEN, VARIOUS KINDS OF EPOXY BASED NANOCOMPOSITES HAVE BEEN MADE BY MIXING SIO_2, ZNO, AL_2O_3 AND OTHER MICROFILLERS. MOREOVER, AS AN APPROACH TOWARD PRACTICAL APPLICATION OF NANOCOMPOSITES FOR INSULATING MATERIALS FOR SUPERCONDUCTING TRANSFORMERS, NANO AND MICRO-FILLER COMBINATIONS HAVE BEEN TESTED USING DIFFERENT ELECTRODE GEOMETRIES TO DETERMINE THEIR SURFACE FLASHOVER PROPERTIES IN LIQUID NITROGEN. WE PAID OUR MAIN FOCUSES ON THE BREAKDOWN STRENGTH OF NANOCOMPOSITES ACCORDING TO THEIR NANO PARTICLE SIZE AND THEIR CONTENT OF FILLERS.

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OF EDUCATION, SCIENCE AND TECHNOLOGY, REPUBLIC OF KOREA

5LPE-02

BREAKDOWN CHARACTERISTICS OF THE LIQUEFIED SF_6 GAS AND CF_4 GAS IN LIQUID NITROGEN FOR HIGH VOLTAGE BUSHINGS IN CRYOGENIC ENVIRONMENT ***S. H. LEE****, W. J. SHIN, U. A. KHAN, J. K. SEONG, S. H. OH, B. W. LEE;* HANYANG UNIVERSITY. — UNTIL NOW, SUITABLE BUSHINGS FOR SUPERCONDUCTING HTS TRANSFORMER WERE NOT DEVELOPED DUE TO THE CRYOGENIC INSULATION ISSUES. DUE TO THE STEEP TEMPERATURE GRADIENT, COMMERCIAL BUSHINGS WHICH INSULATED BY SF_6 GASES COULD NOT DIRECTLY APPLY TO THE CRYOGENIC EQUIPMENT DUE TO THE LIQUIDATION OF SF_6 IN CRYOGENIC ENVIRONMENT. THEREFORE, SUITABLE STRUCTURE AND INSULATION METHODS CONSIDERING THE STEEP TEMPERATURE GRADIENT SHOULD BE DEVELOPED. AS A FUNDAMENTAL STEP TO DEVELOP THE OPTIMUM BUSHINGS FOR HTS TRANSFORMER, THE BREAKDOWN CHARACTERISTICS OF LIQUEFIED SF_6 GAS IN LIQUID NITROGEN HAVE BEEN INVESTIGATED. AND ALSO, THE INSULATION CHARACTERISTICS OF CF_4 GAS WHOSE LIQUEFIED TEMPERATURE IS EXTREMELY HIGH THAN SF_6 WAS TESTED IN ORDER TO VERIFY THE POSSIBILITY TO SUBSTITUTE SF_6 GAS INTO CF_4 FOR THE BUSHING OF HTS TRANSFORMER. FROM THE TEST RESULTS, IT WAS SHOWN THAT MIXTURE OF LIQUEFIED SF_6 GAS AND LIQUID NITROGEN STILL HAVE SIMILAR BREAKDOWN VOLTAGE COMPARING TO PURE LIQUID NITROGEN. THEREFORE, IN CRYOGENIC ENVIRONMENTS, THE USAGE OF SF_6 GAS COULD BE CONSIDERED BY ENHANCING THE PRESSURE OF GAS AND BY MIXING OF SUITABLE GAS TO LOWER THE FREEZING POINTS. IN ADDITION, CF_4 GAS HAS SHOWN EXCELLENT INSULATION PROPERTIES IN SPITE OF CRYOGENIC ENVIRONMENTS AND COULD BE APPLIED AS INSULATION GAS FOR HIGH VOLTAGE BUSHING OF HTS TRANSFORMER.

THIS RESEARCH WAS SUPPORTED BY A GRANT FROM CENTER FOR APPLIED SUPERCONDUCTIVITY TECHNOLOGY OF THE 21ST CENTER FRONTIER R&D PROGRAM FUNDED BY THE MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY, REPUBLIC OF KOREA

5LPE-03

CORRELATION BETWEEN PARTIAL DISCHARGE AND FLASHOVER CHARACTERISTICS OF THE INSULATION COMPONENTS OF 154KV REAL SCALE HTS TRANSFORMER ***S. H. LEE****, I. J. SEO, J. W. KOO, B. W. LEE;* HANYANG UNIVERSITY. — IN CASE OF HTS TRANSFORMER, IT REQUIRES SOPHISTICATED DIAGNOSTIC MEASURING TECHNIQUES IN ORDER TO DETECT ABNORMAL SIGNALS AND PROTECT IT FROM CRITICAL HAZARDS, BECAUSE SOME KINDS OF INTERNAL FAILURES COULD NOT BE IMMEDIATELY INSPECTED OR OBSERVED DUE TO THEIR ENCLOSED AND COMPLICATED STRUCTURE. THEREFORE, IN ORDER TO IMPLEMENT RELIABLE HTS TRANSFORMERS, PARTIAL DISCHARGE DIAGNOSIS TECHNIQUES FOR CRYOGENIC MATERIALS OF HTS TRANSFORMERS SHOULD BE IMPLEMENTED AND ALSO THE CORRELATION BETWEEN PARTIAL DISCHARGE INITIATION VOLTAGE AND FLASHOVER VOLTAGE IN LIQUID NITROGEN.IN THIS PAPER, SOME KINDS OF ARTIFICIAL DEFECTS WERE MADE ON THE INSULATION COMPONENT OF 154KV REAL SCALE HTS TRANSFORMER AND THE PARTIAL DISCHARGE CHARACTERISTICS OF CRYOGENIC DIELECTRIC MATERIALS IMMERSED IN LIQUID NITROGEN WERE INVESTIGATED. ESPECIALLY PHASE RESOLVED PARTIAL DISCHARGE ANALYSIS METHOD WAS USED TO DIAGNOSE PARTIAL DISCHARGES IN LIQUID NITROGEN. AND IN ORDER TO REVEAL THE CORRELATION BETWEEN PARTIAL DISCHARGE AND FLASHOVER OF INSULATING MEDIA, IMPULSE AND AC OVERVOLTAGE TESTS WERE ALSO PERFORMED. AS A RESULT, PARTIAL DISCHARGE ANALYSIS HAS BEEN COMPLETED AND CHARACTERIZATION OF PARTIAL DISCHARGE BEHAVIOR AFFECTING THE FLASHOVER VOLTAGE OF SOLID INSULATION OF HTS TRANSFORMER HAS BEEN PRESENTED AND DISCUSSED.

THIS RESEARCH WAS SUPPORTED BY BASIC SCIENCE RESEARCH PROGRAM THROUGH THE NATIONAL RESEARCH FOUNDATION OF KOREA (NRF) FUNDED BY THE MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY (2009-0089697)

5LPE-04

THE BARRIER EFFECT ON BREAKDOWN IN 154 KV CLASS HTS TRANSFORMER *H. CHEON[1], J. CHOI[1], J. LEE[2], H. LEE[2],* ***S. KIM****[1];* [1]DEPARTMENT OF ELECTRICAL ENGINEERING, GYEONGSANG NATIONAL UNIVERSITY AND ERI, [2]DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING, KOREA UNIVERSITY, SEOUL, KOREA. — LN_2 IS USED AS AN INSULATING MATERIAL AS WELL AS A CRYOGEN FOR 154 KV CLASS HTS TRANSFORMERS, BUT MAIN INSULATION WITH LN_2 ONLY IS NOT ENOUGH, SO RESEARCH ON BARRIER HAS BEEN REALIZED.HOWEVER, MOST OF THE EXPERIMENTS ON THIS BARRIER EFFECT ARE COMBINATION OF PAPER AND GAS (AIR, SF_6, ETC.), AND REPORTS ON BARRIER EFFECT OF LIQUID ARE INSUFFICIENT. MOREOVER, THERE IS ALMOST NO RESEARCH IN CRYOGENIC LIQUID USED FOR SUPERCONDUCTING EQUIPMENT.IN THIS PAPER, WE CONSIDERED THE BREAKDOWN PROPERTIES OF THE BARRIER RELATED TO THE POSITION, THE NUMBER AND MATERIALS. WE ARE ALSO GOING TO USE THIS DATABASE IN THE ELECTRICAL INSULATION DESIGN OF 154 KV CLASS HTS TRANSFORMER.

THIS RESEARCH WAS SUPPORTED BY A GRANT FROM CENTER FOR APPLIED SUPERCONDUCTIVITY TECHNOLOGY OF THE 21ST CENTURY FRONTIER R&D PROGRAM FUNDED BY THE MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY, REPUBLIC OF KOREA.

5LPE-05

INTER-TURN DIELECTRIC PROPERTIES OF YBCO COILS ***H. RODRIGO****[1], G. H. HELLER[1], R. E. MCCLELLAN[1], J. KVITKOVIC[1], S. PAMIDI[1], W. D. MARKIEWICZ[2];* [1]CENTER FOR ADVANCED POWER SYSTEMS, FLORIDA STATE UNIVERSITY, [2]NATIONAL HIGH MAGNETIC FIELD LABORATORY, FLORIDA STATE UNIVERSITY. — MANY ELECTRIC POWER APPLICATIONS OF

HIGH TEMPERATURE SUPERCONDUCTORS REQUIRE INSULATED WIRE. INSULATION THICKNESS AND INTEGRITY AFFECT ELECTROMAGNETIC DESIGN AND LONGEVITY OF THE DEVICES. PANCAKE COILS ARE ONE OF THE COMMON CONFIGURATIONS USED IN SUPERCONDUCTING POWER DEVICES. IN PANCAKE COILS, IT IS THE TURN-TO-TURN INSULATION THAT IS CRITICAL. DIELECTRIC PROPERTIES OF GE VARNISH BASED INSULATION ON YBCO TAPE, APPLIED USING A CONTINUOUS REEL-TO-REEL PROCESS, WERE MEASURED ON SHORT TAPE SECTIONS AND IN THE FORM OF COILS. FOR COMPARISON, SIMILAR MEASUREMENTS WERE CONDUCTED ON TAPES THAT ARE COMMERCIALLY AVAILABLE. DETAILS OF DC BREAKDOWN MEASUREMENTS AND ANALYSES USING WEIBUL STATISTICS ARE PRESENTED.

WORK PERFORMED UNDER DOE CONTRACT NUMBER DE-FC26-07NT43221

5LPE-06

ELECTRICAL INSULATION PAPER AND ITS PHYSICAL PROPERTIES AT CRYOGENIC TEMPERATURES ***E. TUNCER****, G. POLIZOS, I. SAUERS, R. JAMES;* OAK RIDGE NATIONAL LABORATORY. — PAPER IS WIDELY USED IN VARIOUS ENGINEERING APPLICATIONS DUE TO ITS PHYSICAL PROPERTIES AND MANUFACTURING CONDITIONS. AS A RESULT PAPER HAS BEEN SELECTED OR DESIGNED AS AN ELECTRICAL INSULATION MATERIAL FOR PARTS AND COMPONENTS IN HIGH VOLTAGE TECHNOLOGY. IN THE CURRENT STUDY WE SELECT A PAPER EMPLOYED IN CONVENTIONAL TRANSFORMERS AS THE ELECTRICAL INSULATION MATERIAL. THE POTENTIAL OF THIS PAPER IS INVESTIGATED AT CRYOGENIC TEMPERATURES TO DETERMINE ITS PHYSICAL PROPERTIES FOR HIGH TEMPERATURE SUPERCONDUCTIVITY POWER APPLICATIONS. DIELECTRIC AND MECHANICAL MEASUREMENTS WERE PERFORMED USING IMPEDANCE SPECTROSCOPY AND DYNAMIC MECHANICAL ANALYSIS TECHNIQUES. DIELECTRIC PROPERTIES WERE ESTABLISHED AT LOW TEMPERATURES AS A FUNCTION OF FREQUENCY (BETWEEN 20HZ AND 1MHZ) AND TEMPERATURE. DIELECTRIC BREAKDOWN TESTS WERE PERFORMED ON SAMPLES AT 77K USING A LIQUID NITROGEN BATH.

SPONSORED BY THE U.S. DEPARTMENT OF ENERGY, OFFICE OF ELECTRICITY DELIVERY AND ENERGY RELIABILITY, ADVANCED CABLES AND CONDUCTORS UNDER CONTRACT NO. DE-AC05-00OR22725 WITH UT-BATTELLE, LLC.

5LPE-07

UNIFYING DATA HAVING DIFFERENT STRESSED AREA AND VOLUME EFFECTS ON LIQUID NITROGEN BREAKDOWN FIELD *M. O. PACE,* ***I. SAUERS****, D. R. JAMES, E. TUNCER, G. POLIZOS;* OAK RIDGE NATIONAL LABORATORY. — FOR DESIGNERS OF HTS EQUIPMENT USING LIQUID NITROGEN AS A DIELECTRIC, A UNIVERSAL CURVE INCORPORATING AREA/VOLUME EFFECTS FOR EACH CLASS OF STRESSED GAP (ELECTRODE SHAPES), IS SOUGHT TO PROVIDE THE BREAKDOWN FIELD OF A LIQUID NITROGEN GAP WITH ANY VALUES OF THE CLASS PARAMETERS (SIZE OF EACH ELECTRODE AND GAP). THE PRESENT DEVELOPMENT IS FOR A SINGLE UNIVERSAL CURVE FOR THE CLASS WITH SPHERE-SPHERE, PLANE-PLANE AND SPHERE-PLANE GAPS, WITH THREE INDEPENDENT PARAMETERS: THE SIZE OF EACH ELECTRODE AND GAP, AT PRESSURES AT OR SLIGHTLY ABOVE 100 KPA.THE GEOMETRICAL EFFECTS OF STRESSED AREA/VOLUME ARE INCORPORATED FROM EXPERIMENTAL DATA BY PLOTTING EXPERIMENTAL BREAKDOWN FIELD DATA VERSUS NEW GEOMETRICAL QUANTITIES INSTEAD OF THE GAP DISTANCE, SUCH THAT ALL DATA FALL APPROXIMATELY ON ONE UNIVERSAL CURVE FOR A GIVEN CLASS. THIS AVOIDS THE USUAL COMPLEX CHALLENGE OF USING CALCULATED GEOMETRICAL EFFECTS TO MODIFY THE BREAKDOWN FIELD VALUES (ON THE GRAPH ORDINATE), AND INSTEAD USES EXPERIMENTAL INFORMATION TO MODIFY THE GEOMETRICAL PARAMETER (ON THE GRAPH ABSCISSA), SINCE AREA/VOLUME EFFECTS ARE PRIMARILY GEOMETRICAL.THIS APPROACH WILL BE DISCUSSED WITH EXAMPLES. IF THE METHOD PROVES TO BE RELIABLE, IT MAY BE POSSIBLE TO DETERMINE DESIGN PARAMETERS FOR A BROAD RANGE OF GEOMETRIES AND APPLICATIONS AND HELP TO UNIFY SEEMINGLY DISPARATE BREAKDOWN DATA FOUND IN THE LITERATURE.

RESEARCH SPONSORED BY THE U.S. DEPARTMENT OF ENERGY - OFFICE OF ELECTRICITY DELIVERY AND ENERGY RELIABILITY, UNDER CONTRACT DE-AC05-00OR22725 WITH OAK RIDGE NATIONAL LABORATORY, MANAGED AND OPERATED BY UT-BATTELLE, LLC.

5LPE-08

A STUDY ON INSULATION CHARACTERISTICS OF NOMEX PAPER FOR AN HTS CABLE ***Y. ZHANG****, Y. WANG, X. LI;* NORTH CHINA ELECTRIC POWER UNIVERSITY. — NOWADAYS STUDIES ON DEVELOPING HTS (HIGH TEMPERATURE SUPERCONDUCTING) POWER CABLES WITH HIGH TRANSMISSION CAPACITY AND LESS LOSS ARE BEING PERFORMED WORLDWIDE. IN OUR COUNTRY, AN HTS CABLE WHICH ADOPTS CD (COLD DIELECTRIC) INSULATION LAYER IS BEING DEVELOPED. A POSSIBLE CHOICE OF THE CD INSULATION PAPERS IS NOMEX PAPER WHICH HAS LESS DIELECTRIC LOSS AND BETTER MECHANICAL PROPERTIES AT LIQUID NITROGEN TEMPERATURE (ABOUT 77K).IN THIS PAPER, PDIV (PARTIAL DISCHARGE INCEPTION VOLTAGE), AC AND LIGHTING IMPULSE BREAKDOWN STRENGTH AND V-T CHARACTERISTICS OF NOMEX SAMPLE WITH DIFFERENT THICKNESS WERE RESEARCHED IN FIELD TESTS. ALSO, THE RESULT MAY SUPPLY REFERENCE AS A THICKNESS OF INSULATION LAYER FOR 110KV HTS POWER CABLE. *INDEX TERMS*_CABLE, COLD DIELECTRIC, HTS, INSULATION

5LPF-01

INSULATION TEST OF MINI-MODEL FOR DEVELOPMENT OF A 2.5 MJ CLASS CONDUCTION-COOLED HTS SMES *J. CHOI[1], H. CHEON[1], H. KIM[2], K. SEONG[2], K. KIM[3], H. LEE[3],* ***S. KIM[1]****;* [1]DEPARTMENT OF ELECTRICAL ENGINEERING, GYEONGSANG NATIONAL UNIVERSITY AND ERI, [2]SUPERCONDUCTIVITY RESEARCH CENTER, KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE, [3]DEPARTMENT OF MATERIALS SCIENCE AND

ENGINEERING, KOREA UNIVERSITY, SEOUL, KOREA. — A 2.5 MJ CLASS CONDUCTION-COOLED HTS SMES SYSTEM FOR POWER COMPENSATION IS BEING DEVELOPED IN KOREA.THE SYSTEM IS OPERATED IN CRYOGENIC TEMPERATURE AND HIGH VACUUM CONDITION.THE ELECTRICAL INSULATION IN THIS ENVIRONMENT IS A KEY AND AN IMPORTANT ELEMENT FOR THE APPLICATION OF SMES. THEREFORE, WE NEED ACTIVE RESEARCH AND DEVELOPMENT OF INSULATION CONCERNING APPLICATION OF THE CONDUCTION COOLED HTS SMES.IN THIS STUDY, WE EXPERIMENTED ABOUT INSULATION CHARACTERISTICS OF TOROIDAL TYPE HTS SMES AT HIGH VACUUM AND CRYOGENIC TEMPERATURE. AS THIS RESULT, THE INSULATION DESIGN FOR DEVELOPMENT OF 2.5 MJ CLASS CONDUCTION-COOLED HTS SMES WAS PERFORMED.ALSO, THE MINI-MODEL BASE ON THE INSULATION DESIGN WAS MANUFACTURED AND ITS INSULATION TEST WAS CARRIED OUT.

THIS WORK WAS SUPPORTED BY ELECTRIC POWER INDUSTRY TECHNOLOGY EVALUATION & PLANNING, REPUBLIC OF KOREA.

5LPF-02

EXPERIMENTAL STUDY ON THE BARRIER EFFECTS IN GASEOUS HELIUM FOR THE INSULATION DESIGN OF A SUPERCONDUCTING FAULT CURRENT LIMITER USING A SUB-COOLED NITROGEN COOLING METHOD ***H. KANG***[1]*, J. NAH*[2]*, D. BAE*[1]*, Y. CHUNG*[3]*, T. KO*[2]*;* [1]CHUNGJU NATIONAL UNIVERSITY, [2]YONSEI UNIVERSITY, [3]THE UNIVERSITY OF SUWON. — GASEOUS HELIUM SHOULD BE INJECTED INTO A SUB-COOLED LIQUID NITROGEN COOLING SYSTEM TO CONTROL THE PRESSURE BECAUSE OF ITS NON-CONDENSABLE CHARACTERISTICS. UNFORTUNATELY, THE ELECTRICAL BREAKDOWN VOLTAGE OF GASEOUS HELIUM IS NOT GOOD ENOUGH FOR DEVELOPING A HIGH VOLTAGE ELECTRIC MACHINE SUCH AS A SUPERCONDUCTING FAULT CURRENT LIMITER. THEREFORE, THE SOLID BARRIER SHOULD BE USED AROUND THE CURRENT LEADS TO ENHANCE THE DIELECTRIC CHARACTERISTICS OF CURRENT LEADS IN GASEOUS HELIUM. IN THIS STUDY, THE DIELECTRIC CHARACTERISTICS OF VARIOUS ELECTRODE SYSTEMS IN GASEOUS HELIUM ARE TESTED AND ANALYZED TO IMPROVE THE DIELECTRIC PERFORMANCE OF A SUB-COOLED LIQUID NITROGEN SYSTEM. DIELECTRIC EXPERIMENTS ACCORDING TO THE GAP LENGTH BETWEEN TWO ELECTRODES AND THE PRESSURE OF GASEOUS HELIUM ARE PERFORMED. ALSO, BARRIER EFFECTS ON THE LIGHTNING IMPULSE DIELECTRIC STRENGTH TEST IN GASEOUS HELIUM ARE EXPERIMENTALLY VERIFIED. THE DIELECTRIC EXPERIMENTS ARE PERFORMED BY INSTALLING BARRIERS MADE OF GLASS FIBER REINFORCED PLASTICS (GFRP) BETWEEN ELECTRODES AND THE BREAKDOWN VOLTAGE ACCORDING TO THE PRESSURE OF GASEOUS HELIUM AND THE NUMBER OF BARRIER IS MEASURED. AS A RESULT, IT IS FOUND THAT BARRIER EFFECTS ARE EFFECTIVE ON THE LIGHTNING IMPULSE DIELECTRIC STRENGTH TEST.

THIS WORK WAS SUPPORTED IN PART BY A GRANT FROM THE CENTER FOR APPLIED SUPERCONDUCTIVITY TECHNOLOGY OF THE 21ST CENTURY FRONTIER R&D PROGRAM FUNDED BY THE MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY, REPUBLIC OF KOREA.

5LPF-03

ANALYSIS ON THE DIELECTRIC CHARACTERISTICS OF INSULATION GASES FOR DEVELOPING A HIGH VOLTAGE SUPERCONDUCTING FAULT CURRENT LIMITER ***H. KANG***[1]*, J. NAH*[2]*, T. KO*[2]*;* [1]CHUNGJU NATIONAL UNIVERSITY, [2]YONSEI UNIVERSITY. — A SUB-COOLED LIQUID NITROGEN COOLING SYSTEM IS KNOWN AS AN APPROPRIATE METHOD FOR DEVELOPING A HIGH VOLTAGE SUPERCONDUCTING FAULT CURRENT LIMITER. THE PRESSURE OF A SUB-COOLED NITROGEN COOLING SYSTEM SHOULD BE CONTROLLED BY INJECTING NON-CONDENSABLE GAS SUCH AS GASEOUS HELIUM AND GASEOUS NEON INTO THE CRYOSTAT. THEREFORE, THE ELECTRICAL BREAKDOWN VOLTAGE OF CURRENT LEADS IS DIRECTLY INFLUENCED BY AN INJECTED GASEOUS MEDIUM. IN THIS STUDY, THE ELECTRICAL INSULATION EXPERIMENTS ON GASEOUS HELIUM AND GASEOUS NEON ARE CONDUCTED AND THE RESULTS ARE COMPARED WITH EACH OTHER. ALSO, THE DIELECTRIC CHARACTERISTICS OF GASEOUS HELIUM AND GASEOUS NEON ARE ANALYZED BY USING AN ELECTRIC UTILIZATION FACTOR. IT IS FOUND THAT THE DIELECTRIC CHARACTERISTICS OF GASEOUS HELIUM ARE SUPERIOR TO THAT OF GASEOUS NEON IN SAME CONDITION. THE EXPERIMENTAL RESULTS ARE APPLICABLE FOR DESIGNING THE CURRENT LEADS OF A HIGH VOLTAGE SUPERCONDUCTING FAULT CURRENT LIMITER.

THIS WORK WAS SUPPORTED IN PART BY A GRANT FROM THE CENTER FOR APPLIED SUPERCONDUCTIVITY TECHNOLOGY OF THE 21ST CENTURY FRONTIER R&D PROGRAM FUNDED BY THE MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY, REPUBLIC OF KOREA.

5LPF-04

EXPERIMENTAL STUDY ON THE LIGHTNING IMPULSE DIELECTRIC CHARACTERISTICS OF SUB-COOLED LIQUID NITROGEN FOR A HIGH VOLTAGE SUPERCONDUCTING FAULT CURRENT LIMITER ***J. NA***[1]*, K. CHANG*[1]*, Y. KIM*[1]*, Y. HWANG*[1]*, H. KANG*[2]*, T. KO*[1]*;* [1]YONSEI UNIVERSITY, [2]CHUNGJU NATIONAL UNIVERSITY. — SUB-COOLED LIQUID NITROGEN (LN_2) CONDITION IS A VERY USEFUL METHOD TO INCREASE THE CURRENT RATING CAPACITY OF YBCO TAPES. THUS, THE LIGHTNING IMPULSE DIELECTRIC CHARACTERISTICS OF SUB-COOLED LN_2 CONDITION SHOULD BE INVESTIGATED FOR DESIGNING HIGH VOLTAGE SUPERCONDUCTING MACHINES. THE SPHERE-PLANE ELECTRODE SYSTEMS WERE USED TO SIMULATE THE INTERNAL STRUCTURE OF HIGH VOLTAGE SUPERCONDUCTING APPARATUSES SUCH AS SUPERCONDUCTING FAULT CURRENT LIMITERS. THE LIGHTNING IMPULSE DIELECTRIC TESTS ON SATURATED AND SUB-COOLED LN_2 CONDITION WERE CARRIED OUT BY USING THE SPHERE-PLANE ELECTRODE SYSTEMS. IN ADDITION, A QUASI-UNIFORM ELECTRIC FIELD DISTRIBUTION BETWEEN THE SPHERE-PLANE ELECTRODES WAS CALCULATED BY THE FINITE ELEMENT METHOD (FEM) SIMULATION TOOL. THE UTILIZATION FACTOR WAS CALCULATED BY THE FEM SIMULATION RESULTS. THE LIGHTNING IMPULSE BREAKDOWN

VOLTAGE OF SUB-COOLED LN_2 CONDITIONS WAS COMPARED WITH SATURATED LN_2 CONDITION THAT OF VARIOUS GEOMETRICAL CONFIGURATIONS BETWEEN SPHERE-PLANE ELECTRODES. FINALLY, THE LIGHTNING IMPULSE BREAKDOWN VOLTAGE WITH 50 % PROBABILITY AND ITS RELATIONS WITH THE UTILIZATION FACTOR HAVE BEEN DESCRIBED IN THIS PAPER.

THIS WORK WAS SUPPORTED BY MANPOWER DEVELOPMENT PROGRAM FOR ENERGY & RESOURCES OF MKE WITH YONSEI ELECTRIC POWER RESEARCH CENTER (YEPRC) AT YONSEI UNIVERSITY, SEOUL, KOREA

5LPF-05

NUMERICAL ANALYSIS AND CONCEPTUAL INSULATION DESIGN OF A SINGLE-PHASE 154 KV CLASS SOLENOID TYPE SUPERCONDUCTING COIL FOR FAULT CURRENT LIMITER ***J. NA***[1]*, Y. KIM*[1]*, K. CHANG*[1]*, H. KANG*[2]*, T. KO*[1]*;* [1]YONSEI UNIVERSITY, [2]CHUNGJU NATIONAL UNIVERSITY. — THE ELECTRICAL INSULATION DESIGN OF HIGH VOLTAGE SUPERCONDUCTING FAULT CURRENT LIMITERS (SFCLS) SHOULD BE CONFIRMED TO BE APPLIED FOR THE STABILIZATION OF THE POWER GRID. THIS PAPER DESCRIBES NUMERICAL ANALYSIS FOR DEVELOPING HIGH VOLTAGE SFCLS BASED ON THE AC DIELECTRIC AND THE LIGHTNING IMPULSE TESTS. THE ELECTRIC FIELD DISTRIBUTIONS FOR NUMERICAL ANALYSIS WERE CALCULATED BY FINITE ELEMENT METHOD SIMULATION TOOL. THE EXPERIMENT RESULTS WERE PERFORMED FOR BEING BASIS ON ELECTRICAL INSULATION DESIGN FOR A SINGLE-PHASE 154 KV CLASS NON-INDUCTIVELY WOUND SOLENOID TYPE SFCL, 89 KV CLASS. CRYOGENIC CONDITION FOR FEM SIMULATION MODEL IS SUB-COOLED LIQUID NITROGEN WITH 65 K AND 2 BAR. THIS PAPER DEALS WITH THE CONCEPTUAL INSULATION DESIGN OF 154 KV SFCL MAINLY COMPOSED OF THREE PARTS, WHICH ARE IMMERSED IN LIQUID NITROGEN. FIRST PART IS ABOUT THE DISTANCE BETWEEN A CRYOSTAT AND A COIL. SECOND PART IS ABOUT THE DISTANCE BETWEEN SERIES CONNECTIONS OF NON-INDUCTIVELY WOUND SOLENOID COILS. THIRD PART IS ABOUT THE DEPTH OF SOLENOID GROOVE AT A TURN-TO-TURN STRUCTURE.

THIS WORK WAS SUPPORTED BY MANPOWER DEVELOPMENT PROGRAM FOR ENERGY & RESOURCES OF MKE WITH YONSEI ELECTRIC POWER RESEARCH CENTER (YEPRC) AT YONSEI UNIVERSITY, SEOUL, KOREA

5LPG-01

QUENCH MEASUREMENTS ON ONE SIS100 DIPOLE ***E. FLOCH****;* GSI. — **QUENCH MEASUREMENTS ON ONE SIS100 DIPOLE**E. FLOCH, A. STAFINIAK, A. BLEILE, F. WALTER, F. MARZOUKI, D. ACKER, C. SCHROEDER, E. FISCHER*ABSTRACT*_THE INTERNATIONAL FAIR PROJECT PLANNED NEXT TO G.S.I (DARMSTADT, GERMANY) WILL LEAD TO THE CONSTRUCTION OF TWO SUPERCONDUCTING SYNCHROTRONS (SIS100 AND SIS300).THIS ARTICLE REPORTS ON THE QUENCH CALCULATIONS AND MEASUREMENTS PERFORMED ON THE 1ST FULL SIZE (3 M LONG) SIS100 DIPOLE. QUENCH PROPAGATION VELOCITIES WERE MEASURED IN THE BUS BARS FOR CURRENTS BETWEEN 2 AND 9 KA (OPERATING CURRENT: 7535 A). THE HOTSPOT TEMPERATURE WAS MEASURED FOR DIFFERENT MIITS (INTEGRAL OF I^2.DT) VALUES BETWEEN 4 AND 9 KA AND COMPARED TO TEMPERATURES COMPUTED WITH THE MIITS EQUATION. THE QUENCH BACK DURING CURRENT DUMPING WAS STUDIED FOR INITIALS CURRENTS BETWEEN 3 AND 9 KA AND TIME CONSTANT BETWEEN 38 AND 345 MS. FINALLY, THE QUENCH RESISTANCE WAS MEASURED FOR A TIME CONSTANT OF 165 MS (VALUE TO BE APPLIED WHEN THE 108 DIPOLES OF SIS100 ARE CONNECTED IN SERIES).*INDEX TERMS*_SIS100 DIPOLE, QUENCH, PROPAGATION VELOCITIES, HOTSPOT TEMPERATURE.

5LPG-02

SUPERCONDUCTING MAGNETS FOR THE NICA ACCELERATOR COMPLEX IN DUBNA ***H. G. KHODZHIBAGIYAN****, V. V. BORISOV, A. V. BYCHKOV, A. D. KOVALENKO, O. S. KOZLOV, O. A. KUNCHENKO, G. L. KUZNETSOV, V. A. MIKHAILOV, E. V. MURAVIEVA, A. V. SHABUNOV, A. Y. STARIKOV;* JOINT INSTITUTE FOR NUCLEAR RESEARCH. — NICA IS THE NEW ACCELERATOR COMPLEX BEING UNDER DESIGN AND CONSTRUCTION AT JINR. THE FACILITY IS AIMED TO PROVIDE COLLIDER EXPERIMENTS WITH HEAVY IONS UP TO URANIUM WITH A CENTER OF MASS ENERGY UP TO 9 GEV/U AND AN AVERAGE LUMINOSITY UP TO 10^{27} $CM^{-2}S^{-1}$. THE COLLISIONS OF POLARIZED DEUTERONS ARE FORESEEN TOO. THE FACILITY INCLUDES TWO INJECTOR LINACS, A NEW SUPERCONDUCTING BOOSTER SYNCHROTRON, THE EXISTING 6A·GEV SUPERCONDUCTING SYNCHROTRON - NUCLOTRON, AND THE NEW SUPERCONDUCTING COLLIDER CONSISTING OF TWO STORAGE RINGS 336 M PERIMETER EACH.THE BOOSTER ACCELERATOR AND THE NICA COLLIDER ARE BASED ON IRON-DOMINATED “WINDOW FRAME”- TYPE MAGNET WITH WINDING OF HOLLOW SUPERCONDUCTOR ANALOGOUS TO THE NUCLOTRON MAGNET. THE STATUS OF THE DESIGN AND MANUFACTURING OF THE FULL SIZE MODEL MAGNETS FOR THE BOOSTER SYNCHROTRON AS WELL AS FOR THE NICA COLLIDER IS PRESENTED.

5LPG-03

FIELD MEASUREMENTS ON CURVED SUPERCONDUCTING MAGNETS ***P. SCHNIZER***[1]*, E. FISCHER*[1]*, A. MIERAU*[1]*, B. SCHNIZER*[2]*, H. R. KIESEWETTER*[1]*;* [1]GSI HELMHOLTZZENTRUM FÜR SCHWERIONENFORSCHUNG MBH, [2]TECHNISCHE UNIVERSITÄT GRAZ. — THE FAIR AND THE NICA PROJECTS WILL USE FAST RAMPED SUPERCONDUCTING MAGNETS WITH A CURVATURE OF ~55 M AND ~15 M RESPECTIVELY. COMPARED TO NORMAL CONDUCTING MACHINES WITH EQUIVALENT FIELD STRENGTH, THE FIELD QUALITY OF SUPERCONDUCTING MAGNETS IS VERY SENSITIVE TO THE REAL GEOMETRIC DETAILS DUE TO ITS MUCH SMALLER YOKE SIZE. FURTHER THE CLOSED CRYOSTAT MAKES IT TEDIOUS TO ADD CORRECTION ELEMENTS AT A LATER STAGE.THEREFORE THE MEASUREMENTS MUST PROVIDE A RELIABLE FULL INFORMATION OF THE MAGNETIC FIELD STRENGTH, THE FIELD DIRECTION AS WELL AS THE FIELD HOMOGENEITY AND ITS HARMONICS.WE OUTLINE THE THEORY DEVELOPED, SHOW

PRINCIPAL USEABLE COORDINATE SYSTEMS, PRESENT THEIR FEATURES, AND OUTLINE HOW THE MEASUREMENT CAN BE MADE IN PRACTICE NEXT TO FIRST TEST RESULTS OBTAINED ON MEASURING THE CURVED SIS100 FULL SIZE MODEL DIPOLE.

5LPG-04

EFFECT OF AN IRON YOKE ON THE FIELD HOMOGENEITY IN A SUPERCONDUCTING DOUBLE-HELIX BENT DIPOLE ***P. J. MASSON****, R. B. MEINKE;* ADVANCED MAGNET LAB. — CHARGED PARTICLE BEAM OPTICS OFTEN REQUIRES LONG STEERING DIPOLES WITH STRINGENT HOMOGENEITY REQUIREMENTS. CONVENTIONAL TECHNIQUE USES SUPERCONDUCTING SADDLE COIL MAGNETS WITH APERTURES LARGE ENOUGH TO ACCOMMODATE THE BENT BEAM. BENT MAGNETS THAT FOLLOW THE BEAM TRAJECTORY WOULD ALLOW REDUCING THE APERTURE, BUT ARE DIFFICULT TO IMPLEMENT, SINCE BENT WINDING CONFIGURATIONS LEAD TO FIELD GRADIENTS THAT DISTURB THE BEAM OPTICS. THE RESULTING FIELD DISTORTIONS ARE SIGNIFICANTLY ENHANCED BY THE SURROUNDING IRON YOKE AND STRONGLY DEPEND ON ITS SHAPE AND SATURATION STATE. AML'S DOUBLE-HELIX (DH) WINDING TECHNOLOGY ALLOWS FOR THE DESIGN OF MAGNETIC FIELD WITH ARBITRARY MULTIPOLE CONTENT THROUGH PRECISE POSITIONING OF CONDUCTORS, THUS MAKING COMPENSATION FOR ANY FIELD IN HOMOGENEITY POSSIBLE. THE PAPER PRESENTS THE ANALYSIS OF THE EFFECT OF THE IRON CORE ON THE FIELD HOMOGENEITY OF A 3.5T BENT DIPOLE BUILT AT THE ADVANCED MAGNET LAB AND THE OPTIMIZED WINDING LEADING TO A PURE DIPOLE FIELD.

5LPG-05

A MODEL DIPOLE FOR FAIR SIS300: 3D DESIGN OF THE MECHANICAL STRUCTURE ***S. FARINON****[1], P. FABBRICATORE[1], R. MUSENICH[1], R. MARABOTTO[2], F. ALESSANDRIA[3], G. BELLOMO[3], M. SORBI[3], G. VOLPINI[3], U. GAMBARDELLA[4];* [1]INFN - SEZIONE DI GENOVA, [2]ASG SUPERCONDUCTORS, [3]INFN - SEZIONE DI MILANO, [4]INFN - FRASCATI LABORATORY. — THE FAIR FACILITY, UNDER DEVELOPMENT AT GSI, INCLUDES THE SYNCHROTRON SIS300 (300 TM RIGIDITY). IN ORDER TO REACH THE REQUIRED HIGH INTENSITIES OF PROTON AND HEAVY IONS BEAMS, THE BENDING DIPOLE MAGNETS HAVE TO BE PULSED FROM THE INJECTION MAGNETIC FIELD OF 1.5 T UP TO 4.5 T MAXIMUM FIELD AT THE RATE OF 1 T/S. THESE 7.8 M LONG MAGNETS HAVE COS-THETA SHAPED COILS WITH A 100 MM BORE WITH THE PARTICULAR CHARACTERISTIC TO BE GEOMETRICALLY CURVED (THE SAGITTA IS 114 MM). THE 2D MECHANICAL CROSS SECTION HAS BEEN DESIGNED IN DETAIL: IT CONSISTS OF 3 MM THICK LAMINATED STAINLESS STEEL COLLARS, ASSEMBLED THROUGH KEYS, AND 1 MM THICK IRON YOKE LAMINATIONS, ASSEMBLED THROUGH LARGE STAINLESS STEEL C-SHAPED CLAMPS. THIS PAPER ANALYZES SOME 3D ASPECTS: THE MECHANICAL BEHAVIOUR OF THE ENDS, THE EFFECT OF THE LONGITUDINAL PRE-STRESS, THE DESIGN OF THE EXTERNAL FLANGE AND OUTER SHELL.

5LPG-06

THE PREPARATION OF THE LASA TEST STATION FOR THE SIS300 MODEL DIPOLE ***M. SORBI****[1], F. ALESSANDRIA[2], G. BELLOMO[1], P. FABBRICATORE[3], S. FARINON[3], U. GAMBARDELLA[4], R. MUSENICH[3], G. VOLPINI[2];* [1]MILAN UNIVERSITY & INFN, [2]INFN SEZ. DI MILANO, [3]INFN SEZ. DI GENOVA, [4]INFN-LNF. — THE FAIR FACILITY, UNDER DEVELOPMENT AT GSI, INCLUDES THE SYNCHROTRON SIS300 (300 TM RIGIDITY). IN ORDER TO REACH THE REQUIRED HIGH INTENSITIES OF PROTON AND HEAVY IONS BEAMS, THE BENDING DIPOLE MAGNETS HAVE TO BE PULSED FROM THE INJECTION MAGNETIC FIELD OF 1.5 T UP TO 4.5 T MAXIMUM FIELD AT THE RATE OF 1 T/S IN A 100 MM DIAMETER BORE. THE FIRST 3.9 M LONG MODEL DIPOLE IS IN ADVANCED CONSTRUCTION AND A FUNCTIONAL TEST IS FORESEEN AT LASA LAB. THIS TEST WILL BE PERFORMED INSIDE A VERTICAL CRYOSTAT IN BOILING HELIUM AT 4.2 K, AND IT IS AIMED TO VERIFY THE OPERATION OF THE MAGNET, ALSO IN PULSED REGIME, AND TO ASSESS THE LOSSES. A FULL CHARACTERIZATION OF THE MAGNET WILL BE PERFORMED LATER IN A LABORATORY EQUIPPED FOR OPERATION AT THE DESIGN CONDITIONS, I.E. SUPERCRITICAL HELIUM AT 4.7 K. THIS PAPER ILLUSTRATES THE DESIGN AND THE INSTALLATION ACTIVITY OF THE TEST STATION AND ITS CAPABILITIES. A DESCRIPTION OF THE MAGNET TEST CONDITIONS AND OF THE EXPECTED RESULTS WILL ALSO BE GIVEN.

5LPG-07

MAGNETIC DESIGN OPTIMIZATION AND QUENCH STUDY OF A HIGHLY SATURATED SUPERFERRIC QUADRUPOLE FOR FAIR SUPER-FRS MULTIPLETS ***I. RODRIGUEZ****, F. TORAL, L. GARCÍA-TABARÉS, E. MOLINA;* CIEMAT. — THE FAIR SUPER-FRS SUPERFERRIC MULTIPLETS ARE UNDER DESIGN BY CIEMAT, AS PART OF THE SPANISH CONTRIBUTION TO THIS FACILITY. THE MOST CHALLENGING MAGNET IS THE SO-CALLED TYPE 3 QUADRUPOLE, AS IT FEATURES A LARGE APERTURE, 500 MM, WITH A GRADIENT OF 10 T/M AND A MAGNETIC LENGTH OF 800 MM. FIELD QUALITY REQUEST IS QUITE TIGHT, +/- 8 UNITS (1E-4) FOR GRADIENTS BELOW 8 T/M. OUR ANALYSIS IS BASED ON A PRELIMINARY DESIGN, WHOSE MAIN DRAWBACK WAS THE HUGE MASS OF THE COLD IRON, ABOUT 6800 KG, WHICH COMPLICATES COOLING AND ASSEMBLY. A NEW DESIGN WITH LIGHTER IRON IS PRESENTED AND OPTIMIZED IN THIS PAPER. THE MOST DIFFICULT PROBLEM IS TO ACHIEVE THE REQUESTED FIELD QUALITY WITH A HIGHLY SATURATED IRON YOKE, WHICH HAS BEEN SOLVED BY DRILLING HOLES AND SHAPING THE POLE ENDS OF THE IRON YOKE. ON THE OTHER HAND, REDUCING THE IRON MASS REQUIRES INCREASING AMPERE TURNS AND SATURATION, TOGETHER WITH THE STORED ENERGY AND THE MAXIMUM VOLTAGE AND TEMPERATURE IN CASE OF A QUENCH. THUS, A GOOD QUENCH SIMULATION IS ESSENTIAL. A CUSTOM QUENCH MODEL HAS BEEN DEVELOPED USING A FINITE DIFFERENCES METHOD IN MATLAB TO SOLVE THE ADIABATIC HEAT BALANCE EQUATION INSIDE A COIL, TAKING INTO ACCOUNT THE MATERIAL PROPERTIES DEPENDENCE ON TEMPERATURE. THE QUENCH MODEL HAS BEEN IMPROVED AND VALIDATED BY SEVERAL QUENCH PROPAGATION TESTS ON A FULLY IMPREGNATED AND INSTRUMENTATED NBTI SOLENOID.

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5LPG-08

RADIATION RESISTANT SUPERFERRIC QUADRUPOLE MAGNETS WITH WARM IRON ***S. CHOUHAN****, D. COLE, J. DEKAMP, C. WILSON, A. F. ZELLER;* NATIONAL SUPERCONDUCTING CYCLOTRON. — THE FACILITY FOR RARE ISOTOPE BEAM TO BE BUILT AT MICHIGAN STATE UNIVERSITY WILL BE CABLE OF PROVIDING BEAMS OF ANY ELEMENT AT ENERGIES OF 200 MEV/U AT BEAM POWERS OF UP TO 400 KW. FRAGMENT PRODUCTION TARGETS ARE IN CLOSE PROXIMITIES TO THE SUPERCONDUCTING QUADRUPOLE MAGNETS. THESE MAGNETS HAVE TO OPERATE IN THE HIGH-RADIATION ENVIRONMENT, WITH CALCULATED RADIATION DOSES OF MORE THAN 10 MGY PER YEAR. THE DESIGN OF A LARGE BORE, SUPERFERRIC QUADRUPOLE MAGNET THAT PROVIDES HIGH FIELD GRADIENT OF 15 T/M AND EFFECTIVE LENGTH OF 0.6 M IS PRESENTED. THE CURRENT DESIGN IS "WARM-IRON" WITH A NOMINAL YOKE LENGTH OF 520 MM AND A POLE RADIUS OF 135 MM. A COIL DESIGN BASED ON SPINEL INSULATED CABLE-IN-CONDUIT CONDUCTOR THAT PROVIDES AMPLE CURRENT MARGIN PROVIDES SIGNIFICANT LONGER LIFETIME AGAINST RADIATION DAMAGE. THE MAJOR CHALLENGES ARE THE TIGHT GEOMETRY, HIGH FORCES AND REMOTE HANDLING OF AN IRRADIATED MAGNET. THIS PAPER PRESENT THE MAGNET DESIGN INCLUDES COIL FORCES AND COIL RESTRAINT SYSTEM. IN ADDITION, COIL PROPERTIES, QUENCH CALCULATION, CONDUCTOR STABILITY AND FULL MECHANICAL DETAILS ARE ALSO PRESENTED.

SUPPORTED BY U. S DEPARTMENT OF ENERGY

5LPH-01

ALTERNATIVE MECHANICAL STRUCTURE FOR LARP NB_3SN QUADRUPOLES ***M. ANERELLA****[1], J. COZZOLINO[1], G. AMBROSIO[2], S. CASPI[3], H. FELICE[3], P. KOVACH[1], M. LAMM[2], G. SABBI[3], J. SCHMALZLE[1], P. WANDERER[1];* [1]BROOKHAVEN NATIONAL LABORATORY, [2]FERMI NATIONAL ACCELERATOR LABORATORY, [3]LAWRENCE BERKELEY NATIONAL LABORATORY. — THIS PAPER DESCRIBES AN ALTERNATIVE STRUCTURE FOR THE 120MM NB3SN QUADRUPOLE MAGNET PRESENTLY UNDER DEVELOPMENT FOR USE IN THE PHASE 2 UPGRADE FOR LHC AT CERN. THE GOALS OF THIS STRUCTURE ARE TO BUILD ON THE EXISTING TECHNOLOGY DEVELOPED IN LARP WITH THE LQ AND HG SERIES MAGNETS AND TO FURTHER OPTIMIZE THE FEATURES REQUIRED FOR OPERATION IN THE ACCELERATOR. THESE FEATURES INCLUDE MECHANICAL ALIGNMENT NEEDED FOR FIELD QUALITY AND PROVISIONS FOR COLD MASS COOLING WITH 1.9K HELIUM IN A HELIUM PRESSURE VESSEL. THE STRUCTURE WILL ALSO OPTIMIZE COIL AZIMUTHAL AND AXIAL PRE-LOAD FOR HIGH GRADIENT OPERATION, AND WILL INCORPORATE FEATURES INTENDED TO IMPROVE MANUFACTURABILITY, THEREBY IMPROVING RELIABILITY AND REDUCING COST.

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5LPH-02

FABRICATION AND TEST OF 90MM NB3SN MODEL BASED ON DIPOLE TYPE COLLAR ***R. C. BOSSERT****, N. ANDREEV, G. CHLACHIDZE, V. S. KASHIKHIN, V. V. KASHIKHIN, M. J. LAMM, F. NOBREGA, I. NOVITSKI, M. TARTAGLIA, G. VELEV, A. V. ZLOBIN;* FERMI NATIONAL ACCELERATOR LABORATORY. — FERMILAB IS DEVELOPING LARGE-APERTURE HIGH-GRADIENT QUADRUPOLES BASED ON NB3SN SUPERCONDUCTOR FOR THE PLANNED UPGRADE OF INTERACTION REGIONS OF THE LARGE HADRON COLLIDER (LHC). A SERIES OF 90-MM TQC QUADRUPOLE MODELS USING A COLLAR-BASED MECHANICAL STRUCTURE HAVE BEEN FABRICATED AND TESTED WITHIN THE FRAMEWORK OF THE US-LHC ACCELERATOR RESEARCH PROGRAM (LARP) USING QUADRUPOLE-SYMMETRIC STAINLESS STEEL COLLAR LAMINATIONS. THIS PAPER DESCRIBES THE DESIGN FEATURES OF DIPOLE-TYPE COLLARS AND COLLARING TECHNIQUES FOR THE TQC QUADRUPOLES. MAGNET TEST INCLUDES QUENCH PERFORMANCE AND FIELD QUALITY MEASUREMENTS AT 4.5 AND 1.9 K. RESULTS OF MAGNETIC AND MECHANICAL ANALYSIS AND MODEL PERFORMANCE FOR TQC QUADRUPOLES BASED ON DIPOLE-TYPE AND QUADRUPOLE-TYPE COLLARS ARE COMPARED AND DISCUSSED.

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5LPH-03

DESIGN VARIANTS OF A NESTED ORBIT CORRECTOR MAGNET FOR AN LHC INNER TRIPLET UPGRADE ***B. AUCHMANN****, M. KARPPINEN;* CERN, TE-MSC. — A FUTURE UPGRADE OF THE LHC INNER TRIPLETS WILL REQUIRE ORBIT CORRECTORS TO ENSURE FULL CONTROL OF THE BEAM POSITION AND ANGLE AT THE INTERACTION POINTS, AND TO CORRECT FOR THE MISALIGNMENT OF THE LOW-B QUADRUPOLES UP TO 0.5 MM. SPACE CONSTRAINTS IN THE TRIPLET CALL FOR A NESTED SOLUTION OF VERTICAL AND HORIZONTAL BENDING MAGNETS. RECENT STUDIES INDICATE THAT THE ENERGY DEPOSITION IN THE SUPERCONDUCTING COILS CAN BE REDUCED UP TO A FACTOR FIVE BY ADDING A 10 MM THICK STAINLESS STEEL LINER. THESE 2 CM, TOGETHER WITH AN ENHANCED BEAM ACCEPTANCE, INCREASE THE INNER COIL DIAMETER TO 140 MM, FROM 90 MM IN THE CURRENTLY INSTALLED ORBIT CORRECTORS. THE MAIN DIFFICULTIES OF A NESTED DIPOLE ASSEMBLY ARE THE ABSORPTION OF THE TORQUE THAT ACTS UPON BOTH COILS, AND THE BALANCED PRE-COMPRESSION OF BOTH LAYERS. THE INCREASED IRRADIATION LEVEL CALLS FOR AN ADEQUATE CHOICE OF MATERIALS, AND ENHANCED COOLING. THE CURRENT NESTED CORRECTORS IN THE LHC FEATURE IMPREGNATED COILS THAT ARE PRE-COMPRESSED BY AN ALUMINUM SHRINKING CYLINDER, AND ECCENTRIC YOKE LAMINATIONS SURROUNDED BY A STAINLESS STEEL OUTER SHELL. THIS SOLUTION WILL BE EVALUATED IN VIEW OF THE CURRENT DESIGN PROBLEM, AND

COMPARED TO OTHER VARIANTS, SUCH AS A THIN-COLLAR OPTION WITH A FORCE-RETAINING STRUCTURE INVOLVING THE YOKE.

5LPH-04

THERMODYNAMIC MODELING OF NEW LHC INNER TRIPLET QUADRUPOLE MAGNETS ***D. BOCIAN***[1], *F. BORGNOLUTTI*[2], *G. AMBROSIO*[1], *F. CERUTTI*[2], *P. FESSIA*[2], *G. KIRBY*[2], *M. LAMM*[1], *A. MEREGHETTI*[2], *N. MOKHOV*[1]; [1]FERMI NATIONAL ACCELERATOR LABORATORY, P.O. BOX 500, BATAVIA, IL 60510-0500, USA, [2]CERN, CH 1211, GENEVA 23, SWITZERLAND. — IN HADRON COLLIDERS SUCH AS THE LHC, THE ENERGY DEPOSITED IN THE SUPERCONDUCTORS BY THE PARTICLES LOST FROM THE BEAMS OR COMING FROM THE COLLISION DEBRIS PROVOKE QUENCHES DETRIMENTAL TO THE ACCELERATOR OPERATION. IN A PREVIOUS PAPER, A NETWORK MODEL HAS BEEN USED TO STUDY THE THERMODYNAMIC BEHAVIOR OF MAGNET COILS AND TO CALCULATE THE QUENCH LEVELS IN THE LHC MAGNETS FOR EXPECTED BEAM LOSS PROFILES. IN A POSSIBLE PHASE I LHC UPGRADE, THE PRESENT INNER TRIPLET QUADRUPOLES WILL BE REPLACED WITH A NEW SET OF LARGER APERTURE QUADRUPOLES OF THE SAME MATERIAL(NB-TI). FOR THESE NEW MAGNETS, A NEW INSULATION SCHEME AIMING AT A MORE EFFICIENT HEAT TRANSPORT FROM THE COIL TO THE HELIUM BATH HAS BEEN PROPOSED. THIS SCHEME RELIES ON LEAVING OPEN HELIUM PATHS BETWEEN THE BATH AND THE CABLE. IN THIS PAPER WE USE THE THERMODYNAMIC MODEL TO COMPARE THE TWO INSULATION SCHEMES. THE DETAILED STUDY OF HELIUM COOLING CHANNELS EFFICIENCY AND HEAT EVACUATION SCHEME WITH RESPECT TO DIFFERENT MAGNET COIL SETUPS ARE PRESENTED. SOME CONCLUSIONS ARE DRAWN ALSO ON THE PROPOSED PHASE II LHC UPGRADE USING NB_3SN SUPERCONDUCTING MAGNETS.

5LPH-05

THERMAL RUNAWAYS IN LHC INTERCONNECTIONS: EXPERIMENTS ***G. P. WILLERING***, *L. BOTTURA, P. FESSIA, G. PEIRO, S. LE NAOUR, R. PRINCIPE, T. REGNALIA, D. RICHTER, C. SCHEUERLEIN, A. VERWEIJ;* CERN. — THE BURN-OUT OF ONE OF THE INTERCONNECTIONS BETWEEN LHC SUPERCONDUCTING DIPOLE MAGNETS CAUSED A SERIOUS INCIDENT IN SEPTEMBER 2008 THAT DELAYED OPERATION OF THE ACCELERATOR FOR MORE THAN ONE YEAR. THIS EVENT WAS TRACED TO A DEFECT IN ONE OF THE SOLDERED JOINT BETWEEN TWO SUPERCONDUCTING CABLES STABILIZED BY A COPPER BUSBAR.A COMBINATION OF (1) A POOR CONTACT BETWEEN THE SUPERCONDUCTING CABLE AND THE COPPER STABILIZER AND (2) AN ELECTRICAL DISCONTINUITY IN THE STABILIZER AT THE LEVEL OF THE CONNECTION CAN LEAD TO AN UNPROTECTED QUENCH OF THE BUS. ONCE THE HEATING POWER IN THE UNPROTECTED SUPERCONDUCTING CABLE EXCEEDS THE HEAT REMOVAL CAPACITY A THERMAL RUN-AWAY OCCURS, RESULTING IN A FAST MELT-DOWN OF THE NON-STABILIZED CABLE.WE HAVE PERFORMED A THOROUGH INVESTIGATION OF THE CONDITIONS UPON WHICH A THERMAL RUN-AWAY IN THE DEFECT CAN OCCUR. TO THIS AIM, WE HAVE PREPARED HEAVILY INSTRUMENTED SAMPLES WITH WELL-DEFINED AND CONTROLLED DEFECTS. IN THIS PAPER WE DESCRIBE THE EXPERIMENT, THE ANALYSIS OF THE DATA, AND WE SUMMARIZE THE MAIN RESULTS WHICH ARE RELEVANT TO DELIMIT THE CONDITIONS OF SAFE OPERATION FOR THE LHC. THE RESULTS OBTAINED, AND SPECIFICALLY A CONTROLLED REPLICA OF THE SEPTEMBER 2008 INCIDENT DEMONSTRATE THE NECESSITY TO RE-WORK ALL MAIN CIRCUITS INTERCONNECTS IN THE LHC TO OPERATE SAFELY AT THE NOMINAL ENERGY.

5LPH-06

PRODUCTION AND QUALITY ASSURANCE OF THE INTERCONNECTION SPLICES OF THE MAIN BUS BARS DURING THE LHC 2008-2009 SHUTDOWN *F. BERTINELLI*[1], *L. BOTTURA*[1], *J. DALIN*[1], *P. FESSIA*[1], *R. H. FLORA*[2], *S. J. HECK*[1], *H. PFEFFER*[2], *H. PRIN*[1], ***C. E. SCHEUERLEIN***[1], *P. A. THONET*[1], *J. TOCK*[1], *L. R. WILLIAMS*[1]; [1]CERN, GENEVA, [2]FERMILAB, BATAVIA. — THE INTERCONNECTION SPLICES OF THE MAIN BUS BARS IN THE LARGE HADRON COLLIDER ARE ASSEMBLED BY INDUCTIVE SOLDERING OF THE RUTHERFORD TYPE CABLES AND COPPER STABILISER. THE RESISTANCE OF THE COPPER STABILISER JOINT BECOMES OF UTMOST IMPORTANCE FOLLOWING A MAGNET QUENCH WHEN THE MAGNET CURRENT IS DUMPED IN DUMP RESISTORS. FOLLOWING THE SPLICE FAILURE AT THE ORIGIN OF THE SEPTEMBER 2008 INCIDENT, THE ASSEMBLY PROCESS AND THE QUALITY ASSURANCE HAVE BEEN IMPROVED, WITH NEW MEASUREMENT AND DIAGNOSTICS METHODS INTRODUCED. THE INTRODUCTION OF GAMMA RADIOGRAPHY HAS ALLOWED THE VISUALIZATION OF VOIDS BETWEEN CABLE AND STABILISER. A ROOM TEMPERATURE RESISTANCE MEASUREMENT HAS BEEN INTRODUCED AS A SIMPLE, NON-DESTRUCTIVE TEST TO MEASURE THE ELECTRICAL CONTINUITY OF THE SPLICE IN ITS NORMAL CONDUCTING STATE. THE ULTRASONIC TEST HAS BEEN PERFORMED SYSTEMATICALLY AND VISUAL INSPECTIONS OF THE DIFFERENT SPLICE COMPONENTS BEFORE AND AFTER INTERCONNECTION HAVE BEEN REINFORCED. THE ADDITIONAL INFORMATION GAINED HAS ALLOWED TARGETED IMPROVEMENTS IN THE SPLICE PRODUCTION PROCESS, E.G. PRECISION MACHINING OF SPLICE COMPONENTS, ADDITIONAL SOLDERING FOIL AND COPPER SHIMS ADDED IN CRITICAL AREAS.

5LPH-07

ELECTRICAL INTERCONNECTION OF SUPERCONDUCTING STRANDS BY ELECTROLYTIC CU DEPOSITION ***C. E. SCHEUERLEIN***[1], *D. SCHÖRLING*[1], *S. J. HECK*[1], *A. AMS*[2]; [1]CERN, GENEVA, [2]TECHNISCHE UNIVERSITÄT BERGAKADEMIE FREIBERG. — ULTRASONIC (US) WELDING IS THE STATE-OF-THE-ART TECHNOLOGY FOR THE ELECTRICAL INTERCONNECTION OF NB-TI/CU STRANDS, AND SPLICE RESISTANCES AS LOW AS 3 NΩ HAVE BEEN ROUTINELY ACHIEVED FOR ABOUT 35 000 SPLICES FOR THE LARGE HADRON COLLIDER (LHC) WITH A STRAND OVERLAP LENGTH OF ONLY 1 CM. HOWEVER, US WELDING CAN NOT EASILY BE APPLIED FOR THE INTERCONNECTION OF BRITTLE SUPERCONDUCTORS DUE THE FRAGILITY OF THESE STRANDS. AS AN ALTERNATIVE METHOD FOR THE ELECTRICAL

INTERCONNECTION OF BRITTLE SUPERCONDUCTING STRANDS, TEST SPLICES HAVE BEEN PRODUCED BY ELECTROLYTIC DEPOSITION OF CU ONTO THE TWO STRANDS TO BE INTERCONNECTED. THE RESISTANCE OF FIRST TEST SPLICES PRODUCED BY ELECTROLYTIC CU DEPOSITION WITH A STRAND OVERLAP LENGTH OF 3 CM AT 4.2 K IS ABOUT 10 NΩ, SIMILAR TO THE RESISTANCE OF SPLICES WITH THE SAME STRAND OVERLAP LENGTH PRODUCED BY SOFT SOLDERING. INTERCONNECTION BY ELECTROLYTIC CU DEPOSITION CAN BE DONE BEFORE OR AFTER THE REACTION HEAT TREATMENT, AND IT PRODUCES A MECHANICALLY STRONG CONNECTION.

5LPH-08

SUPERCONDUCTING LINK BUS DESIGN FOR THE ACCELERATOR PROJECT FOR UPGRADE OF LHC ***F. NOBREGA****, J. BRANDT, S. CHEBAN, S. FEHER, M. KADUCAK, V. KASHIKHIN, T. PETERSON;* FERMILAB. — THE ACCELERATOR PROJECT FOR UPGRADE OF LHC (APUL) IS A U.S. PROJECT PARTICIPATING IN AND CONTRIBUTING TO CERN'S LARGE HADRON COLLIDER (LHC) UPGRADE PROGRAM. FERMI NATIONAL ACCELERATOR LABORATORY IN COLLABORATION WITH BROOKHAVEN NATIONAL LABORATORY IS DEVELOPING SUB-SYSTEMS FOR THE UPGRADE OF THE LHC FINAL FOCUS MAGNET SYSTEMS. PART OF THE UPGRADE CALLS FOR VARIOUS LENGTHS OF SUPERCONDUCTING POWER TRANSMISSION LINES KNOWN AS SC LINKS, WHICH ARE UP TO 100M LONG. THE SC LINK ELECTRICALLY CONNECTS THE CURRENT LEADS IN THE DISTRIBUTION FEED BOXES TO THE INTERACTION REGION MAGNETS. THE SC LINK IS AN EXTENSION OF THE MAGNET BUS HOUSED WITHIN A CRYOSTAT. THE PRESENT CONCEPT FOR THE BUS CONSISTS OF 22 POWER CABLES, 4 X 13KA, 2 X 7KA, 8 X 2.5KA AND 8 X 0.6KA BUNDLED INTO ONE BUS. DIFFERENT CABLE AND STRAND POSSIBILITIES WERE CONSIDERED FOR THE BUS DESIGN INCLUDING RUTHERFORD CABLE. THE RUTHERFORD CABLE BUS DESIGN POTENTIALLY WOULD HAVE REQUIRED SPLICES AT EACH SHARP ELBOW IN THE SC LINK. THE ADVANTAGE OF THE ROUND BUS DESIGN IS THAT SPLICES ARE ONLY REQUIRED AT EACH END OF THE BUS DURING INSTALLATION AT CERN. THE ROUND BUS IS VERY FLEXIBLE AND IS SUITABLE FOR PULLING THROUGH THE CRYOSTAT. DEVELOPMENT OF THE ROUND BUS PROTOTYPE AND OF 2 SPLICE DESIGNS IS DESCRIBED IN THIS PAPER. MAGNETIC ANALYSIS AND MECHANICAL TEST RESULTS OF THE 13KA CABLE AND SPLICES ARE PRESENTED.

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5LPJ-01

SHIELDING OF MAGNETIC FIELDS BY REBCO COATED CONDUCTORS ***S. MATSUMOTO****, T. KIYOSHI, A. UCHIDA;* NIMS. — A LARGE SHIELDING OF MAGNETIC FIELDS BY REBCO COATED CONDUCTORS WITH A HIGHLY ORIENTED SUPERCONDUCTING LAYER HAS BEEN DISCUSSED. A DECAY OF A SHIELDING CURRENT IN THE CONDUCTOR IS BELIEVED TO CAUSE AN UNSTABLE CONFIGURATION OF MAGNETIC FIELDS. THE SHIELDING OF MAGNETIC FIELDS WAS MEASURED USING A HALL SENSOR INSTALLED BETWEEN BUNDLES STACKED WITH COMMERCIAL HASTELLOY SUBSTRATE REBCO COATED CONDUCTORS 12 MM IN WIDTH. THE SHIELDING EFFECT DEPENDED ON THE NUMBER OF CONDUCTORS OF THE BUNDLE AND THE ROUTE OF THE APPLIED MAGNETIC FIELDS; IT WAS OBSERVED EVEN OVER 10 T. IN STEADY MAGNETIC FIELDS, THE MAGNETIC FIELD MEASURED BETWEEN BUNDLES GOT CLOSER GRADUALLY TO THE APPLIED MAGNETIC FIELDS, WHICH WAS EXPLAINED BY THE FLUX CREEP MODEL. THE FIELD COOLED BUNDLES OF 30 CONDUCTORS COULD HOLD OVER 2 T AFTER DECREASING THE APPLIED MAGNETIC FIELDS FROM 11 T TO 0 T AT 4.2 K. THE BUNDLE IS EXPECTED TO APPLY AS A QUASI BULK MAGNET. THE LARGE SHIELDING OF APPLIED MAGNETIC FIELDS AND THE UNSTABLE CONFIGURATION OF MAGNETIC FIELDS SHOULD BE CONSIDERED FOR DEVELOPING REBCO MAGNETS.

5LPJ-02

CONDUCTION-COOLED SUPERCONDUCTING MAGNET WITH 250MM BORE SIZE ***Q. WANG****;* INSTITUTE OF ELECTRICAL ENGINEERING, CHINESE ACADEMY OF SCIENCES. — A CONDUCTION-COOLED MAGNET WAS DESIGNED, FABRICATED AND TESTED. A TWO-STAGE 4 K GIFFORD-MCMAHON (GM) CRYOCOOLER WITH THE SECOND-STAGE POWER IN 1.5 W IS USED TO COOL THE SUPERCONDUCTING MAGNET FROM ROOM TEMPERATURE TO 4 K. THE SUPERCONDUCTING MAGNET HAS THE OPERATING CURRENT OF 120A, THE EFFECTIVE WARM HOLE OF 250 MM, THE MAXIMUM CENTER FIELD OF 5 TESLA. THE SUPERCONDUCTING MAGNET WILL BE USED AS MATERIAL PROCESSING. IN THIS PAPER, THE DETAILED DESIGN, FABRICATION AND TEST ARE PRESENTED.

5LPJ-03

COUPLED THERMAL-MAGNETIC ANALYSIS ON THERMALLY ACTUATED SUPERCONDUCTING FLUX PUMP ***Y. MURATA****[1], Z. HONG[2], Y. YAN[2], T. COOMBS[2];* [1]HITACHI, LTD., [2]UNIVERSITY OF CAMBRIDGE. — THIS PAPER PRESENTS A NUMERICAL ANALYSIS OF THE THERMALLY ACTUATED SUPERCONDUCTING FLUX PUMP DESCRIBED IN [1]. VISUALIZATION OF THE BEHAVIOR OF THE MAGNETIC FLUX HELPS OUR UNDERSTANDING OF FLUX INJECTION MECHANISM. THE GOVERNING EQUATIONS ARE MAXWELL EQUATIONS AND THE SUPERCONDUCTING MATERIAL IS USUALLY DESCRIBED BY MEANS OF A NONLINEAR E-J CHARACTERISTIC. MAXWELL EQUATIONS CAN BE WRITTEN IN DIFFERENT FORMULATIONS ACCORDING TO THE CHOSEN STATE VARIABLES. IN THIS WORK, THE MAGNETIC VECTOR POTENTIAL IS CONSIDERED AS STATE VARIABLES. IN ADDITION, IN ORDER TO CONFIRM THE VALIDITY OF THE RESULT, WE CONDUCTED THE PRELIMINARY FLUX PUMP EXPERIMENT. THIS RESULT QUALITATIVELY AGREES WELL WITH THE EXPERIMENTAL ONE AND GIVES SOME ADVICE TO APPLY IT FOR ENGINEERING DEVICE. IN PARTICULAR WHEN THE FLUX PUMP SYSTEM IS ATTACHED TO OR DETACHED FROM THE BULK, THE ELECTROMAGNETIC EFFECT SHOULD BE RESTRICTED AS MUCH AS POSSIBLE. THE EFFECT CAN BE ESTIMATED USING THIS NUMERICAL METHOD, WHICH IS USEFUL FOR THE ENGINEERING DESIGN. THE FLUX PUMP SYSTEM UTILIZES A PARTICULAR BEHAVIOR THAT THE

PERMEABILITY OF SOME MATERIALS SUCH AS GADOLINIUM IS SENSITIVE TO THE TEMPERATURE. HEREWITH A SIMPLE HEATER ALLOWS THE SIMPLE CONTROL OF THE FLUX PUMP SYSTEM.[1] T. COOMBS, ET AL. ,PHYSICA C, 468, PP. 153-159 (2008)

5LPJ-04

CRYO-COOLING SYSTEM OF A HTS CONDUCTOR CHARACTERISTICS MEASUREMENT APPARATUS ***A. CHEN****, F. XU, X. LIU, J. CAO, L. LI;* HARBIN INSTITUTE OF TECHNOLOGY. — A HTS CONDUCTOR CHARACTERISTICS MEASUREMENT APPARATUS IS DESIGNED AND CONSTRUCTED AT HARBIN INSTITUTE OF TECHNOLOGY (HIT). THE GOAL IS TO MEASURE THE CRITICAL CURRENT AND AC LOSS OF VARIOUS HTS TAPE OR VARIOUS HTS TRANSPOSED CONDUCTORS. THE UNIFORM MAGNETIC FIELD OF 0-0.25T IS GENERATED IN THE SAMPLE ZONE BY AN IRON CORED MAGNET, THE RELATIVE FIELD DEVIATION IS DESIGNED WITHIN 2.5%. THE UNIFORM TEMPERATURE OF 65-77K IN THE SAMPLE ZONE IS KEPT BY THERMAL CONDUCTION OR NATURAL CONVECTION, THE MAXIMUM TEMPERATURE DEVIATION IS BETWEEN 0.25-0.5K. BASED ON THE DESIGN IDEA OF BRAZING COPPER BAND ONTO THE EXTERIOR SIDEWALL OF THE DEWAR INNER VESSEL THAT PRESENTED BY H.M. CHANG ET.AL., WE BRAZED TWO COPPER BANDS ON THE EXTERIOR SIDEWALL OF THE DEWAR INNER VESSEL AT DIFFERENT HEIGHT TO ENSURE THE TEMPERATURE UNIFORMITY. THE BENEFIT IS GM CRYO-COOLER PLACING OUTSIDE THE LIQUID NITROGEN VESSEL. DURING REPLACING THE SAMPLE, THE CRYOGENIC SYSTEM CAN STILL OPERATE NORMALLY. BASED ON HEAT TRANSFER ANALYSIS, THE KEY COMPONENTS ARE DESIGNED. SOME CRYOGENIC TEST RESULTS OF THE APPARATUS WILL BE PRESENTED IN THIS PAPER WITH DISCUSSION.

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5LPJ-05

MAGNETIZATION OF SUPERCONDUCTING PELLETS IN HIGHLY INHOMOGENEOUS MAGNETIC FIELD ***J. LOPEZ****[1], R. MAYNOU[1], X. GRANADOS[2], R. TORRES[1], R. BOSCH[3];* [1]EUETIB (UPC), [2]ICMAB-CSIC, [3]UPC. — THE MAGNETIZATION OF SUPERCONDUCTING PELLETS IS A WORTH POINT IN THE DEVELOPMENT OF TRAPPED FLUX SUPERCONDUCTING MOTORS. EXPERIMENTAL AND SIMULATED DATA HAVE BEEN REPORTED EXTENSIVELY ACCORDING TO THE FRAMEWORK OF ONE OR SEVERAL PULSES OF A HOMOGENEOUS MAGNETIZING FIELD APPLIED TO A PELLET OR A SET OF PELLETS. IN CASE OF RADIAL ROTORS OF LOW POWER MOTORS, HOWEVER, THE USE OF THE COPPER COILS TO PRODUCE THE STARTING MAGNETIZATION OF THE PELLETS PRODUCES A HIGHLY INHOMOGENEOUS MAGNETIC FIELD WHICH CANNOT BE CONSIDERED BY THE STANDARD MODEL. IN THIS WORK WE PRESENT AN ANALYSIS OF THE MAGNETIZATION OF THE SUPERCONDUCTING CYLINDRICAL ROTOR OF A SMALL MOTOR BY USING A COMMERCIAL FEM PROGRAM, BEING THE ROTOR MAGNETIZED BY THE WORKING COPPER COILS OF THE MOTOR. WE REPORT ON THE MAGNETIZATION OBTAINED AND HEAT GENERATED IN THE HTSC PELLETS, IN SEVERAL POSSIBLE CONFIGURATIONS.

NANOSELECT PROJECT OF THE CONSOLIDER PROGRAM; THE MICINN (MAT2008-01022,NAN2004-09133-CO3-01); XERMAE AND EUETIB

5LPK-01**COLDDIAG: A COLD VACUUM CHAMBER FOR DIAGNOSTICS** ***S. CASALBUONI****[1], T. BAUMBACH[1], S. GERSTL[1], A. GRAU[1], M. HAGELSTEIN[1], D. SAEZ DE JAUREGUI[1], C. BOFFO[2], G. SIKLER[2], V. BAGLIN[3], R. CIMINO[4], M. COMMISSO[4], B. SPATARO[4], M. COX[5], J. SCHOUTEN[5], E. WALLÈN[6], R. WEIGEL[7], J. CLARKE[8], T. BRADSHAW[9];* [1]INSTITUTE FOR SYNCHROTRON RADIATION, KARLSRUHE INSTITUTE OF TECHNOLOGY, [2]BABCOCK NOELL GMBH, [3]CERN, [4]INFN, [5]DIAMOND LIGHT SOURCE, [6]MAXLAB, [7]MAX-PLANCK INSTITUTE FOR METAL RESEARCH, [8]STFC DARESBURY LABORATORY, [9]STFC RUTHERFORD APPLETON LABORATORY. — ONE OF THE STILL OPEN ISSUES FOR THE DEVELOPMENT OF SUPERCONDUCTING INSERTION DEVICES IS THE UNDERSTANDING OF THE HEAT LOAD INDUCED BY THE BEAM PASSAGE. WITH THE AIM OF MEASURING THE BEAM HEAT LOAD TO A COLD BORE AND IN ORDER TO GAIN A DEEPER UNDERSTANDING IN THE BEAM HEAT LOAD MECHANISMS, A COLD VACUUM CHAMBER FOR DIAGNOSTICS IS UNDER CONSTRUCTION. WE PLAN TO HAVE ACCESS WITH THE SAME SET-UP TO A NUMBER OF DIFFERENT DIAGNOSTICS, SO WE ARE IMPLEMENTING: I) RETARDING FIELD ANALYZERS TO MEASURE THE ELECTRON FLUX, II) TEMPERATURE SENSORS TO MEASURE THE TOTAL HEAT LOAD, III) PRESSURE GAUGES, IV) AND MASS SPECTROMETERS TO MEASURE THE GAS CONTENT. THE INNER VACUUM CHAMBER WILL BE REMOVABLE IN ORDER TO TEST DIFFERENT GEOMETRIES AND MATERIALS. COLDDIAG IS BUILT TO FIT IN A SHORT STRAIGHT SECTION AT ANKA, BUT WE ARE PROPOSING ITS INSTALLATION IN DIFFERENT SYNCHROTRON LIGHT SOURCES WITH DIFFERENT ENERGIES AND BEAM CHARACTERISTICS. A FIRST INSTALLATION IN DIAMOND IS UNDER DISCUSSION. HERE WE DESCRIBE THE TECHNICAL DESIGN REPORT OF THIS DEVICE AND THE PLANNED MEASUREMENTS WITH BEAM.

5LPK-02**AN FBG SENSOR FOR STRAIN MEASUREMENT IN SUPERCONDUCTING MAGNETS** ***H. ZHANG****;* INSTITUTE OF ELECTRICAL ENGINEERING, CHINESE ACADEMY OF SCIENCES. — **ABSTRACT_**CRYOGENIC STRAIN SENSING WAS EXPERIMENTALLY DEMONSTRATED OF A FIBER BRAGG GRATING (FBG) SENSOR AT TEMPERATURES AS LOW AS 4.2 K. A LINEAR DEPENDENCE OF THE CENTRAL WAVELENGTH VERSUS THE EXPERIENCED STRAIN WAS OBSERVED, AND THE MEASURED STRAIN SENSITIVITY WAS 1.4PM(MM/M)$^{-1}$. THE STRAIN EXPERIMENT WAS REPEATED THREE TIMES IN LIQUID HELIUM ENVIRONMENT, THE MEASURED RESULTS AGREED QUITE WELL EVERY TIME. MOREOVER, THE STRAIN RESPONSE OF THE FBG SENSOR WAS INVESTIGATED AT DIFFERENT CRYOGENIC TEMPERATURES ALSO. THE STRAIN RESPONSE OF FBG SENSOR IS REPEATABLE AND RELIABLE AT CRYOGENIC TEMPERATURE. THIS FBG SENSOR HAS BEEN USED TO MEASURE STRAIN IN LOW TEMPERATURE SUPERCONDUCTING MAGNET SUCCESSFULLY.

5LPK-03**HIGH-TEMPERATURE SUPERCONDUCTING YBACUO DEVICE FOR MEASURING WEAK MAGNETIC FIELDS** ***N. D. KUZMICHEV***[1]*, V. V. SLAVKIN*[2]*;* [1]MACHINE-BUILDING INSTITUTE, [2]SARANSK COOPERATIVE INSTITUTE, RUSSIAN UNIVERSITY OF COOPERATION. — HIGH-TEMPERATURE SUPERCONDUCTING YBACUO DEVICE FOR MEASURING WEAK MAGNETIC FIELDSV. V. SLAVKIN[A], N. D. KUZ'MICHEV[B],[A] SARANSK COOPERATIVE INSTITUTE, RUSSIAN UNIVERSITY OF COOPERATION, SARANSK, 430027 RUSSIA[B] OGAREV MORDOVIAN STATE UNIVERSITY, SARANSK, 430000 RUSSIAE-MAIL: KUZMICHEVND@RAMBLER.RUTHE EARLIER DATA FOR THE MAGNETIC PROPERTIES OF $YBA_2CU_3O_{7-X}$ POLYCRYSTALS ARE USED TO DESIGN A HIGHLY SENSITIVE DEVICE MEASURING WEAK MAGNETIC FIELDS. THE SENSITIVITY OF THE DEVICE IS CLOSE TO THAT OF SQUIDS AND MUCH HIGHER THAN THE SENSITIVITY OF FLUX-GATE METERS. AT THE SAME TIME, THE DEVICE IS SIMPLER IN DESIGN AND MORE RELIABLE IN OPERATION THAN SQUIDS. UNLIKE SQUIDS, THE DEVICE MAKES IT POSSIBLE TO DIRECTLY MEASURE THE MAGNETIC FIELD STRENGTH, HAS A WIDE MEASURING RANGE, AND EXHIBITS A WELL-DEFINED DIRECTIONAL PATTERN.

5LPK-04

SOME ASPECTS OF WINDING GEOMETRY CONTROL FOR ITER SUPERCONDUCTING COILS FROM MAGNETIC MEASUREMENTS ***I. Y. RODIN***[1]*, V. M. AMOSKOV*[2]*, V. A. BELYAKOV*[2]*, S. A. EGOROV*[2]*, A. A. FIRSOV*[2]*, I. V. GORNIKEL*[3]*, V. G. IVKIN*[2]*, V. P. KUCHTIN*[2]*, V. P. KUCHTIN*[2]*, E. A. LAMZIN*[2]*, A. A. LANCETOV*[2]*, M. S. LARIONOV*[2]*, N. A. MAXIMENKOVA*[2]*, N. A. SHATIL*[2]*, S. E. SYTCHEVSKY*[2]*, V. N. VASILIEV*[1]*;* [1]THE D.V. EFREMOV SCIENTIFIC RECEARCH INSTITUTE OF ELECTROPHYSICAL APPARATUS (NIIEFA), [2]THE D.V.EFREMOV SCIENTIFIC RECEARCH INSTITUTE OF ELECTROPHYSICAL APPARATUS (NIIEFA), [3]ALPHYSICA INC.. — A FEASIBILITY HAS BEEN DEMONSTRATED FOR NUMERICAL RECONSTRUCTION OF GEOMETRICAL DISPLACEMENTS OR DEFORMATIONS OF TURNS OCCURRED IN THE MANUFACTURE AND ASSEMBLY OF MAGNET COILS USING MAGNETIC MEASUREMENTS. FOR VALIDATION OF THE PROPOSED APPROACH, TEST RESULTS OF RECONSTRUCTION OF POSSIBLE MISALIGNMENTS AND DEVIATIONS OF THE ITER PF1 COIL ARE PRESENTED.THE METHOD DESCRIBED IS APPLICABLE FOR A VARIETY OF COILS.

5LPK-05

INSTRUMENTATION FOR LOCAL AND INTEGRAL MAGNETIC FIELD MEASUREMENTS OF SUPERCONDUCTING UNDULATOR COILS ***A. GRAU****, T. BAUMBACH, S. CASALBUONI, S. GERSTL, M. HAGELSTEIN, D. SAEZ DE JAUREGUI;* INSTITUTE FOR SYNCHROTRON RADIATION, KARLSRUHE INSTITUTE OF TECHNOLOGY. — IN THIS CONTRIBUTION WE DESCRIBE THE PLANNED INSTRUMENTATION TO PERFORM MAGNETIC MEASUREMENTS OF THE LOCAL FIELD, OF THE FIELD INTEGRALS AND OF THE MULTIPOLE COMPONENTS OF SUPERCONDUCTING UNDULATOR COILS IN A COLD IN VACUUM (CRYOGEN FREE) ENVIRONMENT. THIS IS PART OF OUR R&D PROGRAM FOR SUPERCONDUCTING INSERTION DEVICES TO IMPROVE AND PERFORM QUALITY MANAGEMENT OF THEIR MAGNETIC FIELD PROPERTIES.PRECISE MEASUREMENTS OF THE MAGNETIC PROPERTIES ARE OF FUNDAMENTAL IMPORTANCE FOR THE CHARACTERIZATION OF THE INSERTION DEVICES BEFORE INSTALLATION IN SYNCHROTRON LIGHT SOURCES.

5LPK-06

A HIGH ACCURACY HALL PROBES TEST BENCH FOR SMALL MULTIPOLES FIELD MEASUREMENTS ***M. STATERA***[1]*, L. BARION*[2]*, P. BENATI*[1]*, S. BERTELLI*[1]*, G. CIULLO*[1]*, M. CONTALBRIGO*[2]*, P. F. DALPIAZ*[1]*, G. GUIDOBONI*[1]*, P. LENISA*[1]*, L. PAPPALARDO*[1]*;* [1]FERRARA UNIVERSITY - INFN, [2]INFN. — A CRYOGENIC TEST BENCH FOR MEASURING SMALL SUPERCONDUCTING MULTIPOLES USING HALL PROBES, PART OF THE R&D ON VERY HIGH INTENSITY POLARIZED H/D ATOMIC BEAM SOURCE, IS PRESENTED. THE TEST BENCH WAS BUILT AND TESTED IN FERRARA INFN LABORATORIES AND IS USED TO PERFORM FIELD MAPPING AND FOURIER ANALYSIS ON THE MEASURED FIELD OF SMALL SUPERCONDUCTING MULTIPOLES AT 4.2 K AND UP TO 600 A FEEDING CURRENT.THE TEST BENCH IS USED TO TRAIN THE SMALL SUPERCONDUCTING MAGNETS AND TO PERFORM THE MAGNETIC FIELD CHARACTERIZATION. THE MAGNETIC FIELD IS MEASURED BOTH INSIDE AND OUTSIDE THE MAGNET, SO THAT ALSO THE FRINGE FIELD IS MEASURED.TESTING THE MAGNETS UNDER OPERATING CONDITION ALLOWS A REALISTIC AND RELIABLE MEASUREMENT OF THE MAGNET QUALITY FOR PROTOTYPES AND SMALL PRODUCTIONS MAGNETS. COMPARING THE RESULTS WITH FEM SIMULATIONS SUPPLIES A UNIQUE TOOL TO TUNE THE SIMULATIONS PARAMETERS.THE RESULT OF THE FIELD MAPPING OF A SUPERCONDUCTING SEXTUPOLE WITH HIGHER ACCURACY WITH RESPECT TO FIRST MEASUREMENT IS PRESENTED. THE HIGH ACCURACY IS REACHED THANKS TO THE IMPROVED HALL PROBES MOVEMENT SYSTEM.

5LPK-07

NOVEL SET-UP FOR THE DEFINITION OF THE MAGNETIC FIELD QUALITY OF SUPER- AND NORMALLY CONDUCTING ACCELERATOR MAGNETS ***Y. A. KLIMCHENKO****, V. G. IVKIN, A. A. LANCETOV, I. Y. RODIN;* THE D.V. EFREMOV SCIENTIFIC RESEARCH INSTITUTE OF ELECTROPHYSICAL APPARATUS. — THE DEFINITION OF THE MAGNETIC FIELD QUALITY IS IMPORTANT PART OF THE ACCELERATOR MAGNETS PRODUCTION. TWO MAIN TECHNIQUES ARE USED TO ACQUIRE THE INITIAL DATA. ONE IS THE HARMONIC ANALYSIS BASED ON THE DATA OF ROTATABLE MEASURING COILS AND ANOTHER IS THE MEASURING OF THE MAGNETIC CHARACTERISTICS BY THE HALL PROBES. HIGH PRECISION EQUIPMENT IS NECESSARY TO REALIZE THESE TECHNIQUES. TRADITIONALLY, SOME SPECIAL DEVICES LIKE PRECISION ANALOG INTEGRATOR ARE USED. MODERN DEVELOPMENT OF DIGITAL TECHNIQUES ALLOWS REPLACE ANALOG DEVICES WITH DIGITAL ONES TO IMPROVE THE QUALITY OF MEASUREMENTS.THE PAPER PRESENTS THE SETUP TO REALIZE THE MODERN METHODS OF MAGNETIC FIELD MEASURING. THE NATIONAL INSTRUMENTS HARDWARE AND LAB VIEW SOFTWARE ALLOWED BUILDING HIGH PRECISION AND SIMPLE

IN USE DATA ACQUISITION SYSTEM WITH NECESSARY PARAMETERS. AS A NEW DEVELOPMENT THE WAY TO USE ADC AS A HIGH PRECISION INTEGRATOR IS SHOWN.THE DESCRIBED SETUP WAS USED DURING ACCEPTANCE TESTS OF THE DESY ACCELERATOR SUPERCONDUCTING SOLENOID WITH THE GAP. FURTHER PLANS ARE TO USE THIS SETUP TO MEASURE THE MAGNETIC CHARACTERISTICS OF NORMALLY CONDUCTING MAGNETS OF XFEL PROJECT.

5LPL-01

QUENCH DETECTION METHOD OF HTS MODEL COIL USING A SERIES-TYPE THERMOCOUPLE ***D. KIM***[1], *J. KIM*[1], *A. KIM*[1], *M. PARK*[1], *I. YU*[1], *K. SIM*[2], *S. KIM*[2], *J. CHO*[2]; [1]CHANGON NATIONAL UNIVERSITY, [2]KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE. — RECENTLY, HTS (HIGH TEMPERATURE SUPERCONDUCTING) WIRE HAS BEEN DEVELOPED FOR THE PURPOSE OF BEING APPLIED TO POWER CABLES, MOTORS AND GENERATORS, ETC. THE QUENCH DETECTION IS ONE OF THE NOTABLE ISSUES FOR THE SAFE OPERATION OF SUPERCONDUCTING DEVICES. EXCESSIVE JOULE HEATING CAUSES SERIOUS DAMAGE TO THE SUPERCONDUCTOR WHEN THE QUENCH OCCURS IN THE HTS COIL. THEREFORE, QUENCH DETECTION METHOD MUST BE APPLIED TO THE HTS COIL SYSTEM.THIS PAPER PROPOSES A QUENCH DETECTION METHOD AND THE TEST RESULTS ON A HTS BSCCO (BISMUTH STRONTIUM CALCIUM COPPER OXIDE) WIRE AND HTS COIL ARE DISCUSSED. A SERIES-TYPE THERMOCOUPLE WAS FABRICATED FOR THE QUENCH DETECTION. SEVERAL THERMOCOUPLES WERE WELDED AS A SERIES-TYPE. THEREFORE, THE SERIES-TYPE THERMOCOUPLE HAS MANY DETECTING POINTS. THE TEMPERATURE VARIATION WAS DETECTED AT EACH POINT BY USING EMF (ELECTROMOTIVE FORCE).THE AUTHORS INVESTIGATED THE FEASIBILITY OF THE PROPOSED METHOD THROUGH THE QUENCH DETECTION TESTS FOR BSCCO COILS. THIS METHOD HAS ADVANTAGES SUCH AS SIMPLE STRUCTURE AND COST EFFECTIVE AND PROTECTS THE HTS COIL BY DETECTING THE PARTIAL QUENCH AND ITS PROPAGATION.

THIS RESEARCH WAS SUPPORTED BY A GRANT FROM CENTER FOR APPLIED SUPERCONDUCTIVITY TECHNOLOGY OF 21ST CENTURY FRONTIER R&D PROGRAM FUNDED BY THE MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY, REPUBLIC OF KOREA

5LPL-02

QUENCH PROPAGATION IN A CONDUCTION-COOLED MGB_2 COIL AND THE PROTECTION DESIGN ***T. HOLUBEK***[1], *L. ROSTILA*[2], *D. DAMIANI*[1], *A. CAPELLUTO*[1], *R. MARABOTTO*[1], *D. NARDELLI*[1], *M. MODICA*[1]; [1]ASG SUPERCONDUCTORS, [2]COLUMBUS SUPERCONDUCTORS. — IN THE PAST YEARS, MUCH EFFORT HAVE BEEN PAID TO DEVELOP RELIABLE, LONG-LENGTH MGB_2 CONDUCTORS, PROPER FOR MANUFACTURING MEDIUM-FIELD MAGNETS, OPERATING AT TEMPERATURES AROUND 20 K. STABLE OPERATION OF SUCH A DEVICE, HOWEVER, IS ONE OF THE MOST IMPORTANT TASKS TO BE SOLVED BEFORE THE FABRICATION. THIS WORK PRESENTS A NUMERICAL STUDIES ON A QUENCH PROPAGATION IN THE CONDUCTION-COOLED SUPERCONDUCTING MGB_2 COIL. THE COIL WINDING ADOPTED A LAYOUT AND A MATERIAL PROPERTIES OF A CONDUCTOR FABRICATED BY THE COLUMBUS SUPERCONDUCTORS. LOSSES ARISING FROM THE MAGNETIC FIELD VARIATION ARE ASSUMED IN THE MODEL. THE IMPACT OF A HOT SPOT LOCATION, A THICKNESS OF AN ELECTRICAL INSULATION USED IN THE WINDING AND AN OPERATING TO CRITICAL CURRENT RATIO ON THE COIL BEHAVIOR IS STUDIED, AND CONSEQUENTLY, APPROPRIATE COIL PROTECION WAS DESIGNED.

5LPL-03

THERMAL/ELECTRICAL STABILITIES OF YBCO COATED CONDUCTOR (CC) TAPES IMPREGNATED WITH A SOLID ARGON (SAR)-LN2 MIXTURE ***J. SONG***[1], *K. KIM*[1], *K. KIM*[1], *J. LEE*[1], *H. KIM*[2], *H. CHEON*[3], *S. KIM*[3], *H. LEE*[1]; [1]KOREA UNIVERSITY, KOREA, [2]KOREA ELECTROTECHNOLOGY RESEARCH INSTITUTE, KOREA, [3]DEPARTMENT OF ELECTRICAL ENGINEERING, GYEONGSANG NATIONAL UNIVERSITY AND ERI, KOREA. — RECENTLY, THE COOLING SYSTEM USING A SOLID CRYOGEN (SC) SUCH AS SOLID NITROGEN (SN2) WAS INTRODUCED FOR HIGH TEMPERATURE SUPERCONDUCTING (HTS) APPLICATIONS. HOWEVER, THERMAL CONTACT BETWEEN SC AND HTS TAPES HAS BECOME CONSIDERABLY WORSE AFTER REPEATED OVER-CURRENT RUNS, RESULTING IN A 'THERMAL DRY-OUT' PROBLEM. FOR AN EFFECTIVE OPTION TO IMPROVE THE POOR THERMAL CONTACT CHARACTERISTICS, THE NEW-TYPE OF CRYOGEN, THE MIXTURE OF SOLID ARGON (SAR) WITH A SMALL AMOUNT OF LIQUID NITROGEN (LN2), IS INTRODUCED IN THIS STUDY. IN ORDER TO EVALUATE THE PERFORMANCE OF THIS CRYOGEN MIXTURE, THE VOLTAGES AND TEMPERATURES OF THE YBCO CC TAPES ARE MEASURED AT 65 K DURING OVER-CURRENT TESTS. THE EXPERIMENTAL RESULTS SHOW THAT THERMAL AND ELECTRICAL STABILITIES OF THE YBCO CC TAPES HAS IMPROVED DRASTICALLY WHEN IT IS IMPREGNATED WITH THE MIXED CRYOGEN. THIS INDICATES THAT A SMALL AMOUNT OF LN2 PLAYS A ROLE AS A HEAT EXCHANGER THAT CAN ENHANCE THE THERMAL CONTACT BETWEEN SAR AND THE YBCO CC TAPE.

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5LPL-04

AC LOSS OF SUPERCONDUCTING RACETRACK COIL IN VARIOUS MAGNETIC CONDITIONS ***Z. HONG***, *M. AINSLIE, W. YUAN, R. PEI, Y. YAN, W. XIAN, T. COOMBS;* CAMBRIDGE UNIVERSITY. — HIGH-TEMPERATURE SUPERCONDUCTORS HAVE CREATED THE OPPORTUNITY FOR A STEP CHANGE IN THE TECHNOLOGY OF POWER APPLICATIONS. RACETRACK SUPERCONDUCTING COILS MADE FROM YBCO COATED CONDUCTORS HAVE BEEN USED IN SEVERAL ENGINEERING APPLICATIONS INCLUDING SEMS, ROTOR FIELD WINDING AND STATOR WINDING OF ELECTRIC MACHINES. AC LOSS IS ONE OF THE MOST IMPORTANT FACTORS THAT DETERMINE THE DESIGN AND PERFORMANCE OF SUPERCONDUCTING DEVICES.

IN THIS PAPER, A NUMERICAL MODEL IS DEVELOPED TO CALCULATE THE AC LOSS IN SUPERCONDUCTING COILS IN DIFFERENT MAGNETIC CONDITIONS. THIS PAPER FIRST DISCUSSES THE AC LOSSES OF COILS IN SELF FIELD ONLY WHICH IS THE CONDITION UNDER THE SEMS APPLICATIONS. IT THAN GOES ONTO INVESTIGATE THE AC LOSS OF THE COIL CARRYING DC CURRENT AND BEING EXPOSED TO AC RIPPLE FIELD. THIS SCENARIO CORRESPONDS TO USING SUPERCONDUCTING COIL AS THE ROTOR FIELD WINDING OF AN ELECTRIC MACHINE. FINALLY, THE SITUATION OF USING SUPERCONDUCTING COIL AS THE STATOR WINDING OF THE MACHINE IS INVESTIGATED. IN THIS CASE THE AC LOSS OF THE COIL CARRYING AC TRANSPORT CURRENT AND BEING EXPOSED TO AC FIELD IS CALCULATED. SEVERAL FACTORS THAT WOULD AFFECT THE VALUE OF AC LOSS ARE DISCUSSED, INCLUDING THE NUMBER OF TURNS OF THE COIL, THE PHASE DIFFERENCE BETWEEN THE EXTERNAL FIELD AND THE TRANSPORT CURRENT AND THE ANGLE OF THE FIELD.

5LPL-05

ACHIEVEMENT OF HIGH HEAT REMOVAL CHARACTERISTIC OF SUPERCONDUCTING MAGNETS WITH BUILT-IN OSCILLATING HEAT PIPES ***T. MITO***[1]*, K. NATSUME*[2]*, N. YANAGI*[1]*, H. TAMURA*[1]*, T. TAMADA*[3]*, K. SHIKIMACHI*[3]*, N. HIRANO*[3]*, S. NAGAYA*[3]*;* [1]NATIONAL INSTITUTE FOR FUSION SCIENCE, [2]THE GRADUATE UNIVERSITY FOR ADVANCED STUDIES, [3]CHUBU ELECTRIC POWER CO., INC.. — WE ARE DEVELOPING CRYOGENIC OSCILLATING HEAT PIPES (OHP) BUILT INTO THE WINDINGS AIMING TO IMPROVE THE HEAT REMOVAL CHARACTERISTIC OF HIGH-TC SUPERCONDUCTING (HTS) MAGNETS. IT IS ACTUALLY DIFFICULT FOR HTS MAGNETS TO TAKE OUT THE HEAT GENERATED IN THE WINDINGS, BECAUSE THE THERMAL DIFFUSIVITY OF EACH COMPONENT MATERIALS OF THE MAGNET SUCH AS COPPER, ALUMINUM ALLOY, EPOXY RESIN, GFRP, ETC., DECREASE WITH AN INCREASE OF THE OPERATING TEMPERATURE. THEREFORE, A LOCAL HOT SPOT CAN BE EASILY GENERATED IN THE MAGNET, AND THERE ARE POSSIBILITIES OF DEGRADATION OF SUPERCONDUCTING PROPERTIES AND/OR MECHANICAL DAMAGE BY THERMAL STRESSES. AS A NEW COOLING TECHNOLOGY WHICH CAN ENHANCE THE HEAT REMOVAL CHARACTERISTIC OF THE MAGNETS, THE OHP IS PROPOSED TO BE IMBEDDED IN THE MAGNET WINDINGS. AS PROOF OF THE FEASIBILITY OF THE CRYOGENIC OHP, THE STABLE OPERATION IN THE TEMPERATURE RANGE FROM 17 K TO 91 K HAS ALREADY BEEN CONFIRMED BY USING HYDROGEN, NEON, AND NITROGEN AS THE WORKING FLUID OF THE OHP. IN ADDITION, IT HAS BEEN SHOWN TO BE ABLE TO ACHIEVE HIGH THERMAL CONDUCTIVITY THAT SURPASSED HIGH PURITY METALS. IN THIS PAPER, THE METHOD OF CONNECTING TWO OR MORE OHPS IN VARIOUS INSTALLATION DIRECTIONS IMBEDDED IN THE MAGNET WINDINGS IS PROPOSED, AND IT IS PLANNED TO BE CONFIRMED WITH THE DUMMY MAGNET THAT BUILDS IN THE OHPS.

5LPM-01

CERTIFICATION OF SUPERCONDUCTING SOLENOID-BASED FOCUSING LENSES *J. DIMARCO, D. F. ORRIS, T. M. PAGE, R. H. RABEHL,* ***M. A. TARTAGLIA****, I. TERECHKINE, J. C. TOMPKINS;* FERMILAB. — THE FIRST SUPERCONDUCTING FOCUSING LENSES FOR THE BEAM LINE OF A R&D PROTON LINAC HAVE BEEN ASSEMBLED INTO CRYOSTATS AND TESTED. THE LENSES ARE BUILT FOR INSTALLATION IN THE LOW ENERGY SECTION OF THE LINAC, WHICH USES COPPER CROSSBAR-H (CH) STYLE RF CAVITIES. ONE OF THE TESTED CH-SECTION LENS ASSEMBLIES INCLUDES A PAIR OF WEAK ORTHOGONAL STEERING DIPOLES NESTED WITHIN A STRONG FOCUSING SOLENOID, AND HAS SIX VAPOR COOLED POWER LEADS. THE OTHER DEVICE HAS ONLY THE FOCUSING SOLENOID WITHOUT EMBEDDED DIPOLE CORRECTORS, AND UTILIZES A SINGLE PAIR OF HTS POWER LEADS. A TOTAL OF 23 COLD MASSES FOR FOCUSING LENSES WERE FABRICATED, TESTED, AND PREPARED FOR INSTALLATION INTO THE CRYOSTATS. THE LENS TEST/CERTIFICATION PROGRAM IS ONGOING TO MEASURE THE THERMAL PERFORMANCE OF THE CRYOSTAT, COOLING REQUIREMENTS FOR THE CURRENT LEADS, QUENCH PERFORMANCE OF ALL SUPERCONDUCTING COMPONENTS, PRECISE DETERMINATION OF THE MAGNETIC AXIS, AND DIPOLE FIELD TRANSFER FUNCTIONS AND ANGLES. THIS REPORT PRESENTS RESULTS OBTAINED FOR THE TWO TESTED DEVICES.

5LPM-02

DESIGN AND PERFORMANCE OF FOCUSING LENSES FOR INSTALLATION INTO SUPERCONDUCTING CRYOMODULES OF A PROTON LINAC *T. H. NICOL, D. A. SERGATSKOV, M. A. TARTAGLIA,* ***I. TERECHKINE****, J. C. TOMPKINS;* FERMILAB. — THE HIGH ENERGY SECTIONS OF THE FERMILAB R&D PROTON LINAC WILL UTILIZE SUPERCONDUCTING SPOKE RESONATOR (SSR) RF CAVITIES. THESE WILL BE ASSEMBLED INTO CRYOMODULES WITH STRONG SOLENOID FOCUSING LENSES INSTALLED BETWEEN THE CAVITIES. A DESIGN FOR LENSES HAS BEEN MADE FOR THE LOWER (SS1) AND HIGHER (SS2) ENERGY RANGES OF THE SSR-SECTION. PROTOTYPE LENSES FOR BOTH SS1 AND SS2 SECTIONS HAVE BEEN BUILT AND TESTED. MAGNETIC SHIELDING WAS DESIGNED AND BUILT TO REDUCE THE SOLENOID FRINGE FIELD ON THE CAVITY WALL BELOW THE 10MT LEVEL, AND A PROTOTYPE LENS EQUIPPED WITH THE SHIELDING WAS TESTED IN A TEST CRYOSTAT. WE DISCUSS THE LENS DESIGN AND THE RESULTS FROM QUENCH TESTING AND MAGNETIC MEASUREMENTS ON THE LENSES.

5LPM-03

CONCEPTUAL DESIGN OF AN OPEN MIDPLANE DIPOLE MODEL FOR MUON COLLIDER RING ***A. V. ZLOBIN****, N. ANDREEV, R. BOSSERT, V. V. KASHIKHIN, N. V. MOKHOV, I. NOVITSKI;* FERMILAB. — CONCEPTUAL DESIGN OF 10 T SUPERCONDUCTING DIPOLE MAGNET FOR A MUON COLLIDER WITH A 1.5 TEV C.O.M. ENERGY AND AN AVERAGE LUMINOSITY OF 10^34 CM-2S-1 IS PRESENTED. IN CONTRARY TO PROTON MACHINES, THE DIPOLE MAGNET FOR MUON COLLIDER SHOULD HAVE AN OPEN MIDPLANE TO HANDLE ABOUT 0.5 KW/M OF DYNAMIC HEAT LOADS FROM THE MUON BEAM DECAYS. THE MAGNET COIL IS BASED ON NB3SN SUPERCONDUCTOR AND DESIGNED TO PROVIDE AN ADEQUATE OPERATING FIELD IN THE 40-MM APERTURE WITH

THE CRITICAL CURRENT MARGIN REQUIRED FOR RELIABLE MACHINE OPERATION. THE MAGNET CROSS-SECTION WAS OPTIMIZED TO ACHIEVE THE BEST POSSIBLE FIELD QUALITY IN THE MAGNET APERTURE OCCUPIED WITH BEAMS. THE DEVELOPED MECHANICAL STRUCTURE PROVIDES AN ADEQUATE COIL PRESTRESS AND SUPPORT AT THE MAXIMUM LEVEL OF LORENTZ FORCES IN THE COIL. THE MAGNET PARAMETERS ARE REPORTED AND COMPARED WITH THE REQUIREMENTS.

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5LPM-04

DESIGN AND CONSTRUCTION OF THE FINAL FOCUS QUADRUPOLE R&D MAGNET FOR SUPER-KEKB ***N. OHUCHI****, K. TSUCHIYA, M. TAWADA, N. HIGASHI, Z. ZHANGUO;* KEK. — FOR UPGRADING THE KEKB ACCELERATOR, SUPER-KEKB, THE FINAL FOCUS QUADRUPOLE SYSTEM OF TWO BEAMS, ELECTRON AND POSITRON, IS BEING STUDIED. THIS SYSTEM CONSISTS OF SUPERCONDUCTING QUADRUPOLE DOUBLETS FOR EACH BEAM, AND THE QUADRUPOLES ARE REQUESTED TO LOCATE CLOSE TO THE BEAM INTERACTION POINT AS MUCH AS POSSIBLE IN ORDER TO ATTAIN THE SPECIFIC LUMINOSITY OF 8×10^{35}. THE DESIGNED R&D SUPERCONDUCTING QUADRUPOLE HAS THE INNER RADIUS OF 41.6 MM AND THE MAGNET LENGTH OF 400 MM. FROM THE SPACE CONSTRAINT IN THIS INTERACTION REGION, THE FOUR SUPERCONDUCTING QUADRANT COILS ARE WOUND WITH A SINGLE WIRE OF □ 0.648 MM. THE QUADRANT COIL IS COMPOSED OF FOUR LAYERS OF THE THIN COIL, AND THE TOTAL TURN NUMBER OF THE SUPERCONDUCTING WIRE IS 81. THIS R&D MAGNET IS DESIGNED TO GENERATE THE FIELD GRADIENT OF 28.26 T/M AT THE OPERATING CURRENT OF 368 A. IN THIS PAPER, WE WILL DESCRIBE THE DESIGN AND CONSTRUCTION OF THIS R&D MAGNET.

5LPM-05

MAGNETIC FIELD DESIGN OF DIPOLE MAGNET WOUND WITH HIGH TC SUPERCONDUCTOR TAPE CONSIDERING CURRENT TRANSPORT CHARACTERISTICS WITH ANISOTROPIC MAGNETIC FIELD DEPENDENCE ***K. TAKAHASHI****[1], N. AMEMIYA[1], N. OKADA[1], T. NAKAMURA[1], T. OGITSU[2], T. TOSAKA[3], T. KURUSU[3], T. YOSHIYUKI[3], K. NODA[4];* [1]KYOTO UNIVERSITY, [2]HIGH ENERGY ACCELERATOR RESEARCH ORGANIZATION, [3]TOSHIBA CORPORATION, [4]NATIONAL INSTITUTE OF RADIOLOGICAL SCIENCES. — HIGH TC SUPERCONDUCTORS ARE ATTRACTIVE FOR APPLICATIONS TO ACCELERATOR MAGNETS FROM THE VIEW POINT OF IMPROVING COOLING EFFICIENCY AS WELL AS THERMAL STABILITY. WHEN DESIGNING ACCELERATOR MAGNETS USING HIGH TC SUPERCONDUCTOR TAPES, THEIR CURRENT TRANSPORT CHARACTERISTICS WITH ANISOTROPIC MAGNETIC FIELD DEPENDENCE MUST BE CONSIDERED.THE CURRENT TRANSPORT CHARACTERISTICS OF AN YBCO COATED CONDUCTOR ARE MEASURED IN VARIOUS MAGNETIC FIELDS, AND THEY ARE FORMULATED WITH THE PERCOLATION DEPINNING MODEL.BASED ON THE FORMULATED CURRENT TRANSPORT CHARACTERISTICS, WE DESIGN A DIPOLE MAGNET FOR A ROTATING GANTRY FOR CARBON CANCER THERAPY. THE REFERENCE RADIUS OF THE MAGNET IS 30 MM, THE INNER RADIUS OF THE COIL IS 60 MM, THE DIPOLE COMPONENT OF THE GENERATED MAGNETIC FIELD IS 3 T, AND THE HIGHER MULTI-POLE COMPONENTS OF THE MAGNETIC FIELD NORMALIZED BY THE DIPOLE COMPONENT ARE LESS THAN 10^{-3}. THE ENTIRE LOSS OF THE MAGNET AS WELL AS THE DISTRIBUTION OF THE GENERATED ELECTRIC FIELD IS CALCULATED. THE DEPENDENCE OF THE CRITICAL CURRENT DENSITY ON MAGNETIC FIELD SUBSTANTIALLY INFLUENCES THE GENERATED ELECTRIC FIELD AND LOSS OF THE MAGNET.

THIS WORK WAS SUPPORTED IN PART BY JAPAN SCIENCE AND TECHNOLOGY AGENCY.

5LPM-06

DESIGN STUDY OF 4 T SUPERCONDUCTING SECTOR MAGNETS IN A 450 MEV/NUCL BOOSTER CYCLOTRON FOR CARBON-ION THERAPY ***S. SANFILIPPO****, M. SCHIPPERS, M. NEGRAZUS, M. CALVI, A. GABARD;* PAUL SCHERRER INSTITUT. — A CYCLOTRON FOR CARBON-ION THERAPY, BASED ON AN ACCELERATOR SYSTEM OF TWO COUPLED CYCLOTRONS, IS DEVELOPED. THE FIRST CYCLOTRON PROVIDES AMONGST OTHER PARTICLES, 250 MEV/NUCL CARBON IONS. FOR TREATMENTS AT DEEP TUMOUR SITES, THESE CARBON IONS ARE BOOSTED TO 450 MEV/NUCL IN A SEPARATE SECTOR CYCLOTRON, CONSISTING OF SIX SECTOR MAGNETS WITH SUPERCONDUCTING COILS AND THREE RF CAVITIES. WE WILL REPORT ON OUR FIRST RESULTS OF A FEASIBILITY STUDY OF THE SUPERCONDUCTING SECTOR MAGNETS OF THIS BOOSTER CYCLOTRON. THESE H-TYPE MAGNETS OF ABOUT 200 TONS SHOULD CREATE A FIELD OF 3-4 T IN A GAP OF 2-3 CM, WITH AN ACTIVE FIELD REGION OF APPROXIMATELY 1 M^2 AND A STORED ENERGY OF 20-30 MJ. TO PREVENT CONCAVE MAGNET POLE EDGES AND TO ACHIEVE SYMMETRY IN THE DESIGN OF THE MAGNET, THE INTRODUCTION OF A RADIAL GRADIENT IN THE SECTOR IS PROPOSED. THE RESULTS OF OUR DIFFERENT GEOMETRY INVESTIGATIONS TO ACHIEVE THE DESIRED MAGNETIC FIELD, WITH A FIELD STRENGTH VARYING FROM 3 T TO 4 T OVER 0.8 M, ARE PRESENTED. ONE OF THE GEOMETRIES IS BASED ON A CONFIGURATION WITH TILTED COILS. STRESSES DURING POWER RAMPING AND AT STEADY STATE ARE EVALUATED USING A 3D FINITE ELEMENT ANALYSIS. THE DETAILS OF THE SUPERCONDUCTING COIL ARE REPORTED, INCLUDING THE SELECTION OF THE SUPERCONDUCTING MATERIAL, THE TYPE OF WIRES, THE CABLE LAYOUT AND THE FINAL WINDING PROCEDURE. A COOLING STRATEGY IS ALSO PROPOSED AND THE PRELIMINARY CONCLUSIONS ARE REPORTED.

5LX-01

(INVITED) **UTILIZATION OF LARGE HEAT CAPACITY SUBSTANCES FOR IMPROVING THE STABILITY OF SUPERCONDUCTING MAGNETS (REVIEW OF EXPERIMENTAL RESULTS)** ***V. E. KEILIN****;* KURCHATOV INSTITUTE. — SEVERAL

YEARS AGO AT KURCHATOV INSTITUTE THE R&D PROGRAM TO EXPLORE THE FEASIBILITY OF SC WINDINGS DOPING WITH LARGE HEAT CAPACITY SUBSTANCES (LHCS) IN ORDER TO IMPROVE THEIR STABILITY. WE STARTED FROM AN "EXTERNAL" DOPING BY THE LHCS POWDER MIXED WITH EPOXY RESIN USING THE WET WINDING PROCESS. LATER ON AT BOCHVAR INSTITUTE THE METHODS TO INTRODUCE LHCS INSIDE SC WIRES (BOTH NBTI & NB3SN BASED) WERE DEVELOPED. THE COMPARATIVE TESTS OF DOPED WIRES MODEL WINDINGS AND SHORT SAMPLES HAVE SHOWN VERY OPTIMISTIC RESULTS REGARDING A CONSIDERABLE INCREASE OF CRITICAL ENERGIES, IMPROVING OF THERMOMAGNETIC STABILITY AND TRAINING BEHAVIOR. THE STATE-OF-THE-ART OF THESE METHODS ARE REVIEWED AND THEIR PERSPECTIVES ARE DISCUSSED.

5LX-02

NB3SN CONDUCTOR AND CABLE DEVELOPMENT FOR HIGH FIELD ACCELERATOR MAGNETS AT CERN ***L. BOTTURA***[1]*, C. BERRIAUD*[2]*, B. BORDINI*[1]*, L. OBERLI*[1]*, G. DE RIJK*[1]*, L. ROSSI*[1]*;* [1]CERN, [2]CEA-SACLAY. — CERN IS ACTIVELY PURSUING AN R&D PROGRAM FOR HIGH FIELD DIPOLES AND QUADRUPOLE MAGNETS (HFM) IN SUPPORT OF UPGRADE STUDIES FOR THE LARGE HADRON COLLIDER (LHC). AS USUAL, THE PROCUREMENT AND CHARACTERIZATION OF STRAND AND CABLE ARE AT THE CORE OF THIS PROGRAM. FOLLOWING THE RESULTS OBTAINED DURING THE NEXT EUROPEAN DIPOLE (NED) R&D PHASE, OFFICIALLY CLOSED IN 2008, WE HAVE ADJUSTED THE STRAND AND CABLE DESIGNS TO IMPROVE THE PROJECTED PERFORMANCE AND EASE MAGNET MANUFACTURING. SPECIFICALLY, THE TARGET CRITICAL CURRENT DENSITY JC AT 12 T AND 4.2 K HAS BEEN MODERATELY REDUCED FROM 3000 A/MM2 TO 2500 A/MM2 OF NON-COPPER, AND THE STRAND DIAMETER REDUCED FROM 1.25 MM TO 1 MM. THIS RESULTED IN CABLES WITH LOWER DEGRADATION, IMPROVED MARGIN WITH RESPECT TO SELF-FIELD INSTABILITY AND BETTER COIL WINDING PROPERTIES. IN THIS PAPER WE JUSTIFY THE CHOICES MADE, PRESENT OUR STATE-OF-THE-ART, AND GIVE AN OUTLINE OF THE PROCUREMENT AND PERFORMANCE TARGETS FOR THE COMING YEARS.

5LX-03

CONDUCTOR DEVELOPMENT FOR ACCELERATOR MAGNETS *E. BARZI*[1]*,* ***N. ANDREEV***[1]*, M. LAMM*[1]*, V. LOMBARDO*[1]*, D. TURRIONI*[1]*, A. RUSY*[1]*, R. YAMADA*[1]*, A. V. ZLOBIN*[1]*, L. MOTOWIDLO*[2]*;* [1]FERMILAB, [2]SUPRAMAGNETICS INC.. — A FUNDAMENTAL PART OF THE R&D IN SUPERCONDUCTING ACCELERATOR MAGNETS IS THE DEVELOPMENT AND STUDY OF ELECTRICAL, MECHANICAL AND THERMAL PROPERTIES OF THE SUPERCONDUCTING STRANDS AND CABLES. A NUMBER OF BRITTLE SUPERCONDUCTORS INCLUDING NB3SN OF VARIOUS DESIGNS, NB3AL, MGB2 AND YBCO COATED CONDUCTOR WERE USED TO MAKE RUTHERFORD-TYPE AND 6 AROUND 1 ROUND CABLES OF VARIOUS GEOMETRIES. THE DEVELOPMENT AND TEST OF CABLES TO BE USED IN MAGNET MODELS AIM AT REDUCING DEGRADATION OF TRANSPORT PROPERTIES, AND AT QUANTIFYING THE EFFECT OF THE TRANSVERSE PRESSURE CONVEYED TO THE CABLE DURING MAGNET FABRICATION AND OPERATION. SHORT SAMPLES OF DIFFERENT CABLES WERE DESIGNED AND FABRICATED WITHIN A RANGE OF PACKING FACTORS TO COMPARE RESULTS OF IC MEASUREMENTS MADE ON ROUND VIRGIN STRANDS WITH THOSE MADE ON EXTRACTED STRANDS AND ON CABLES. FINALLY CABLES WERE TESTED USING A SUPERCONDUCTING TRANSFORMER AND RESULTS COMPARED TO THOSE OF THE EXTRACTED STRANDS. THESE STUDIES HAVE ALLOWED FURTHER ADVANCES IN STRAND DEVELOPMENT FROM INDUSTRY, AND HAVE PRODUCED THE MOST APPROPRIATE CABLES TO BE USED IN MAGNETS.

THIS WORK WAS SUPPORTED BY DOE

5LX-04

CRITICAL CURRENT AND STABILITY OF HIGH-JC NB_3SN RUTHERFORD CABLES FOR ACCELERATOR MAGNETS ***W. DE RAPPER***[1]*, R. OBERLI*[2]*, B. BORDINI*[2]*, E. TAKALA*[2]*, H. TEN KATE*[1]*;* [1]CERN/UNIVERSITY OF TWENTE, [2]CERN. — IN THE FRAMEWORK OF FUTURE LHC UPGRADES USING NB_3SN MAGNETS, SUPPORTED IN PART BY THE U.S. LHC ACCELERATOR RESEARCH PROGRAM (LARP) AND THE EUROPEAN EUCARD PROGRAMS, CERN IS INTENSIFYING ITS RESEARCH ON NB_3SN RUTHERFORD CABLES. IN THE FRESCA CABLE TEST FACILITY AT CERN THREE NEW NB_3SN CABLE SAMPLES WERE INVESTIGATED CONCERNING THEIR QUENCH CURRENT AND STABILITY PERFORMANCE. THE THREE SAMPLES ARE BASED ON RRP STRANDS WITH COMPARABLE LAYOUT. TWO CABLES HAVE 27 STRANDS WITH 0.7 MM DIAMETER WHILE THE STRANDS HAVE 54 OR 108 SUPERCONDUCTING SUB-ELEMENTS. THE THIRD CABLE HAS 18 STRANDS WITH 1.0 MM DIAMETER WITH 108 SUB-ELEMENTS. THE CABLES HAVE A WIDTH OF 10 MM AND HAVE TRANSPOSITION PITCHES IN THE 65-75 MM RANGE. THE FIRST TWO CABLES ARE USED IN MAGNETS BUILT FOR LARP WHILE THE THIRD CABLE IS MADE FOR THE SHORT MODEL COIL (SMC) PROGRAM AT CERN.THE PERFORMANCE OF THE CABLES IS MEASURED AS A FUNCTION OF THE BACKGROUND MAGNETIC FIELD UP TO 10 T WITH RAMP RATES OF 10 TO 1000 A/S AND OPERATING TEMPERATURE OF 1.9 AND 4.3 K. A HALL PROBE ARRAY IS USED TO STUDY THE CURRENT DISTRIBUTION IN THE CABLES AND WITH HEATERS THE CABLE STABILITY AND CURRENT REDISTRIBUTION ARE STUDIED.THIS PAPER REPORTS ON THE PERFORMANCE OF THE CABLES ACROSS THE MAGNETIC FIELD RANGE (SHOWING LIMITED STABILITY AT LOW FIELDS AND CRITICAL CURRENT AT AROUND 8-10T). EFFECTS OF A CHANGE IN STRAND LAYOUT AND DIAMETER IN SIMILAR CABLE GEOMETRY ARE DEMONSTRATED.

5LY-01

ENDESA SUPERCABLE, A 3.2 KA, 138 MVA, MEDIUM VOLTAGE SUPERCONDUCTING POWER CABLE ***R. SOIKA***[1]*, X. GRANADOS GARCIA*[2]*, S. CASCANTE NOGALES*[3]*;* [1]NEXANS DEUTSCHLAND GMBH, [2]ICMAB-CSIC, [3]ENDESA. — NEXANS AND ICMAB HAVE COLLABORATED ON THE ENDESA SUPERCABLE PROJECT, A 30 M LONG, MEDIUM-VOLTAGE SUPERCONDUCTING AC POWER CABLE. THE CABLE WAS DEVELOPED AND MANUFACTURED

WITHIN THE FRAMEWORK OF THE ENDESA NOVARE PROGRAM. WITH A RATED CURRENT OF 3200 A, A SYSTEM BASED ON THIS CABLE CAN TRANSMIT 138 MVA AT ITS ENVISIONED OPERATING VOLTAGE OF 25 KV.THE CABLE HAS SUCCESSFULLY PASSED ALL HIGH VOLTAGE AND LOAD CYCLE TESTS. THE LOAD CYCLES CONSISTED OF TEN 24-HOUR CYCLES DURING WHICH, WITH A VOLTAGE OF $2*U_0$ APPLIED FOR THE FULL DURATION OF THE 10 TEST CYCLES, THE RATED CURRENT OF 3200 A WAS APPLIEDFOR 8 HOURS, OR 1/3 OF THE TIME OF A SINGLE CYCLE. THE AC LOSSES OF THE CABLE WERE ALSO MEASURED. WHILE THE CABLE WAS DESIGNED FOR 25 KV, TESTING HAS BEEN PERFORMED AT 20KV, A VOLTAGE LIMITED BY THE TERMITATIONS AVAILABLE THAT WERE RATED FOR THE 20 KV CLASS.THE SUCCESSFUL PROTOTYPE TESTING OF THE CABLE CONFIRMED THE DESIGN, MANUFACTURING, AND PERFORMANCE OF THIS HIGH TRANSMISSION CAPACITY CABLE: TO OUR KNOWLEDGE, IT IS THE HIGHEST AMPACITY POWER CABLE SO FAR THAT HAS PASSED THE RIGOROUS LOAD CYCLE TEST PROTOCOL OF A SIMILARLY RATED CONVENTIONAL CABLE.

5LY-02

DEVELOPMENT OF 275 KV 3 KA HTS POWER CABLE ***S. MUKOYAMA***[1]*, M. YAGI*[1]*, T. YONEMURA*[1]*, T. NOMURA*[1]*, N. FUJIWARA*[2]*, Y. ICHIKAWA*[2]*, Y. AOKI*[3]*, T. SAITOU*[4]*, N. AMEMIYA*[5]*, A. ISHIYAMA*[6]*, N. HAYAKAWA*[7]*;* [1]FURUKAWA ELECTRIC, [2]ISTEC SRL, [3]SHOWA CABLE SYSTEM, [4]FUJIKURA, [5]KYOTO UNIVERSITY, [6]WASEDA UNIVERSITY, [7]NAGOYA UNIVERSITY. — HTS CABLES ARE EXPECTED TO BE NEXT GENERATION TRANSMISSION LINE BECAUSE OF THE COMPACT, LIGHTWEIGHT, LARGE CAPACITY, AND LOW LOSS FEATURES. ESPECIALLY, SINCE THE YBCO WIRE HAS A HIGH CRITICAL CURRENT, HIGH MAGNETIC-FIELD PROPERTY, LOW AC LOSS, AND LOW COST, USING YBCO WIRES FOR A HTS CABLE SEEMS TO BE ONE OF THE MOST PROMISING WAYS TO MAKE THE HTS CABLE ATTRACTIVE. WE STARTED TO DEVELOP THE 275 KV CLASS HTS CABLES THAT WILL BE USED FOR FUTURE LARGE CAPACITY LINES BASED ON THE NEEDS OF JAPANESE TRANSMISSION NETWORKS FOR BULK TRANSMISSION POWER. THE FOLLOWING TECHNICAL DEVELOPMENTS WILL BE CARRIED OUT; HIGH CURRENT AND LOW AC LOSS CABLE CONDUCTOR, AND HIGH VOLTAGE INSULATION AND LOW DIELECTRIC LOSS CABLE. REGARDING HIGH CURRENT AND LOW AC LOSS CABLE CONDUCTOR, 3KA CABLES HAVE BEEN FABRICATED AND THE AC LOSSES HAVE BEEN MEASURED. WE FOUND THAT USING THIN YBCO WIRES MAKES AC LOSSES REDUCE FROM EXPERIMENTS. WE ALSO HAVE INVESTIGATED INSULATION MATERIALS SUCH AS DIELECTRIC LOSS PROPERTIES, MECHANICAL PROPERTIES, PARTIAL DISCHARGE (PD) PROPERTIES, AND WITHSTANDING VOLTAGE PROPERTIES. POLYPROPYLENE LAMINATED PAPER IS WELL-BALANCED PAPER FOR HIGH VOLTAGE WITHSTANDING AND LOW DIELECTRIC LOSS CABLE. BASED ON THESE R&D ACHIEVEMENTS, DEMONSTRATION OF 30 M 275KV/3KA HTS CABLE IS PLANNED IN NEXT STEP FROM 2011.THIS WORK WAS SUPPORTED BY THE NEW ENERGY AND INDUSTRIAL TECHNOLOGY DEVELOPMENT ORGANIZATION (NEDO).

5LY-03

ANALYSIS OF CURRENT LIMIT CHARACTERISTIC ON 110KV HTS CABLE ***Q. SUN****, H. ZHANG, H. LIU, Y. WANG;* NORTH CHINA ELECTRIC POWER UNIVERSITY. — THE CURRENT LIMIT CHARACTERISTIC OF HIGH TEMPERATURE SUPERCONDUCTING (HTS) CABLE IS ONE OF RESEARCH TOPICS IN THE APPLICATION OF SUPERCONDUCTING CABLE. THIS PAPER DISCUSSES THE NONLINEAR IMPEDANCE CHARACTERISTICS OF HTS CABLE AND THE EFFECT ON THE CHANGE OF OVER-CURRENT DURING THE TRANSIENT PROCESS OF POWER SYSTEM. FURTHERMORE, CURRENT LIMIT CHARACTERISTIC OF HTS CABLE IS ANALYZED THEORETICALLY, AND THE SIMULATION DEMONSTRATES THAT THE HTS CABLE HAS AN OBVIOUS GREATER CURRENT LIMIT EFFECT COMPARED WITH THE CONVENTIONAL CABLE. IT COULD LIMIT THE AMPLITUDE OF FAULT CURRENT IN THE FIRST AND SECOND CYCLE AFTER THE FAULT HAPPENS. THE INFLUENCE ON THE ATTENUATION PROCESS OF SYSTEM FAULT CURRENT AND CURRENT LIMIT CHARACTERISTICS RESULT FROM THE CHANGE OF SUPERCONDUCTING CABLE PARAMETERS.AND THE RESULT WOULD PROVE THAT THE AMPLITUDE OF FAULT CURRENT COULD BE LIMITED BY HTS CABLE DURING THE SYSTEM TRANSIENT PROCESS, BUT THE QUENCH LEAD BY THAT MIGHT AFFECT THE ACT OF RECLOSING AFTER THE CLEAN-OUT OF FAULT.KEY WORDS: HIGH TEMPERATURE SUPERCONDUCTING (HTS) CABLE, TRANSIENT PROCESS, IMPEDANCE CHARACTERISTICS, CURRENT LIMIT CHARACTERISTIC, QUENCH.

5LY-04

CONCEPTUAL DESIGN OF A SUPERCONDUCTING POWER TRANSMISSION CABLE FOR SPECIALIZED HIGH POWER APPLICATIONS ***T. J. HAUGAN****, P. N. BARNES;* U.S. AIR FORCE RESEARCH LABORATORY. — THE DESIGN OF A SUPERCONDUCTING ELECTRICAL POWER TRANSMISSION SYSTEM WAS STUDIED FOR SPECIALIZED HIGH POWER APPLICATIONS, INCLUDING AIRBORNE WITH OPERATING VOLTAGE FIXED AT 270 VOLTS AND LESS THAN 30 METER LENGTH. A CRYOGENIC-BASED SYSTEM FOR EITHER DC OR AC 60 HZ TRANSMISSION WAS DESIGNED USING COMMERCIAL-OFF-THE-SHELF (COTS) PARTS INCLUDING BI-SR-CA-CU-O OR Y-BA-CU-O SUPERCONDUCTING WIRES, CRYOGENIC VACUUM LINES, AND MINIATURIZED CRYOCOOLERS. THE PERFORMANCE OF THE SUPERCONDUCTING SYSTEM WAS COMPARED TO CU WIRES. FOR 5 MW-CLASS OR 20 KA POWER TRANSMISSION IN DC MODE AT 270 VOLTS, THE SYSTEM PERFORMANCE WAS STRONGLY IMPROVED BY REDUCING WEIGHT ~ 80KG/METER, REDUCING HEAT LOSS ~ 1KW/METER, AND REDUCING VOLUME ~10X. A CROSS-OVER POINT EXISTS IN THE DESIGN AT ABOUT 1-2 KA, ABOVE WHICH THE ADVANTAGES OF THE CRYOCOOLED SYSTEM ARE REALIZED. THE CROSSOVER POINT, HOWEVER DEPENDS ON THE SPECIFICS OF THE DESIGN AND TRADEOFF PARAMETERS, AND PARTICULARLY THE CABLE ARCHITECTURE AND THE SIZE AND WEIGHT OF THE CRYOGENIC VACUUM TUBING CHOSEN. THE DESIGNS AND ANALYSIS WILL BE PRESENTED.

AIR FORCE OFFICE SCIENTIFIC RESEARCH

5LY-05

SYSTEM OPTIMIZATION CALCULATIONS FOR A PULSE OR RAMP DC YBCO CABLE WITH CONDUCTION OR GAS COOLING ***M. D. SUMPTION;*** THE OHIO STATE UNIVERSITY. — IN THIS WORK WE USED ANALYTIC EXPRESSIONS AND GENERAL CONSIDERATIONS TO CALCULATE THE LOSSES AND MINIMUM CABLE AND SYSTEM VOLUMES FOR PULSE OR RAMP DC YBCO CABLES UNDER VARIOUS CONDITIONS. WE PARAMETERIZED VARIOUS COMPONENTS OF THE SYSTEMS, INCLUDING THE TEMPERATURE DEPENDENCE OF J_C, THE CRYOSTAT VOLUMES AND LOSSES AS A FUNCTION OF RADIUS, AND THE CABLE LOSS AND CAPACITY AS A FUNCTION OF CABLE SIZE. WE THEN COMPARED THE PARAMETERS OF CU BASED SYSTEMS, TRANSMISSION-LIKE SINGLE LAYER SYSTEMS, AND ROEBEL SYSTEMS, IN TERMS OF TOTAL MASS, VOLUME, YBCO TAPE CONSUMPTION, OPERATING TEMPERATURE, AND LOSS GENERATION. AFTER THIS, WE CONSIDERED AND COMPARED SOME INITIAL CONSIDERATIONS ABOUT SYSTEM COOLING, ASSUMING IN THIS CASE EITHER CONDUCTION OR CRYOGENIC HELIUM GAS CONVECTION. FINALLY, WE COMPARED SYSTEM PARAMETERS FOR A NUMBER OF DIFFERENT WAVE FORM, RAMP RATE, AND DUTY CYCLES. A COMPARISON TO AN FEM BASED MODEL AT A FEW SPECIFIC DESIGN POINTS IS THEN USED TO DISCUSS THE LIMITATIONS OF THIS APPROACH.

5LY-06

YBCO COATED CONDUCTOR CABLING FOR LOW AC-LOSS AND HIGH-FIELD MAGNET APPLICATIONS ***D. VAN DER LAAN[1], F. DOUGLAS[1], R. DUCKWORTH[2], T. HA[2], Y. ZHANG[2], V. SELVAMANICKAM[3];*** [1]NIST, [2]ORNL, [3]UNIVERSITY OF HOUSTON. — THE NEXT GENERATION OF HIGH-FIELD MAGNETS FOR HIGH-ENERGY PHYSICS AND FUSION APPLICATIONS REQUIRE OPERATING FIELDS THAT CANNOT BE REACHED WITH LOW-TEMPERATURE SUPERCONDUCTORS, SUCH AS NBTI OR NB3SN; THUS, HIGH-TEMPERATURE SUPERCONDUCTORS OPERATING AT 4-30 K NEED TO BE CONSIDERED TO REACH THESE GOALS. A NEW METHOD TO CABLE YBA2CU3O7-DELTA COATED CONDUCTORS HAS BEEN DEVELOPED, WHICH ALLOWS FOR FULL TRANSPOSITION OF THE INDIVIDUAL CONDUCTORS, A HIGH CABLE CRITICAL CURRENT, LOW INDUCTANCE, AND A RELATIVELY HIGH ENGINEERING CURRENT DENSITY, WHICH ARE REQUIREMENTS FOR MANY OF THESE APPLICATIONS. THE FEASIBILITY OF THE CONCEPT HAS BEEN DEMONSTRATED BY CONSTRUCTING SEVERAL SINGLE- AND MULTI-LAYER CABLES, 20 TO 40 CM LONG, WITH VARIOUS TWIST PITCHES OF THE INDIVIDUAL TAPES. THE CRITICAL CURRENT OF THE CABLES IS MEASURED AT 76 K AS A FUNCTION OF CABLE BENDING RADIUS. TRANSPORT AC-LOSS MEASUREMENTS WERE ALSO CARRIED OUT AT 77 K AND 60 HZ TO DETERMINE THE INFLUENCE OF PITCH LENGTH AND BENDING RADIUS ON AC-LOSS.

THIS WORK WAS SUPPORTED IN PART BY THE U.S. DEPARTMENT OF ENERGY, OFFICE OF ELECTRICITY DELIVERY AND ENERGY RELIABILITY.

5LY-07

ALTERNATIVE DESIGN CONCEPTS FOR MULTI-CIRCUIT HTS LINK SYSTEMS ***A. BALLARINO;*** CERN. — SUPERCONDUCTING CABLES FOR POWER TRANSMISSION USUALLY CONTAIN TWO CONDUCTORS FOR DC APPLICATION, OR THREE CONDUCTORS FOR AC, WITH HIGH VOLTAGE INSULATION. IN CONTRAST, FOR SOME APPLICATIONS RELATED TO ACCELERATORS IT IS CONVENIENT TO TRANSFER HIGH CURRENTS VIA SUPERCONDUCTING LINKS FEEDING A NUMBER OF CIRCUITS AT RELATIVELY LOW VOLTAGE, OF THE ORDER OF A KILOVOLT, OVER DISTANCES OF UP TO A FEW HUNDRED METERS. FOR POWER TRANSMISSION APPLICATIONS BASED ON COOLING VIA SUB-COOLED LIQUID NITROGEN, SUITABLE HTS CONDUCTORS ARE ONLY AVAILABLE IN THE FORM OF TAPE, AND A MULTI-LAYER VARIANT CAN BE ENVISAGED FOR THE MULTI-CIRCUIT LINKS. HOWEVER, WHERE COOLING TO TEMPERATURES OF THE ORDER OF 20 K IS FEASIBLE, MGB_2 CONDUCTOR, AVAILABLE IN THE FORM OF BOTH TAPE AND WIRE, CAN ALSO BE ENVISAGED AND IN THE LATTER CASE USED TO ASSEMBLE ROUND CABLES. THERE ARE, THEREFORE, TWO DISTINCT TOPOLOGIES THAT CAN BE ENVISAGED FOR USE IN APPLICATIONS TO MULTI-CIRCUIT LINK SYSTEMS. IN THIS PAPER THE MERITS OF THE TWO APPROACHES ARE COMPARED, AND CASE STUDIES RELATED TO APPLICATIONS TO THE LHC ARE PRESENTED.

5LY-08

NAVAL SHIP TO SHORE HIGH TEMPERATURE SUPERCONDUCTING POWER TRANSMISSION CABLE FEASIBILITY ***P. FERRARA,*** *J. KEPHART, B. FITZPATRICK, N. SPIVEY, J. PIENKOS, M. PYRYT, M. UVA;* NAVAL SURFACE WARFARE CENTER - CARDEROCK DIVISION. — THE US NAVY IMPLEMENTED “COLD IRONING” DECADES AGO TO REDUCE WEAR ON SHIPBOARD POWER GENERATION EQUIPMENT. “COLD IRONING” IS THE SITUATION WHEN A SHIP IS RECEIVING POWER FROM THE SHORE SO IT DOES NOT HAVE TO RUN ITS ENGINES ALLOWING THE VESSEL TO RUN “COLD”. THIS SERVES AS AN ECONOMICAL WAY TO KEEP SHIP SYSTEMS IN OPERATION BY USING LAND BASED GENERATED POWER. WHILE THE SHIP IS WAITING TO BE CONNECTED TO SHORE POWER, THE GENERATORS MUST REMAIN ACTIVE, CONTINUE TO BURN FUEL, AND REQUIRE THE SHIP’S ENGINEERING SUPPORT CREW.THE PROCESS TO ATTACH A SHIP TO SHORE POWER IS TO USE NUMEROUS COPPER CABLES EXTENDING FROM POWER STATIONS ON THE PIER TO RECEPTACLES ON BOARD THE SHIP. THE COPPER CABLES ARE CUMBERSOME, HEAVY, AND HARD TO HANDLE. THE WEIGHT OF THE CABLES REQUIRES A COORDINATED EFFORT BETWEEN A CREW ON THE PIER, AND A CREW ON THE SHIP. IN MANY INSTANCES HANDLING THESE CABLES REQUIRES THE USE OF A CRANE, OR A BOOM TRUCK, TO GET THEM FROM THE PIER SIDE POWER STATIONS UP TO THE SHIP’S CONNECTION POINT.A FEASIBILITY STUDY HAS BEEN CONDUCTED TO INVESTIGATE USING HTS CABLES TO TRANSMIT POWER FROM LAND BASED POWER STATIONS TO NAVAL SHIPS. SINCE A SINGLE HTS CABLE CAN REPLACE AN ARRAY OF COPPER CABLES THE TIME ASSOCIATED WITH CONNECTING THE SHIP TO SHORE POWER CAN BE DECREASED, AND CAN REDUCE THE AMOUNT OF TIME THE SHIP HAS TO RUN ITS GENERATORS. THE DIFFERENCE IN WEIGHT WILL ALSO INCREASE SAFETY FOR THE PERSONNEL HANDLING THE CABLES.

THE AUTHORS WOULD LIKE TO ACKNOWLEDGE THE SUPPORT PROVIDED BY THE OFFICE OF NAVAL RESEARCH, NAVAL FACILITIES ENGINEERING COMMAND, NAVAL STATION NORFOLK, AND MR. DENIS COLAHAN.

5LZ-01

RECENT DEVELOPMENTS IN 2G HTS COIL TECHNOLOGY ***D. HAZELTON****;* SUPERPOWER, INC.. — RECENT DEVELOPMENTS IN 2G HTS COIL TECHNOLOGY ARE PRESENTED HIGHLIGHTING THE ABILITY OF 2G HTS WIRE TO FUNCTION UNDER VARYING OPERATING CONDITIONS WITHOUT DEGRADATION. THE CHALLENGES OF USING 2G HTS WIRE IN VARIOUS COIL CONSTRUCTIONS AND APPLICATIONS ARE DISCUSSED. SEVERAL APPLICATIONS WHERE THE CONDUCTOR IS SUBJECTED TO DEMANDING OPERATIONAL PERFORMANCE REQUIREMENTS INCLUDE INSERT COILS AND HIGH SPEED ROTATING MACHINERY. RECENT COILS HAVE TAKEN ADVANTAGE OF THE ADVANCES IN 2G HTS CONDUCTOR WITH ADVANCED PINNING THAT PROVIDES FOR IMPROVED IN FIELD PERFORMANCE OF THE CONDUCTOR. THESE ADVANCEMENTS, AS WELL AS THE ABILITY OF THE WIRE TO BE TAILORED (STABILIZATION, INSULATION, AC LOSSES) TO FIT VARIOUS OPERATING PARAMETERS WILL ALSO BE DISCUSSED.

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5LZ-02

A BI-2223 LAYER-WINDING COIL USING 550M TAPE INCLUDING A JOINT INSIDE THE WINDING ***H. KITAGUCHI****[1], T. HAYASHI[2], H. KUMAKURA[1];* [1]NATIONAL INSTITUTE FOR MATERIALS SCIENCE, [2]SUMITOMO ELECTRIC INDUSTRIES, LTD.. — PROGRESS IN BI-2223/AG CONDUCTORS IS REMARKABLE DUE TO THE CT-OP (CONTROLLED-OVERPRESSURE) SINTERING TECHNIQUE, WHICH IMPROVES I_C, MECHANICAL PROPERTIES, AND HERMETIC ABILITY AGAINST LIQUID COOLANT [1,2].IN ORDER TO DEMONSTRATE THE FEASIBILITY AND THE POTENTIAL OF BI-2223/AG TAPES FOR MAGNET APPLICATIONS, WE FABRICATED A SMALL LAYER-WOUND COIL USING BI-2223/AG/CU-ALLOY TAPES. WE USED TWO TAPES, 330M- AND 210M-PIECES, IN ORDER TO EXAMINE THE POSSIBILITY OF EXTENSION OF CONDUCTOR LENGTH THROUGH A LAP-JOINT INSIDE THE COIL. THESE TWO TAPES WERE SOLDERED WITHOUT REMOVING CU-ALLOY LAMINATION. THE WINDING HAS THE DIMENSIONS: INNER DIA. 57 MM, OUTER DIA. 89 MM, COIL HEIGHT: 154 MM, 2,355 TURNS. WE TESTED THIS COIL AT 4.2 K IN 0-12 T. THE TEST COIL CARRIED 193 A (0.1 MV/CM CRITERION) AND GENERATED 3.30 T IN THE AXIAL DIRECTION OF THE COIL IN EXTERNAL 12 T (15.3 T IN TOTAL). THE CRITICAL CURRENT IS CLOSE TO THE SHORT SAMPLE PERFORMANCE IN THE PERPENDICULAR FIELDS. SPLICE RESISTANCE AT THE JUNCTION STAYED ABOUT 1 MΩ AT 4.2 K.[1] N. AYAI, ET AL., IEEE TRANS. ON APPL. SUPERCOND. 19(2007), 3014-3017.[2] N. AYAI, ET AL., IEEE TRANS. ON APPL. SUPERCOND. 17(2007), 3075-3078.

5LZ-03

ISSUES WITH THE THERMAL PROCESSING OF BI-2212 WIND & REACT SOLENOIDS ***D. MYERS****, U. TROCIEWITZ, J. JIANG, Y. VIOUCHKOV, E. HELLSTROM, D. LARBALESTIER;* NATIONAL HIGH MAGNETIC FIELD LABORATORY. — PREVIOUS WORK ON BI-2212 WIND AND REACT COILS HAS REVEALED INCONSISTENCIES IN TRANSPORT PROPERTIES OF THE LAYERS THAT ARE LOCATED CLOSEST TO THE BORE TUBE OF THE COIL FORMER. SOMETIMES PROPERTIES ARE ENHANCED, SOMETIMES DEGRADED. THUS FAR, THESE COILS HAVE BEEN WOUND ON EITHER MACOR OR INCONEL COIL FORMERS, WHERE IT WAS FOUND THAT A VARIETY OF CHEMICAL REACTIONS OCCURS BETWEEN THE CONDUCTOR AND BORE TUBE THAT MAY CONTRIBUTE TO THE DEGRADATION OF TRANSPORT PROPERTIES. BESIDES THIS, STRAIN GRADIENTS AS A RESULT OF THE REACTION PROCESS MAY PLAY A ROLE AS WELL. IN THE CONTEXT OF OUR WORK WITHIN THE VERY HIGH FIELD SUPERCONDUCTING MAGNET COLLABORATION (VHFSMC), WE ARE SEEKING TO UNDERSTAND AND POTENTIALLY ELIMINATE THESE ISSUES. A SERIES OF SMALL TEST-COILS ARE BEING STUDIED THAT EMPLOY ALTERNATIVE SOLUTIONS FOR THE BORE TUBE, SUCH AS SINTERED ALUMINA. IN-FIELD TRANSPORT PROPERTIES AND MICROSTRUCTURAL PROPERTIES OF CROSS SECTIONS FROM THESES COILS WILL BE PRESENTED AND THE IMPLICATIONS ON THE USE OF STRUCTURAL MATERIALS IN BI-2212 COIL MANUFACTURING WILL BE DISCUSSED.

5LZ-04

FLUX PUMP FOR HTS MAGNETS ***C. HOFFMANN****[1], D. POOKE[2], D. CAPLIN[3];* [1]INDUSTRIAL RESEARCH LTD., [2]HTS-110 LTD., [3]IMPERIAL COLLEGE. — MAGNETS FABRICATED WITH HTS WIRE CAN NOT BE OPERATED IN A TRUE PERSISTENT MODE AS SUPERCONDUCTING JOINTING BETWEEN HTS WIRES HAS NOT BEEN ACHIEVED TO DATE. IN ORDER TO MAINTAIN A CONSTANT MAGNETIC FIELD IN A HTS MAGNET A POWER SUPPLY HAS TO BE PERMANENTLY EMPLOYED, WHICH THEN LEADS TO HEAT LOSSES IN THE CRYO-SYSTEM THROUGH THE EMPLOYMENT OF CURRENT LEADS. BY USING A FLUX PUMP THESE LOSSES CAN BE MINIMISED. WE PRESENT A NEW FLUX PUMP CONCEPT BASED ON 2G HTS WIRE. THIS DEVICE ENERGIZED AT 77K A 2.7MH 2G HTS DOUBLE-PANCAKE COIL TO ITS CRITICAL CURRENT OF 48A WITHIN 3 MINUTES. THE OPERATING PRINCIPLE WILL BE DESCRIBED, AND CURRENT RAMPING AND LONG-TERM CURRENT STABILITY DATA PRESENTED. CONSIDERING THE SIMPLICITY OF THE DEVICE AND THE POTENTIAL TO INCREASE THE GENERATED CURRENT TO 200A AND MORE, THIS NEW FLUX PUMP IS VERY PROMISING FOR HTS MAGNET APPLICATIONS.

5LZ-05

TRAPPED FIELD CHARACTERISTICS OF YBCO THIN PLATES AND BULK ANNULI FOR COMPACT NMR MAGNET APPLICATIONS ***S. HAHN****[1], S. BERMOND[1], D. PARK[1], S. KIM[2], J. BASCUÑÁN[1], J. VOCCIO[3], M. TOMITA[4], A. ZHUKOVSKY[1], Y. IWASA[1];* [1]MASSACHUSETTS INSTITUTE OF TECHNOLOGY, [2]OKAYAMA NATIONAL UNIVERSITY, [3]AMERICAN SUPERCONDUCTOR CORPORATION, [4]RAILWAY TECHNICAL RESEARCH INSTITUTE. — IN 2009, WE STARTED A 2-YEAR PROGRAM TO BUILD A

COMPACT NMR MAGNET ASSEMBLED FROM YBCO ANNULI, OF WHICH A TARGET NMR FREQUENCY IS 150 MHZ IN A ROOM-TEMPERATURE BORE OF 9 MM. THE MAGNET IS COMPRISED OF A STACK OF 1500 THIN PLATES AND 2 BULK ANNULI; THE THIN-PLATE STACK IS PLACED IN THE MIDDLE OF THE MAGNET WHILE EACH BULK ANNULUS AT THE TOP AND BOTTOM EXTENT OF THE MAGNET. THIS PAPER PRESENTS TRAPPED FIELD CHARACTERISTICS OF THE YBCO THIN PLATES AND BULK ANNULI, INDIVIDUALLY AND AS A STACK. MEASURED TRAPPED FIELDS ARE ANALYZED USING A NON-LINEAR FINITE ELEMENT METHOD IN ORDER TO ESTIMATE THE BEST ASSEMBLY ORDER OF THE PLATES. BASED ON MEASURED AND CALCULATED RESULTS, A FINAL DESIGN OF THE 150 MHZ COMPACT NMR MAGNET IS PRESENTED INCLUDING A CUSTOMIZED CRYOSTAT DESIGN.

THIS WORK IS SUPPORTED BY THE NATIONAL INSTITUTE OF BIOMEDICAL IMAGING AND BIOENGINEERING

5LZ-06

ACOUSTIC EMISSION IN A SUPERCONDUCTING FORCE-BALANCED HELICAL COIL ***S. NOMURA***[1], *K. TSUBOI*[1], *K. ITO*[1], *H. TSUTSUI*[1], *S. TSUJI-IIO*[1], *A. NINOMIYA*[2], *R. SHIMADA*[1]; [1]TOKYO INSTITUTE OF TECHNOLOGY, [2]SEIKEI UNIVERSITY. — FORCE-BALANCED COIL (FBC) IS A HELICALLY WOUND HYBRID COIL OF TOROIDAL FILED COILS AND A SOLENOID. THE FBC CAN SIGNIFICANTLY REDUCE THE REQUIRED MASS OF THE STRUCTURE FOR INDUCED ELECTROMAGNETIC FORCES. BASED ON THE FBC DESIGN, A SUPERCONDUCTING MODEL COIL USING NBTI STRANDS HAS BEEN DEVELOPED. THE CRITICAL COIL CURRENT AND THE CRITICAL MAGNETIC FILED AT 4.2 K ARE 552 A AND 7.1 T, RESPECTIVELY. THE HAND-MADE WINDINGS WERE NEITHER IMPREGNATED WITH EPOXY RESIN NOR REINFORCED WITH STAINLESS STEEL WIRES. FOUR TEST RUNS WERE CONDUCTED AT INTERVALS OF SEVERAL MONTHS WITH LIQUID HELIUM COOLING, INCLUDING SUPERCOOLED LIQUID HELIUM BASED ON THE SATURATED VAPOR PRESSURE. THE MODEL FBC MAINTAINED THE TRAINING PHENOMENA EVEN AFTER THE COIL WAS WARMED UP TO ROOM TEMPERATURE. AFTER 107 QUENCHES THE MAXIMUM QUENCH CURRENT WAS 492 A, CORRESPONDING TO 89% OF THE CRITICAL CURRENT, AND IT WAS SUCCESSFULLY EXCITED UP TO 6.3 T. IN THE THIRD AND FOURTH TEST RUNS, THE QUENCH PROPERTIES WERE INVESTIGATED USING ACOUSTIC EMISSION (AE) MEASUREMENTS. THIS STUDY MAINLY CONTRIBUTES TO ESTIMATING THE RELATIONSHIP BETWEEN THE PERFORMANCE AND THE HELICAL WINDING CONDITIONS OF THE MODEL FBC BASED ON THE AE SIGNALS.

5LZ-07

REDUCTION IN THE MAGNITUDE OF SCREENING CURRENT-INDUCED MAGNETIC FIELD FOR YBCO COILS ***Y. YANAGISAWA***[1], *H. NAKAGOME*[1], *T. TAKEMATSU*[2], *R. HU*[2], *T. TAKAO*[2], *D. UGLIETTI*[3], *T. KIYOSHI*[3], *M. TAKAHASHI*[4], *H. MAEDA*[4]; [1]GRADUATE SCHOOL OF ENGINEERING, CHIBA UNIVERSITY, [2]FACULTY OF SCIENCE AND TECHNOLOGY, SOPHIA UNIVERSITY, [3]SUPERCONDUCTING MATERIALS CENTER, NATIONAL INSTITUTE FOR MATERIALS SCIENCE, [4]SYSTEMS AND STRUCTURAL BIOLOGY CENTER, RIKEN. — IN A PREVIOUS PAPER [1], WE DEMONSTRATED THAT THE SCREENING CURRENT-INDUCED MAGNETIC FIELD FOR AN YBCO SOLENOID DEPENDS ON THE COIL SHAPE. IT CAUSES TWO MAJOR PROBLEMS FOR A HIGH FIELD MAGNET; (I) A TEMPORAL DRIFT OF THE CENTRAL MAGNETIC FIELD DUE TO ITS RELAXATION AND (II) A REDUCTION IN THE CENTRAL MAGNETIC FIELD. THE FORMER IS STABILIZED BY USING A CURRENT SWEEP REVERSAL TECHNIQUE [2], WHILE THE LATTER REMAINS UNSOLVED. IN THIS PAPER, WE INVESTIGATE A METHOD TO REDUCE THE MAGNITUDE OF SCREENING CURRENT-INDUCED MAGNETIC FIELD. BASED ON A NUMERICAL SIMULATION DESCRIBED IN THE PREVIOUS PAPER [1], IT IS DEMONSTRATED THAT THE RATIO OF THE YBCO TAPE WIDTH TO THE INNER DIAMETER OF THE SOLENOID IS AN IMPORTANT PARAMETER, DETERMINING THE MAGNITUDE OF SCREENING CURRENT-INDUCED MAGNETIC FIELD. A SMALL RATIO CORRESPONDS TO A SMALL FIELD. IF THE RATIO IS SUFFICIENTLY SMALL, THE SCREENING CURRENT INDUCED FIELD CAN BE DEGAUSSED BY RAMPING THE COIL CURRENT UP AND DOWN AROUND THE OPERATION CURRENT, SEVERAL TIMES, AS IN THE CASE OF ACCELERATOR MAGNET. FOR EXAMPLE, FOR A MINIMUM VOLUME DESIGN COIL, THE SCREENING CURRENT-INDUCED MAGNETIC FIELD IS AS SMALL AS -2 % OF THE CENTRAL MAGNETIC FIELD IF THE RATIO VALUE EQUALS TO 0.02, WHICH IS DEGAUSSED TO -0.3 % BY THE DEGAUSSING CURRENT CYCLE.[1] Y. YANAGISAWA ET. AL, TO BE PUBLISHED IN IEEE TRANS. APPL. SUPERCOND.[2] Y. YANAGISAWA ET. AL, PHYSICA C 469 (2009) 1996-1999.

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5MPA-01

THERMODYNAMIC PARAMETERS OF SMBA2CU3OX WITH VARYING OXYGEN CONTENT ***A. KORTYKA***[1], *R. PUZNIAK*[1], *A. WISNIEWSKI*[1], *H. W. WEBER*[2], *C. Y. TANG*[3], *X. YAO*[3], *K. CONDER*[4]; [1]INSTITUTE OF PHYSICS POLISH ACADEMY OF SCIENCES, [2]ATOMINSTITUT, VIENNA UNIVERSITY OF TECHNOLOGY, 1020 VIENNA, AUSTRIA, [3]DEPARTMENT OF PHYSICS, SHANGHAI JIAO TONG UNIVERSITY, SHANGHAI 200240, P. R. CHINA, [4]LABORATORY FOR DEVELOPMENTS AND METHODS, PAUL SCHERRER INSTITUTE, CH-5232 VILLIGEN PSI, SWITZERLAND. — THE INTRINSIC AND EXTRINSIC PROPERTIES OF HIGH TEMPERATURE SUPERCONDUCTORS STRONGLY DEPEND ON THE SUPERCONDUCTING CARRIER CONCENTRATION, WHICH CAN BE EASILY CONTROLLED BY VARYING THE OXYGEN CONTENT IN 123 COMPOUNDS. HOWEVER, THE DEPENDENCE OF THE THERMODYNAMIC PROPERTIES ON THE OXYGEN CONTENT WAS ONLY STUDIED IN DETAIL FOR THE Y123 COMPOUND AND IS NOT WELL KNOWN FOR OTHER 123 SUPERCONDUCTORS.WE REPORT ON THE DEPENDENCE OF THE INTRINSIC AND EXTRINSIC PROPERTIES ON THE OXYGEN CONTENT IN SM123 SINGLE CRYSTALS GROWN BY THE TOP SEEDED SOLUTION GROWTH TECHNIQUE. THE SPECIFIC OXYGEN CONTENT, CORRESPONDING TO T_C VARYING BETWEEN 41 AND 85 K, WAS OBTAINED BY A CONTROLLED OXYGENATION PROCESS. THE DC MAGNETIZATION MEASUREMENTS WERE MADE IN A 7 T SQUID MAGNETOMETER. BY APPLYING MAGNETIZATION

SCALING, $H_{C1}(T)$, K, $H_C(T)$, AND $H_{C2}(T)$ WERE DETERMINED. THE EXTRINSIC PARAMETERS H_{IRR}, $J_C(B)$, AND $F_{PIN}(B)$ WERE ASSESSED AS WELL. A TORQUE MAGNETOMETER WITH EXTERNAL MAGNETIC FIELDS OF UP TO 9 T WAS USED TO MEASURE THE ANGULAR DEPENDENCE OF THE TORQUE AND TO DETERMINE THE EFFECTIVE MASS ANISOTROPY. DESPITE THE VERY SIMILAR ANISOTROPIES OF SM123 AND Y123, THE FORMER SHOWS HIGHER CROSSOVER FIELDS WHICH ARE RELATED TO BETTER VORTEX PINNING IN THIS COMPOUND.

THIS WORK IS SUPPORTED BY THE EUROPEAN NESPA PROJECT AND BY THE POLISH RESEARCH PROJECTS NO. N N202 4132 33 AND N N202 2412 37.

5MPA-02

NEW APPROACHES FOR ENHANCEMENT OF J_C FOR RE123 MELT-SOLIDIFIED BULKS ***T. AKASAKA**, J. SHIMOYAMA, Y. ISHI, H. OGINO, K. KISHIO;* UNIVERSITY OF TOKYO. — TYPICAL RE123 MELT-SOLIDIFIED BULKS GROWN FROM SEED CRYSTALS ARE COMPOSED OF THE *A*- AND *C*-GROWTH REGIONS. THE CRITICAL CURRENT PROPERTIES, MICROSTRUCTURES AND CRYSTALLINITY ARE DIFFERENT BETWEEN THESE REGIONS PARTLY DUE TO DIFFERENCES IN THE UNDERCOOLING CONDITIONS. PARTICULARLY IN THE *A*-GROWTH REGION WHICH GROWS RADIAL DIRECTION FROM THE SEED CRYSTAL, J_C, T_C AND IRREVERSIBILITY FIELD OF Y123 BULKS WERE FOUND TO SYSTEMATICALLY DECREASE WITH AN INCREASE IN DISTANCE FROM THE SEED CRYSTAL IN OUR PREVIOUS STUDIES. IN ORDER TO ACHIEVE HOMOGENEOUS AND EXCELLENT CRITICAL CURRENT PROPERTIES IN WHOLE PART OF THE Y123 BULKS, WE HAVE DEVELOPED TWO EFFECTIVE METHODS, ONE IS CHANGING THE GROWTH DIRECTION BY PUTTING ND123 SEED CRYSTALS WITH THEIR *C*-AXIS PARALLEL TO THE SURFACE OF THE BULKS AND THE OTHER IS ADDITION OF POST-ANNEALING PROCESS UNDER REDUCING ATMOSPHERES AT ~800°C AFTER THE CRYSTAL GROWTH.FROM THE FORMER METHOD, WE HAVE FOUND THE *C*-GROWTH REGION GROWN TOWARDS RADIAL DIRECTION MAINTAINED HIGH J_C EVEN AT PARTS FAR FROM THE SEED CRYSTAL, RESULTED IN HIGH J_C PROPERTIES IN LARGER PART OF BULKS COMPARED TO THE CONVENTIONAL Y123 BULKS. THE LATTER METHOD ALSO IMPROVED HOMOGENEITY IN J_C OF THE BULK EVEN IN THE *A*-GROWTH REGION. CHANGES IN THE LATTICE CONSTANTS OF Y123 SUGGESTED THAT PARTIAL SUBSTITUTION OF Y FOR BA IN THE Y123 CRYSTAL WAS SUCCESSFULLY SUPPRESSED BY POST-ANNEALING IN REDUCING ATMOSPHERES.

5MPA-03

EFFECT OF NANO-SCALE OF $Y_2BA_4CUMO_Y$ (M:AG, CE) ADDITION IN BULK Y-BA-CU-O SUPERCONDUCTORS ***P. CHEN**[1], S. LIU[1], S. CHEN[2], I. CHEN[1], M. WU[3];* [1]DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING, NATIONAL CHENG KUNG UNIVERSITY, TAINAN, TAIWAN, [2]DEPARTMENT OF POLYMER ENGINEERING, NATIONAL TAIWAN UNIVERSITY OF SCIENCE AND TECHNOLOGY, TAIPEI, TAIWAN, [3]INSTITUTES OF PHYSICS, ACADEMIA SINICA, TAIPEI, TAIWAN. — THIS STUDY REPORT A METHOD TO PRODUCE HIGH CRITICAL CURRENT DENSITY YBCO BULK WITH REDUCED POROSITY BY ADDITION OF 1 MOL % NANO-SCALE $Y_2BA_4CUMO_Y$ (Y2411, M = AG, CE). WITH THE ADDITION OF 1 MOL % Y2411, CRITICAL CURRENT DENSITY (JC) OF YBCO BULK IS ~ 1.2×10^5 A/CM^2 COMPARED WITH THAT SAMPLE WITHOUT ADDITION IS ~ 3.0×10^4 A/CM^2, WHICH REFLECT ABOUT 4 TIMES ENHANCEMENT.Y2411 NANO-PARTICLES WERE PREPARED BY SOL-GEL PROCESS WITH METAL NITRATE WITH POLYACRYLIC ACID (PAA) SOLUTION AS PRECURSORS, FOLLOWED BY HEATING TO 1000^{O}C FOR 3HRS. XRD ANALYSIS INDICATED THAT THE PARTICLES ARE WELL CRYSTALLINE. IN THE AS-GROWN SAMPLE, WELL DISPERSED Y2411 NANO PARTICLES WERE OBSERVED IN THE Y123 MATRIX BY SEM AND EPMA. IN ADDITION, THE MICRO-SIZED Y211 AND ITS DISTRIBUTION DID NOT CHANGED BY THE ADDITION OF Y2411 NANO PARTICLES. AT LAST, WITH THE ADDITION OF Y2411, THE POROSITY OF YBCO WAS REDUCED TO LESS THAN 1 %, IN COMPARED WITH ~ 7~8 % IN TYPICAL YBCO BULK SAMPLES GROWN BY TOP-SEEDED MELT-TEXTURED METHOD. THIS REDUCTION OF POROSITY IS BELIEVED TO IMPROVE THEIR MECHANICAL PROPERTIES.

THIS STUDY WAS SUPPORTED BY THE NATIONAL SCIENCE COUNCIL, TAIWAN, REPUBLIC OF CHINA, UNDER CONTRACT NSC 96-2112-M-006-012-MY3.

5MPA-04

INFLUENCE OF MAGNETIC SECONDARY PHASES ON SUPERCONDUCTING AND MAGNETIC PROPERTIES OF MELT-TEXTURED $GDSR_2RUCU_2O_{8\text{-DELTA}}$ SAMPLES *R. CIANCIO[1], **M. GOMBOS**[2], S. PACE[2], M. POLICHETTI[2], A. VECCHIONE[2], D. ZOLA[2];* [1]UNIVERSITÀ DI SALERNO, DIP. FISICA "E.R.CAIANIELLO" AND CNR-IOM TRIESTE, [2]CNR-SPIN SALERNO AND UNIVERSITÀ DI SALERNO, DIP. FISICA "E.R.CAIANIELLO". — ALTHOUGH THEIR NATURE IS STILL DEBATED, SUPERCONDUCTING AND MAGNETICALLY ORDERED PHASES COEXIST IN THE SAME CELL IN $GDSR_2RUCU_2O_{8\text{-DELTA}}$ (GD1212). SPONTANEOUS VORTEX PHASE CREATION HAS BEEN HYPOTHESISED TO EXPLAIN MEISSNER EFFECT ABSENCE IN GD1212. THE UNAVAILABILITY OF SINGLE CRYSTALS MAKES RELEVANT THE FABRICATION OF MACROSCOPIC ORIENTED SAMPLES BY MELT TEXTURING TECHNIQUES TO FURTHER STUDY THIS MATERIAL.DUE TO ORIENTED DOMAINS SMALL SIZE IN SAMPLES PRODUCED SO FAR, A BETTER UNDERSTANDING OF MELTING REACTION IS NEEDED TO IMPROVE FABRICATION. FOR THIS PURPOSE, A SERIES OF GD1212 PELLETS WERE ANNEALED AT TEMPERATURES BELOW AND ABOVE THE MELTING POINT. TG-DTA IN O_2 ATMOSPHERE SHOWS COMPLEX OXYGEN ABSORPTION BEHAVIOUR AND A REACTION PEAK, ASSOCIATED TO DECOMPOSITION, NEAR 1070°C. XRD AND SEM, SUPPLEMENTED BY EDS, REVEAL PARTIAL MELTING AND THE PRESENCE OF DIFFERENT PHASES DEPENDING ON THE ANNEALING TEMPERATURE. SUSCEPTIBILITY AND MAGNETIZATION MEASUREMENTS SHOW GD1212 SUPERCONDUCTING AND MAGNETIC TRANSITIONS, BUT ALSO GD_2CUO_4 (GD214) MAGNETIC TRANSITION. GD214, COMING FROM GD1212 DECOMPOSITION, LIKELY PLAYS A ROLE IN VORTEX GENERATION.

5MPA-05

STRUCTURAL PARAMETERS AND GRANULARITY IN RUTHENOCUPRATES: IMPACT OF SR/GD AND SR/ND RATIO *A. ROY,* ***A. K. GHOSH****;* DEPARTMENT OF PHYSICS, JADAVPUR UNIVERSITY, KOLKATA 700032, INDIA. — SYNTHESIS OF HOMOGENEOUS BULK MATERIAL OF RUTHENOCUPRATE SUPERCONDUCTORS NEEDS SEVERAL STEPS OF THE SOLID STATE REACTION. IN THE PRESENT STUDY WE HAVE CHOSEN TWO TYPES OF RUTHENOCUPRATE SUPERCONDUCTING MATERIALS NAMELY RU-1212 AND RU-1222. BOTH SAMPLES ARE STUDIED IN THE PRESENCE OF ND AND GD IN (0.5, 0.5, 0) SITE. A COMMON ROUTE HAS BEEN FOLLOWED FOR THE SYNTHESIS OF THESE COMPOUNDS. ALL SAMPLES IN EVERY STEPS DURING THE SYNTHESIS ARE CHARACTERIZED BY XRD, SEM AND EDX. THE STUDY OF THE STRUCTURAL PARAMETERS AND THE GRAIN SIZE DISTRIBUTION ARE FOUND TO BE SENSITIVE TO THE STABILIZATION OF THE SR/ND AND SR/GD RATIO AND DISTRIBUTION. THE SENSITIVITY TO THE DILUTION OF THE RATIO IS CLEARLY OBSERVED IN INTERMEDIATE STEPS WHICH IN TURN AFFECTS PHYSICAL PROPERTIES AROUND THE PARACOHERENCE REGION. THE MECHANISM OF THE DILUTION AND ITS ROLE IN THE SYNTHESIS OF THE HOMOGENEOUS MATERIAL HAVE BEEN STUDIED IN DETAIL. TRANSPORT PROPERTIES AND MAGNETIC MEASUREMENT WOULD BE PRESENTED TO INVESTIGATE THE IMPACT ON SEVERAL SUPERCONDUCTING PARAMETERS RELATED TO THE TRANSITION REGION IN THESE RUTHENOCUPRATES.

AJAY KUMAR GHOSH WOULD LIKE TO ACKNOWLEDGE CSIR, INDIA FOR FINANCIAL ASSISTANCE THROUGH A PROJECT 03 (1132) 08/EMRII.

5MPA-06**QUANTITATIVE DETERMINATION OF SOLUBILITY AND DIFFUSIBILITY OF ZNO DOPANT IN THE LIQUID PHASE OF YBCO SUPERCONDUCTOR DURING TSMTG PROCESS** *C. WANG[1],* ***S. HUANG****[1], I. CHEN[1], M. WU[2];* [1]NATIONAL CHENG KUNG UNIVERSITY, [2]INSTITUTES OF PHYSICS, ACADEMIA SINICA, TAIPEI, TAIWAN. — DOPING IMPURITY INTO HIGH TEMPERATURE SUPERCONDUCTOR (HTS) MATRIX FOR FLUX PINNING USE IS THE GENERAL METHOD TO ENHANCE ITS CRITICAL CURRENT DENSITY (JC). AS THE NANO-TECHNOLOGY BECOMES MORE AND MORE MATURE RECENTLY, WE CAN OBTAIN THE DOPANT FOR HTS IN VARIOUS SIZE AND SHAPE AS OUR WISH. IN OUR PREVIOUS AND THE LATEST EXPERIMENTAL RESULTS, WE FOUND THAT DOPING DIFFERENT SIZE (NANO AND MICRO) AND SHAPE (PARTICLE AND ROD/WIRE) ZNO IN $Y_1BA_2CU_3O_{7-\Delta}$ (YBCO) BULK WILL CAUSE THEIR JC VALUES IN DIVERGENCE. IT ATTRIBUTE TO TWO REASONS. FIRSTLY, THE SMALLER PARTICLE HAS THE LARGER SURFACE AREA. SECONDLY, THE ROD/WIRE DOPANT CAN BE REGARDED AS THE 1-DIMENSIONAL PINNING CENTER WHICH IS SUPERIOR TO PARTICLE DOPANT (0-DIMENSION). IN ORDER TO MAKE SURE THESE TWO REASONS ARE RELIABLE, WE NEED TO MAKE SURE IF ZNO DO NOT RESOLVE IN MATRIX DURING TOP SEEDING MELT TEXTURING GROWTH (TSMTG) PROCESS. IN THIS STUDY, THE RESOLVING AND DIFFUSION STATUS OF ZN ELEMENT IN YBCO SAMPLE AT PERITECTIC TEMPERATURE WILL BE CONFIRMED. WE QUANTITATIVELY DETERMINE THE SOLUBILITY AND DIFFUSIBILITY OF ZNO DOPANT IN THE LIQUID PHASE OF YBCO. AND FINALLY WE CONFIRM THAT ZNO COMPOUND WILL REMAIN IN YBCO AFTER TSMTG PROCESS. THIS CONCLUSION CAN STAND FOR THE ADVANTAGE OF 1-DIMENSIONAL NANO-RODS DOPANT.

THIS STUDY WAS SUPPORTED BY THE NATIONAL SCIENCE COUNCIL, TAIWAN, REPUBLIC OF CHINA, UNDER CONTRACT NSC 96-2112-M-006-012-MY3

5MPB-01

ENHANCEMENT OF CRITICAL CURRENT DENSITIES AND TRAPPED FLUX OF GD-BA-CU-O BULK HTS DOPED WITH MAGNETIC ALLOY PARTICLES ***K. TSUZUKI****[1], S. HARA[1], Y. XU[1], M. MORITA[2], H. TESHIMA[2], O. YANAGISAWA[3], J. NOUDEM[3], C. HARNOIS[3], M. IZUMI[1];* [1]TOKYO UNIVERSITY OF MARINE SCIENCE AND TECHNOLOGY, [2]NIPPON STEEL CORPORATION, [3]ECOLE NATIONALE SUPERIEURE D'INGENIEURS DE CAEN. — FOR BULK HTS ROTATING MACHINES, ENHANCEMENT OF THE TRAPPED FLUX IS A SIGNIFICANT TASK TO ACHIEVE PRACTICAL APPLICATION WITH HIGH TORQUE DENSITY. THE INCREASE OF CRITICAL CURRENT DENSITY JC USING ARTIFICIAL PINNING CENTERS IS AN EFFICIENT TECHNIQUE TO OBTAIN HIGHER FLUX TRAPPING. WE ATTEMPTED TO ENHANCE BOTH JC AND TRAPPED MAGNETIC FLUX IN BULK HTS WITH MAGNETIC/FERROMAGNETIC SECOND PHASE MATERIALS ADDITIONS TO GENERATE HIGH QUALITY PINNING CORES. FE2O3 PARTICLES, SOFT MAGNETIC ALLOY PARTICLES (MP) AND COO PARTICLES ARE INTRODUCED TO THE GD123 MATRIX. THE MELT GROWTHS OF SINGLE-DOMAIN BULKS WITH DIFFERENT AMOUNTS OF MAGNETIC PARTICLES ADDITIONS WERE PERFORMED IN AIR. ENHANCEMENT OF THE CRITICAL CURRENT DENSITY JC AT 77 K WAS OBTAINED FOR FE2O3 AND MP ADDITIONS, WHILE THE TRANSITION TEMPERATURE OF 93 K WAS NOT DEGRADED. THE EXPERIMENT OF MAGNETIC FLUX TRAPPING WAS THEN CONDUCTED UNDER LN2 COOLING. IN THE BULK WITH 0.4 MOL% OF MP, THE MAXIMUM TRAPPED FLUX AND INTEGRATED MAGNETIC FLUX INCREASED BY 33 % AND 27 %, RESPECTIVELY. ON THE OTHER HAND, THE ADDITION OF COO PARTICLES RESULTED IN A REDUCTION OF BOTH JC AND TRAPPED MAGNETIC FLUX DENSITY. THESE RESULTS INDICATE THAT THE INTRODUCTION OF MAGNETIC ALLOY PARTICLES GIVES SIGNIFICANT EFFECT TO FLUX PINNING PERFORMANCE.

5MPB-02

PREPARATION AND PROPERTIES OF HIGH-QUALITY MELT GROWTH GD123 BULKS WITH LOW VOID DENSITY - FLEXURAL STRENGTH AT 77K - ***H. FUJIMOTO****[1], A. MURAKAMI[2];* [1]RAILWAY TECHNICAL RESEARCH INSTITUTE, [2]HIROSAKI UNIV.. — WE PREPARED A LARGE SINGLE DOMAIN OF MELT GROWTH GDBACUO (GD-123) SUPERCONDUCTING BULKS WITH LOW VOID DENSITY FOR FUTURE APPLICATIONS SUCH AS A SUPERCONDUCTING FLYWHEEL FOR ENERGY STORAGE SYSTEM, MAGNETIC SEPARATION, MOTOR, CURRENT LEAD, AND A BULK MAGNET. GD-123 SUPERCONDUCTORS ARE EXPECTED TO HAVE HIGH J_C AND TRAPPED MAGNETIC FIELD PROPERTIES, HOWEVER RE-123 SUPERCONDUCTORS ARE KNOWN TO INCLUDE A CERTAIN QUANTITY OF VOIDS DUE TO

THE MELT PROCESSES, LEADING TO LOW MECHANICAL STRENGTH. THEREFORE, IT IS VERY CRUCIAL TO UNDERSTAND MECHANICAL BEHAVIORS AND INCREASE MECHANICAL STRENGTH AS WELL AS ELECTRIC AND MAGNETIC PROPERTIES. MELT-TEXTURED SINGLE DOMAIN OF GD-123 SUPERCONDUCTOR ABOUT 30~46 MM IN DIAMETER AND 15 MM IN THICKNESS WITH LOW VOID DENSITY WAS FABRICATED WITH A SEEDING AND TEMPERATURE GRADIENT METHOD; FIRST MELT PROCESSED IN OXYGEN, THEN CRYSTAL GROWTH IN AIR. GD-123 AND GD-211 POWDERS WERE MIXED IN A MOLAR RATIO OF 3:1, AND AG_2O OF 10 WT% AND PT OF 0.5 WT% WERE ADDED TO THE MIXTURE. WE DISCUSS MECHANICAL PROPERTIES; THE FLEXURAL STRENGTH AND SUPERCONDUCTING PROPERTIES OF THE GD-123 BULK IN TERMS OF SIZE. THE RESULTS SHOW THAT THE FLEXURAL STRENGTH OF THE GD-123 AT ROOM TEMPERATURE WITH LOW VOID DENSITY IS 20 % LARGER THAN THAT OF THE GD-123 BULK WITH MELT PROCESSED IN AIR. WE DID NOT FIND ANY DISADVANTAGE IN SUPERCONDUCTING PROPERTIES FOR THE DENSIFIED GD123 BULK IN THIS STUDY.

THE AUTHORS WOULD LIKE TO THANK DR. H. TESHIMA AND DR. M. MORITA OF NIPPON STEEL CO. FOR SAMPLE PREPARATION AND USEFUL DISCUSSIONS.

5MPB-03

INFLUENCE OF OXYGEN HEAT TREATMENT FOR YBCO BULK OF 100 KWH CLASS SUPERCONDUCTOR FLYWHEEL ENERGY STORAGE SYSTEM BEARING ***B. J. PARK***[1]*, S. Y. JUNG*[1]*, C. H. KIM*[1]*, S. D. PARK*[2]*, S. G. DOO*[1]*, J. P. LEE*[1]*, B. C. PARK*[1]*, S. C. HAN*[1]*, Y. H. HAN*[1]*;* [1]KOREA ELECTRIC POWER RESEARCH INSTITUTE, [2]KOREA ATOMIC ENERGY RESEARCH INSTITUTE. — A SUPERCONDUCTOR FLYWHEEL ENERGY STORAGE SYSTEM (SFES) CONSISTS OF NON-CONTACTING HIGH TEMPERATURE SUPERCONDUCTOR (HTS) BEARINGS THAT PROVIDE VERY LOW FRICTIONAL LOSSES AND HIGH ENERGY STORAGE DENSITY WITH HIGH FLYWHEEL ROTATION SPEED. HTS BEARINGS MAINLY CONSIST OF SINGLE GRAIN YBCO BULKS AND OFFER DYNAMIC STABILITY WITHOUT THE USE OF ACTIVE CONTROL. STIFFNESS PROPERTY OF AN HTS BEARING IS THE MAIN INDEX FOR EVALUATING THE CAPACITY OF AN HTS BEARING AND IS DETERMINED BY THE INTERACTION BETWEEN THE HTS BULKS AND THE PERMANENT MAGNET (PM) ROTOR. IN THIS STUDY, IN ORDER TO IMPROVE BEARING STIFFNESS, WE INVESTIGATED THE EFFECT OF OXYGEN HEAT TREATMENT ON BEARING STIFFNESS OF THE YBCO BULKS. THE STIFFNESS OF AN OXYGENATED SINGLE GRAIN YBCO BULK WAS MEASURED AND THE SAMPLE SURFACE LAYER WAS REMOVED BY GRINDING AND STIFFNESS WAS MEASURED AGAIN. FINALLY, OXYGEN RETREATMENT ON THE SURFACE OF THE GRINDED YBCO BULK WAS PERFORMED AND STIFFNESS OF THE YBCO BULK WAS ALSO COMPARED WITH PREVIOUS DATA. AS A RESULT, IT WAS DISCOVERED THAT THE YBCO BULK STIFFNESS AFTER GRINDING WAS SIGNIFICANTLY INFLUENCED BY OXYGEN RETREATMENT. THE NEED FOR OXYGEN RETREATMENT TO IMPROVE A STIFFNESS PROPERTY IN HTS BEARINGS IS ALSO DISCUSSED IN THIS PAPER. THESE RESULTS ARE USED TO DETERMINE THE OPTIMAL DESIGN FOR A 100 KWH CLASS SFES.

THIS RESEARCH WAS SUPPORTED BY A GRANT FROM KOREA INSTITUTE ENERGY TECHNOLOGY EVALUATION AND PLANNING, REPUBLIC OF KOREA

5MPB-04

ANALYSIS OF TEMPERATURE AND MAGNETIC FIELD DISTRIBUTION IN SUPERCONDUCTING BULK DURING PULSED FIELD MAGNETIZATION ***H. FUJISHIRO****, T. NAITO, D. FURUTA;* IWATE UNIVERSITY. — A RE-BA-CU-O SUPERCONDUCTING BULK (RE: RARE EARTH ELEMENT OR Y) CAN TRAP HIGHER MAGNETIC FIELD, BT, USING A PULSED FIELD MAGNETIZATION (PFM). THE BT VALUE BY PFM IS, HOWEVER, PRETTY SMALLER THAN THAT BY THE FIELD-COOLED MAGNETIZATION (FCM) BECAUSE OF A LARGE HEAT GENERATION BY RAPID FLUX MOTION. WE HAVE INVESTIGATED EXPERIMENTALLY THE ENHANCEMENT OF BT BY PFM FROM THE MEASUREMENTS OF TEMPERATURE RISE AND FLUX MOVEMENT. TO EXPLORE THE DESIRED RESEARCH DIRECTION TO THE ENHANCEMENT OF BT BY PFM, IT IS NECESSARY TO ANALYZE BOTH THE FLUX DYNAMICS AND THE HEAT PROPAGATION THEORETICALLY. IN THIS PAPER, WE CONSTRUCTED THE FRAMEWORK OF THEORETICAL SIMULATION USING THE FINITE ELEMENT METHOD (FEM). THE RESULTS OF THE SIMULATION WELL REPRODUCED THE EXPERIMENTAL RESULTS OF THE TIME AND APPLIED-FIELD DEPENDENCE OF BT AND TEMPERATURE RISE. WE PROPOSE A POSSIBLE APPROACH TO ENHANCE THE BT VALUE IN THE HOMOGENEOUS BULK FROM THE VIEWPOINT OF THE THEORETICAL SIMULATION.

5MPB-05

DRILLED BULK HIGH-TEMPERATURE SUPERCONDUCTORS: ENHANCING THE TRAPPED MAGNETIC FLUX BY FILLING THE HOLES WITH A FERROMAGNETIC POWDER *G. P. LOUSBERG, J. FAGNARD, M. AUSLOOS, P. VANDERBEMDEN,* ***B. VANDERHEYDEN****;* UNIVERSITY OF LIEGE, BELGIUM. — FILLING THE HOLES OF A DRILLED BULK HIGH-TEMPERATURE SUPERCONDUCTOR (HTS) WITH A FERROMAGNETIC POWDER IS SHOWN TO ENHANCE ITS TRAPPING PROPERTIES. WE USE EXPERIMENTAL TECHNIQUES (HALL PROBE MAPPING TECHNIQUES AND MAGNETIZATION MEASUREMENTS) TO CHARACTERIZE THE MAGNETIC PROPERTIES OF DRILLED SAMPLES FILLED WITH A SOFT FERROMAGNETIC POWDER. THE ANALYSIS IS COMPLETED BY A NUMERICAL MODEL BASED ON A 3D FINITE-ELEMENT METHOD THAT INVOLVES A CONDUCTIVITY IN THE FORM OF A POWER LAW FOR THE SUPERCONDUCTING MATERIAL, AND A CONSTANT PERMEABILITY FOR THE FERROMAGNETIC MATERIAL. NUMERICAL RESULTS CONFIRM THE EXPERIMENTAL OBSERVATIONS, AND, IN PARTICULAR, THEY SUPPORT THE INCREASE OF TRAPPED FLUX AFTER IMPREGNATION (MAX. 40%) THAT IS OBSERVED WITH HALL PROBE MAPPINGS.

AUTHORS WOULD LIKE TO ACKNOWLEDGE THE FONDS DE LA RECHERCHE SCIENTIFIQUE (FRS-FNRS) OF BELGIUM FOR FINANCIAL SUPPORT

5MPB-06

EFFECT OF FILLER ON TRAPPED FIELD CHARACTERISTICS OF HTS BULKS WITH ARTIFICIAL HOLES ***G. JANG***[1]*, S. HAN*[2]*, C. KIM*[3]*, Y. HAN*[4]*, S. JUNG*[4]*, T. SUNG*[5]*;* [1]CHUNGBUK NATIONAL UNIVERSITY, [2]MASSACHUSETTS INSTITUTE OF TECHNOLOGY, [3]KOREA ATOMIC ENERGY RESEARCH INSTITUTE, [4]KOREA ELECTRIC POWER RESEARCH INSTITUTE, [5]HANYANG UNIVERSITY. — HIGH TEMPERATURE SUPERCONDUCTING (HTS) BULKS HAVE BEEN WIDELY USED IN VARIOUS MAGNETIC LEVITATION SYSTEMS SUCH AS FLYWHEEL ENERGY STORAGE. RECENTLY, A TECHNIQUE TO IMPLEMENT ARTIFICIAL HOLES IN THE HTS BULKS HAS BEEN STUDIED IN ORDER TO IMPROVE TRAPPED FIELD STRENGTH AND, AS A CONSEQUENCE, LEVITATION FORCE. THIS PAPER STUDIES EFFECT OF VARIOUS FILLER IN ARTIFICIAL HOLES ON TRAPPED FIELD CHARACTERISTICS OF HTS BULKS. TRANSIENT AS WELL AS STEADY-STATE BEHAVIOR OF TRAPPED FIELD IS EXAMINED WITH VARIOUS TEST SAMPLES. A NON-LINEAR FINITE ELEMENT METHOD IS ADOPTED TO ANALYZE THE TRAPPED FIELD CHARACTERISTICS AND PROVIDE A NUMERICAL APPROACH TO ESTIMATE TRAPPED FIELD STRENGTH AND LEVITATION FORCE IN HTS BULKS WITH DIFFERENT FILLER IN ARTIFICIAL HOLES.

THIS RESEARCH WAS SUPPORTED BY A GRANT (R-2005-1-393) FROM ELECTRIC POWER INDUSTRY TECHNOLOGY EVALUATION & PLANNING (ETEP), REPUBLIC OF KOREA.

5MPC-01**MPURITIES FORMATION AND ITS EFFECT ON FIELD DEPENDENT PROPERTIES IN THE NANO SIC DOPED MGB2** ***W. YEOH***[1]*, R. ZHENG*[1]*, S. RINGER*[1]*, S. CHEN*[2]*, J. MACMANUS-DRISCOLL*[3]*, X. XU*[4]*, W. LI*[1]*, S. DOU*[4]*;* [1]ELECTRON MICROSCOPE UNIT, UNIVERSITY OF SYDNEY, [2]PHYSICS DEPARTMENT, UNIVERSITI PUTRA MALAYSIA, [3]DEPARTMENT OF MATERIALS SCIENCE AND METALLURGY, UNIVERSITY OF CAMBRIDGE, [4]INSTITUTE FOR SUPECONDUCTING AND ELECTRONIC MATERIALS, UNIVERSITY OF WOLLONGONG. — IN THIS WORK, SIC POWDERS WERE MIXED WITH MG AND B AND REACTED IN EITHER A ONE-STEP *IN SITU* OR TWO-STEP METHOD. MICROSTRUCTURE ANALYSIS SHOWED THAT FORMATION OF VARIOUS IMPURITIES DEPENDS ON SEQUENTIAL INTRODUCTION OF SIC DOPING. MICROSCOPY RESULT INDICATED THAT ONE STEP PROCESSING SAMPLES SHOWED BETTER HOMOGENEITY WITH MAJOR IMPURITIES LIKE MGO AND MG_2SI COMPARED TO THE TWO STEP SINTERING SAMPLES WHERE IMPURITIES LIKE UNREACTED SIC, MGO, MG_2SI, MG(B,C) AND C WERE DETECTED. THE FORMATION OF IMPURITIES AND CARBON SUBSTITUTION (DUE TO DECOMPOSE OF SIC) HAS SUBSTANTIAL EFFECT ON FIELD DEPENDENT PROPERTIES LIKE THE CRITICAL CURRENT DENSITY AND THE UPPER CRITICAL FILED. FROM THE PINNING POINT OF VIEW, ONE STEP PROCESSING SAMPLES ONLY SHOWED STRONGER ENHANCEMENT OVER 4 T AT 6K BUT NOT ANY FIELD AT 20K. THE VARIATION WILL BE EXPLAINED IN TERMS OF CARBON SUBSTITUTION LEVEL, CRITICAL TEMPERATURE, ROOM TEMPERATURE RESISTIVITY, GRAIN SIZE, STRAIN EFFECT AND GRAIN CONNECTIVITY.

THE AUTHORS ACKNOWLEDGE THE FACILITIES AND TECHNICAL ASSISTANCE FROM STAFF AT AUSTRALIAN MICROSCOPY & MICROANALYSIS RESEARCH FACILITY (AMMRF) OF AT THE UNIVERSITY OF SYDNEY. THE PROJECT IS FUDNED BY AUSTRALIAN RESEARCH COUNCIL.

5MPC-02

INFLUENCE OF HEMOGLOBIN ADDITION ON SUPERCONDUCTING PROPERTIES OF HIGHLY DENSE MGB_2 BULK ***M. MAEDA***[1]*, Y. NAKAYAMA*[2]*, Y. ZHAO*[1]*, J. H. KIM*[1]*, Y. KUBOTA*[2]*, S. X. DOU*[1]*;* [1]INSTITUTE FOR SUPERCONDUCTING AND ELECTRONIC MATERIALS, UNIVERSITY OF WOLLONGONG, [2]COLLEGE OF SCIENCE AND TECHNOLOGY, NIHON-UNIVERSITY. — EFFECTS OF HEMOGLOBIN (HB) ADDITION ON SUPERCONDUCTING PROPERTIES OF HIGHLY DENSE MGB_2 BULK WERE INVESTIGATED. HB IS A HEME PROTEIN INCLUDING CARBON, IRON, HYDROGEN, NITROGEN, AND OXYGEN. ALL SAMPLES WERE SYNTHESIZED BY A TWO-STEP HEAT-TREATMENT WITHIN AN *IN SITU* MG DIFFUSIVE REACTION METHOD FOR THE PREPARATION OF NEAR-FULLY-DENSE MGB_2 BULKS. THE SELECTED AMOUNT OF HB FROM 0 % TO 10 % OF TOTAL WEIGHT OF MGB_2 WAS MIXED WITH AN APPRECIATE AMOUNT OF B POWDER IN AIR USING AN AGATE MORTAR. THE MIXTURES WERE PRESSED UNDER A PRESSURE OF 100 MPA INTO SLABS. THE SLABS AND MG POWDERS WERE SEALED IN TA TUBES FILLED WITH AR GAS. THE HEAT-TREATMENT OF SEALED TUBES EMPLOYED A SHORT HIGH TEMPERATURE SINTERING AT 1100 DEGREES C FIRST, FOLLOWED BY A LOW TEMPERATURE ANNEALING AT 710 DEGREES C. WE OBSERVED THAT THE ONSET OF DIAMAGNETISM AT 5 T FOR MGB_2 + 2.5 WT% HB SAMPLE WAS THE HIGHEST OF ALL SAMPLES. WE FOUND THAT HB ADDITION LED TO THE IMPROVEMENT OF CRITICAL CURRENT DENSITIES FOR MGB_2 MATERIALS.

5MPC-03

STRUCTURAL AND SUPERCONDUCTING PROPERTIES OF HIGHLY DENSE MGB_2 BULK WITH PYRENE ADDITION ***M. MAEDA***[1]*, Y. ZHAO*[1]*, J. H. KIM*[1]*, Y. NAKAYAMA*[2]*, Y. KUBOTA*[2]*, S. X. DOU*[1]*;* [1]INSTITUTE FOR SUPERCONDUCTING AND ELECTRONIC MATERIALS, UNIVERSITY OF WOLLONGONG, [2]COLLEGE OF SCIENCE AND TECHNOLOGY, NIHON-UNIVERSITY. — WE INVESTIGATED THE EFFECT OF PYRENE ($C_{16}H_{10}$) ADDITION ON STRUCTURAL AND SUPERCONDUCTING PROPERTIES OF HIGHLY DENSE MGB_2 BULK. WE USED AN *IN SITU* MG DIFFUSIVE REACTION METHOD FOR THE PREPARATION OF NEAR-FULLY-DENSE MGB_2 BULKS THAT ALSO PROVIDES VERY STRONG IN-FIELD PINNING. ALL SAMPLES WERE SYNTHESIZED BY A TWO-STEP TREATMENT COMBINING A SHORT PERIOD OF SINTERING AT 1100 DEGREES C WITH A FOLLOWING ANNEALING AT LOW TEMPERATURE. HIGH-ENERGY SYNCHROTRON RADIATION (SR) POWDER DIFFRACTION EXPERIMENT WAS CARRIED OUT USING A LARGE DEBYE-SCHERRER CAMERA EQUIPPED WITH AN IMAGING PLATE AS A HIGHLY SENSITIVE X-RAY DETECTOR AT THE EXPERIMENTAL HUTCH IN BL02B2 OF SPRING-8. THE SR POWDER DIFFRACTION PATTERNS FOR SAMPLES WERE ANALYZED BY THE RIETVELD METHOD TO REFINE STRUCTURAL

PARAMETERS OF MGB_2. THE RESISTIVITY CURVE AND CRITICAL CURRENT DENSITY PERFORMANCE OF THE SAMPLES WERE EXAMINED. WE HAVE FOUND THAT PYRENE IS EFFECTIVE FOR IMPROVING THE CRITICAL CURRENT DENSITY OF HIGHLY DENSE MGB_2 SUPERCONDUCTOR, EVEN USING AN *IN SITU* MG DIFFUSIVE REACTION METHOD.

5MPC-04

OPTIMISING THE METHOD OF INCORPORATING SI AND C INTO MGB2 *K. Y. TAN[1], **S. CHEN**[1], K. P. LIM[1], K. B. TAN[1], A. H. SHAARI[1], J. L. MACMANUS-DRISCOLL[2];* [1]UNIVERSITI PUTRA MALAYSIA, [2]UNIVERSITY OF CAMBRIDGE. — EITHER SIC OR SEPARATE SI AND C POWDERS WERE IN SITU REACTED WITH MGB2 AND THE SUPERCONDUCTING PROPERTIES COMPARED. ABOVE 5WT.% SIC ADDITION, A SMALLER A-AXIS LATTICE PARAMETER RESULTED COMPARED TO THE SAME LEVEL OF SI+C ADDITION, INDICATING A HIGHER LEVEL OF C SUBSTITUTION. AT 5K, A SIGNIFICANT IMPROVEMENT IN THE FIELD DEPENDENT CRITICAL CURRENT DENSITY, JC(H) WAS NOTICEABLE FOR SAMPLES REACTED WITH SIC OWING TO GREATER C SUBSTITUTION. AT BOTH 5K AND 20K, CO-ADDITION OF SI AND C CAUSED A GREATER DEGRADATION IN THE ORDER OF MAGNITUDE OF JC(H), WHICH CONCURS A LARGER FRACTION OF MG2SI IN THESE SAMPLES.

THIS WORK IS SUPPORTED BY THE UK PRIME MINISTER'S INITIATIVE 2 (PMI2) THROUGH THE BRITISH COUNCIL AND MINISTRY OF SCIENCE, TECHNOLOGY AND INNOVATION MALAYSIA.

5MPC-05**FABRICATION AND SUPERCONDUCTING PROPERTIES OF MGB_2 DOPED WITH POLYSILOXANE BASED COPOLYMERS** ***V. SANDU**[1], G. ALDICA[1], E. SANDU[2], E. CIMPOIASU[3], N. HURDUC[4], I. NOR[4];* [1]NATIONAL INSTITUTE OF MATERIALS PHYSICS-BUCHAREST, [2]HORIA HULUBEI NATIONAL INSTITUTE OF PHYSICS AND NUCLEAR ENGINEERING, MAGURELE, [3]US NAVAL ACADEMY, USA, [4]GHEORGHE ASACHI TECHNICAL UNIVERSITY IASI. — WE PRESENT THE FABRICATION AND SUPERCONDUCTING PROPERTIES OF MGB_2 CERAMIC SAMPLES DOPED WITH LINEAR AND CYCLIC POLYSILOXANE-G-STYRENE AND LINEAR POLYSILOXANE-G-VINYL-FERROCENE. THE SAMPLES HAVE BEEN PREPARED USING THE SPARK PLASMA SINTERING TECHNIQUE. THE USE OF POLYSILOXANE CO-POLYMERS WAS SUGGESTED BY THE APPROPRIATE CONTENT OF CARBON, SILICON, AND OXYGEN WHICH ARE NECESSARY TO INCREASE THE UPPER CRITICAL FIELD AND TO CREATE PINNING CENTERS. SPECIFFICALY, THE SHORT PROCESSING TIME LIMITS THE DIFFUSION LENGTH OF THE CHEMICAL ELEMENTS FROM POLYMER INTO THE SUPERCONDUCTING GRAINS. THUS, IN ADDITION TO THE DOPING WITH CARBON, THE REST OF THE COMPONENTS CREATES PINNING CENTERS ALONG THE POLYMERIC CHAIN ABLE TO PIN BETTER THE FLUX LINES. THE CO-POLYMERIZATION ALLOWED US TO OBTAIN BOTH LINEAR AND CYCLIC CO-POLYMERS AS WELL AS TO CONTROL THE CONTENT OF THE CHEMICAL ELEMENTS, INCLUDING THE PRESENCE OF SMALL AMOUNT OF IRON OXIDES, WHICH ARE RESPONSIBLE FOR THE MAGNETIC PINNING.

THE RESEARCH WAS SUPPORTED BY THE ROMANIAN NASR UNDER THE GRANTS PI-71-045/2007 AND PII-72-151/2008

5MPC-06

THE EFFECT OF ADDITION OF GRAPHENE ON THE SUPERCONDUCTING PROPERTIES OF $MG(B,C_{0.04})_2$ *K. S. B. DE SILVA, **X. XU**, Y. ZHANG, W. X. LI, X. L. WANG, S. X. DOU;* INSTITUTE FOR SUPERCONDUCTING AND ELECTRONIC MATERIALS. — WE REPORT THE SYNTHESIS AND CHARACTERIZATION OF $MG(B,C_{0.04})_2$ DOPED WITH GRAPHENE IN FOLLOWING MOLE PERCENTAGES, *X*=0, 1.5, 3.0, 6.0 AND 12.0 . THE EFFECT OF GRAPHEN DOPING ON THE LATTICE PARAMETER, LATTICE STRAIN, GRAIN SIZE, NORMAL STATE RESISTIVITY(P), SUPERCONDUCTING TRANSITION(T_C), CRITICAL FIELDS (B_{IRR} AND B_{C2}) AND CRITICAL CURRENT DENSITY (J_C), AS WELL AS THE PINNING FORCE(F_P) WERE EVALUATED.WE FOUND THAT THE GRAPHENE DOPING AFFECTS ON THE LATTICE PARAMETERS AS WELL AS THE MICROSTRUCTURE OF MGB_2 SUPERCONDUCTOR.IN CASE OF OPTIMALLY DOPED (X= 3.0 %) SAMPLE, THE CRITICAL CURRENT DENSITY AT 5 K CORRESPONDS TO $1.4*10^5$ A/CM^2 FOR 2T FIELD, WHERE UNDOPED ONE SHOWED $9.6*10^4$ A/CM^2 FOR THE SAME FIELD. THE UPPER CRITICAL FIELD HAS BEEN ENHANCED AT OPTIMAL DOPING LEVEL TO 13T AT 20K. THE FLUX PINNING BEHAVIOR HAS BEEN INVESTIGATED BY FLUX PINNING FORCE DENSITY CURVE AND IT REVEALS THAT THE FLUX PINNING BEHAVIOR HAS IMPROVED NEARLY 1.47 TIMES AND 1.2 TIMES AT 5K AND 20K RESPECTIVELY, DUE TO DOPING.

5MPC-07

THE EFFECTS OF LATTICE DISTORTION ON THE SUPERCONDUCTIVITY FOR NANO-SIC DOPED MGB_2 ***W. LI**[1], R. CHEN[1], Y. LI[2], R. ZENG[1], S. DOU[1];* [1]INSTITUTE FOR SUPERCONDUCTING AND ELECTRONIC MATERIALS, UNIVERSITY OF WOLLONGONG, WOLLONGONG, NSW 2522, AUSTRALIA, [2]SCHOOL OF MATERIALS SCIENCE AND ENGINEERING, SHANGHAI UNIVERSITY, 149 YANCHANG RD., SHANGHAI, 200072 P.R. CHINA. — THE INFLUENCES OF C SUBSTITUTION AND CRYSTALLINITY ON THE CRYSTAL STRUCTURE AND SUPERCONDUCTIVITY FOR DIFFERENT LEVELS NANO-SIC DOPED MGB_2 BULKS SINTERED AT DIFFERENT TEMPERATURES WERE INVESTIGATED SYSTEMATICALLY BY FITTED RAMAN SPECTRA ANALYSIS. THE A-AXIS OF THE MGB_2 LATTICE SHRANK GRADUALLY WITH INCREASING NANO-SIC ADDITION DUE TO THE CARBON (C) SUBSTITUTION-INDUCED LATTICE DISTORTION OF THE HONEYCOMB BORON (B) SHEET, AND AT THE SAME TIME, THE HIGHER THE SINTERING TEMPERATURE THAT WAS USED, THE SMALLER THE LATTICE PARAMETERS. THE ELECTRON-PHONON COUPLING (EPC) DECREASED WITH THE SIC DOPING INCREASED LEVELS DUE TO THE C SUBSTITUTION. CRYSTALS OF 10WT%SIC DOPED MGB_2 BECAME HARMONIC WITH INCREASING *IN-SITU* SINTERING TEMPERATURES. A POSSIBLE EXPLANATION FOR THE T_C IS THAT THE COOPERATION OF THE INTENSITY OF EPC, THE IN-PLANE LATTICE DISTORTION DUE TO THE ELEMENT SUBSTITUTION IN THE BORON SHEETS, AND THE NANOMETER INCLUSIONS, ALL OF WHICH IS IN ACCORDANCE WITH THE

RAMAN SPECTROSCOPY OBSERVATIONS AND THE LATTICE PARAMETERS CALCULATIONS.

THE AUTHORS THANK DR. T. SILVER FOR HER USEFUL DISCUSSIONS. THIS WORK IS SUPPORTED BY THE AUSTRALIAN RESEARCH COUNCIL (PROJECT ID: DP0770205) AND HYPER TECH RESEARCH INC.

5MPC-08

INFLUENCE OF NANOPARTICLE ANTIMONY TRIOXIDE POWDER ON SUPERCONDUCTIVITY IN MGB_2 BULK ***Y. ZHANG;*** INSTITUTE FOR SUPERCONDUCTING & ELECTRONIC MATERIALS. — IN THIS WORK, SB_2O_3 WAS DOPED INTO MGB_2 SAMPLES TO ACT AS AN ADDITION. THE DOPING LEVERL VARIED FROM 2.5% TO 15%. THE EFFECTS OF SB_2O_3 ADDITION ON THE LATTICE PARAMETERS, MICROSTRAIN, CRITICAL TEMPERATURE (T_C), CRITICAL CURRENT DENSITY (J_C), IRREVERSIBILITY FIELD (H_{IRR}), AND UPPER CRITICAL FIELD (H_{C2}) HAVE BEEN INVESTIGATED IN DETAIL. IT HAS BEEN FOUND THAT SB_2O_3 DOPING RESULTS IN A SMALL DEPRESSION IN T_C AND HIGH RESISTIVITY, WHILE H_{C2} AND J_C PERFORMANCE ARE IMPROVED. THE BETTER PERFORMANCE WAS SHOWN IN THE 2.5% - 10% SB_2O_3-DOPED SAMPLE SINTERED AT 800^{O}C. IT WAS OBSERVED THAT THE CRITICAL CURRENT DENSITY (J_C) VALUE WAS 2.4×10^3 ACM^{-2} FOR 2.5% SB_2O_3-DOPED SAMPLE AT 5 K AND 8 T, WHICH IS MORE THAN TWO TIMES HIGHER THAN FOR THE UN-DOPED SAMPLE. SIGNIFICANT J_C IMPROVEMENT AT HIGH FIELDS IS ATTRIBUTED TO THE H_{C2} ENHANCEMENT CAUSED BY THE INCREASED DISORDER.

5MPD-01

INFILTRATION AND GROWTH OF HIGH DENSITY, NEAR-NET SHAPED BULK MGB_2 WITH IMPROVED SUPERCONDUCTING PROPERTIES ***N. HARI BABU***[1]*, A. YAMAMOTO*[2]*, Y. H. SHI*[3]*, D. A. CARDWELL*[3]*;* [1]BRUNEL UNIVERSITY, [2]FLORIDA STATE UNIVERSITY, [3]CAMBRIDGE UNIVERSITY. — THE FABRICATION OF BULK MGB_2 BY CONVENTIONAL SOLID-STATE REACTION OF MG AND B TO RESULTS IN SAMPLES OF VERY LOW DENSITY DUE PRINCIPALLY TO THE HIGH VAPOUR PRESSURE OF MG. UNFORTUNATELY, IT IS NOT POSSIBLE PRACTICALLY TO IMPROVE THE DENSITY OF THESE SAMPLES BY A SUBSEQUENT CONVENTIONAL SINTERING PROCESS. THE INFILTRATION AND GROWTH (IG) PROCESS HAS BEEN EXTENSIVELY USED TO FABRICATE NEAR-NET SHAPED METAL MATRIX, CERAMIC MATRIX AND SUPERCONDUCTING COMPOSITES WITH REDUCED POROSITY. HERE WE DESCRIBED THE USE OF THE IG METHOD TO FABRICATE SUCCESSFULLY BULK MGB_2 OF > 90% THEORETICAL DENSITY THAT EXHIBITS SIGNIFICANTLY IMPROVED CURRENT DENSITY COMPARED TO MGB_2 FABRICATED BY CONVENTIONAL SINTERING. J_C OF THESE SAMPLES UNDER SELF-FIELD IS MEASURED TO BE 260 KA/CM^2, 201 KA/CM^2 AND 96 KA/CM^2 AT 5 K, 20 K AND 30K, RESPECTIVELY. TRANSPORT MEASUREMENTS SHOW THAT THESE SAMPLES EXHIBIT LOW RESISTIVITIES OF 14.86 AND 2.64 MOHM-CM AT 300 K AND 40 K, RESPECTIVELY, AND HIGH CONNECTIVITY. $B_{C2}(0)$ FOR THE BULK MGB_2 SAMPLES FABRICATED BY IG WAS ESTIMATED TO BE ~17 T FROM MAGNETO-RESISTIVITY MEASUREMENTS IN MAGNETIC FIELDS OF UP TO 9 T, WHICH IS COMPARABLE TO SINGLE CRYSTAL VALUE. THE INFILTRATION METHOD HAS ALSO BEEN USED TO JOIN TWO BULK MGB_2 SAMPLES. M-H HYSTERESIS MEASUREMENTS SUGGESTS THAT THESE TWO SURFACES ARE ELECTRICALLY JOINED.

5MPD-02

MGB_2 SUPERCONDUCTORS WITH ADDITION OF OTHER DIBORIDES AND SIC ***L. B. S. DA SILVA***[1]*, D. RODRIGUES JR.*[1]*, G. D. SERRANO*[2]*, V. C. V. METZNER*[1]*, V. A. CHITTA*[3]*, M. T. MALACHEVSKY*[2]*, A. C. SERQUIS*[2]*;* [1]ESCOLA DE ENGENHARIA DE LORENA - UNIVERSIDADE DE SÃO PAULO, [2]CENTRO ATÓMICO BARILOCHE, [3]UNIVERSIDADE DE SÃO PAULO. — THE DISCOVERY OF SUPERCONDUCTIVITY AT 39K IN MGB_2 HAS BEEN CATCHING THE ATTENTION OF SCIENTISTS BECAUSE THE POSSIBILITY TO APPLY THE MATERIAL IN MAGNETS AND ELECTRONIC DEVICES OPERATING IN TEMPERATURES AROUND 20K WITH CRYOCOOLERS. IN THE PRESENT WORK IT IS DESCRIBED A METHODOLOGY TO OPTIMIZE THE CRITICAL CURRENT DENSITIES OF THIS MATERIAL, IN LOW AND HIGH MAGNETIC FIELDS. IN THIS WORK MGB_2 BULKS WERE DEVELOPED AND ANALYZED WITH THE ADDITION OF OTHER DIBORIDES WITH THE SAME C32 HEXAGONAL STRUCTURE AS MGB_2 (TAB_2, ZRB_2, VB_2 AND ALB_2) AND A SIMULTANEOUS ADDITION OF SIC. THE DIBORIDES CONTRIBUTED TO MODIFY THE MG PLANES AND THE SIC CONTRIBUTED WITH C TO REPLACE THE B IN THE CRYSTALLINE STRUCTURE. MICROSTRUCTURAL CHARACTERIZATIONS, PERFORMED USING SEM AND XRD, WERE EXTREMELY IMPORTANT TO DETERMINE THE DISTRIBUTION AND COMPOSITIONAL CHARACTERIZATION OF THE SUPERCONDUCTING PHASE. MAGNETIC SUPERCONDUCTING CHARACTERIZATION USING SQUID WAS PERFORMED TO DETERMINE THE BEST COMPOSITION OF THE MIXTURE AND THE BEST HEAT TREATMENT PROFILE. AS A RESULT WE COULD ANALYZE THE BEHAVIOR OF EACH DOPANT ON THE TRANSPORT CAPACITY OF THESE MATERIALS, INCLUDING THE ANALYSIS OF MAGNETIC FLUX PINNING MECHANISMS.

THE AUTHORS ACKNOWLEDGE THE FINANCIAL SUPPORT BY CNPQ AND CAPES, BRAZIL, AND MINCYT AND UNCUYO, ARGENTINA. DRJ IS A CNPQ RESEARCHER.

5MPD-03

ANISOTROPY OF LI, AL, C AND MN SUBSTITUTED MGB2 SINGLE CRYSTALS STUDIED BY THERMOPOWER AND UPPER CRITICAL FIELD ***K. OGANISIAN***[1]*, K. ROGACKI*[1]*, N. D. ZHIGADLO*[2]*, S. KATRYCH*[2]*, J. KARPINSKI*[2]*;* [1]INSTITUTE OF LOW TEMPERATURE AND STRUCTURE RESEARCH,50-950 WROCLAW, POLAND, [2]LABORATORY FOR SOLID STATE PHYSICS, ETH, 8093 ZÜRICH, SWITZERLAND. — IN THIS WORK WE EXAMINE THE TEMPERATURE DEPENDENCE OF THE IN-PLANE (S_{AB}) AND OUT-OF-PLANE (S_C) THERMOPOWER AND THE IN FIELD MEASURED RESISTIVITY FOR MGB_2 SINGLE CRYSTALS DOPED WITH HOLES AND ELECTRONS BY THE PARTIAL SUBSTITUTION OF LI, AL, C AND MN. FOR UNSUBSTITUTED CRYSTALS, THE THERMOPOWER ANISOTROPY $G_S = 3$ HAS BEEN DETERMINED AT ROOM TEMPERATURE. SUBSTITUTION OF LI

FOR MG, WHICH DOPES MgB_2 WITH HOLES, RESULTS IN A MODERATE DECREASE OF BOTH S_{AB} AND S_C WITHOUT ANY INFLUENCE ON G_S. SUBSTITUTION OF AL FOR MG, WHICH DOPES MgB_2 WITH ELECTRONS, DECREASES S_{AB} AND S_C WITH A RATE ΔS/%AL LARGER THAN ΔS/%LI, HOWEVER G_S REMAINS ALSO UNCHANGED. SUBSTITUTION OF C FOR B, WHICH ALSO DOPES MgB_2 WITH ELECTRONS, DECREASES BOTH S_{AB} AND S_C MUCH MORE EFFECTIVELY AND IN ADDITION REDUCES G_S, *E.G.* FROM 3 TO 2, FOR CRYSTAL WITH 10% OF C (T_C = 29 K). THE ANISOTROPY G_S HAS BEEN COMPARED WITH $G_H = H_{C2}^{AB}/H_{C2}^{C}$ AND THE RESULTS HAVE BEEN ANALYSED WITH RESPECT TO THE INTER- AND INTRABAND SCATTERING PROCESSES. THE RELATIVELY LARGE REDUCTION OF G_S AND G_H FOR THE C-SUBSTITUTED MgB_2 SUGGESTS THAT ALL ELECTRONIC-STRUCTURE-RELATED ANISOTROPIES MAY ALSO REDUCE AND THIS SEEMS TO BE IMPORTANT FOR APPLICATIONS.

THIS WORK WAS SUPPORTED BY THE POLISH MINISTRY OF SCIENCE AND HIGHER EDUCATION UNDER RESEARCH PROJECTS FOR THE YEARS 2009-2010 (PROJECT NO. N N202 235937).

5MPD-04

BORON NANO-SIZED POWDER SYNTHESIZED IN A PLASMA AS A PRECURSOR FOR MgB_2 POWDER AND WIRES ***J. V. MARZIK***[1], *M. RINDFLEISCH*[2], *D. K. FINNEMORE*[3]; [1]SPECIALTY MATERIALS, INC., [2]HYPER TECH RESEARCH, INC., [3]AMES LABORATORY. — BORON NANO-SIZED POWDERS (DOPED AND UNDOPED) WERE SYNTHESIZED BY THE REACTION OF BORON TRICHLORIDE AND HYDROGEN IN AN ARGON RF PLASMA. THE GASES WERE MIXED AND INJECTED INTO THE PLASMA WHERE THEY COMBINED AND FORMED BORON POWDER VIA GAS PHASE NUCLEATION. METHANE GAS WAS ADDED IN THE CASE OF CARBON-DOPED POWDER. THE POWDERS WERE USED AS PRECURSORS FOR MAGNESIUM DIBORIDE (MgB_2) NANO-SIZED POWDER AND FOR THE FABRICATION OF HIGH PERFORMANCE SUPERCONDUCTING MgB_2 WIRES. PARTICLE SIZES OF BORON RANGED FROM 10 TO 250 NM AND CONTAINED A MIXTURE OF AMORPHOUS AND CRYSTALLINE MATERIAL. MgB_2 POWDERS WERE SYNTHESIZED BY DIRECT COMBINATION WITH MAGNESIUM AND HAD PARTICLE SIZE AVERAGES IN THE 200-600 NM RANGE. MgB_2 WIRES WERE FABRICATED BY A POWDER-IN-TUBE METHOD. THE EFFECTS OF CARBON DOPANT CONCENTRATION, CRYSTALLINITY, PARTICLE SIZE, AND MICROSTRUCTURE ON THE SUPERCONDUCTING PROPERTIES OF THE MgB_2 WIRES WERE INVESTIGATED. WIRES MADE THUS FAR FROM THESE POWDERS HAVE ATTAINED CRITICAL CURRENT DENSITIES OF 100,000 A CM^{-2} AT 5 K AND 7 TESLA. UPDATED TEST RESULTS ON MgB_2 BULK POWDER AND SUPERCONDUCTING WIRES MADE FROM BORON NANO-SIZED POWDER WILL BE PRESENTED.

5MPD-05

PROPERTIES OF MGB2 SYNTHESIZED FROM MGB2H8 BY THERMAL DECOMPOSITION ***J. M. ANDRES***[1], *C. MAYORAL*[1], *E. MARTÍNEZ*[2], *R. NAVARRO*[2]; [1]CSIC (ICB), [2]ICMA (CSIC-UNIVERSIDAD DE ZARAGOZA). — THIS PAPER DESCRIBES THE SYNTHESIS OF MAGNESIUM DIBORIDE BY THERMAL DECOMPOSITION OF MAGNESIUM BOROHYDRIDE. THE USE OF MAGNESIUM BOROHYDRIDE FOR MGB2 SYNTHESIS ALLOWS THE PREPARATION OF POWDERS WITH PARTICULAR CHARACTERISTICS. THE OBJECTIVE IS TO OBTAIN OXYGEN-FREE MGB2 FINE POWDER TO USE AS PRECURSOR FOR THE FABRICATION OF METAL/MGB2 WIRES, IN ORDER TO IMPROVE THE HOMOGENEITY AND THE FLUX PINNING OF THE WIRES. DIFFERENT TREATMENTS AT TEMPERATURES ABOVE THE DECOMPOSITION OF THE MAGNESIUM BOROHYDRIDE (AROUND 400 ºC) AND AT INERT ATMOSPHERE (IN ARGON OR VACUUM), EITHER ALONE OR USING SOLVENTS HAVE BEEN CARRIED OUT TO PRODUCE MGB2 POWDER. THIS WAS SUBSEQUENTLY ANALYSED BY SEM-EDX, XRD AND SQUID TO ASSESS THE QUALITY OF THE MGB2 OBTAINED AND THEIR SUPERCONDUCTING PROPERTIES.

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5MPD-06

MECHANICALLY ALLOYED IN-SITU MgB_2: INFLUENCE OF THE PRECURSOR REACTIVITY ON DEFORMABILITY, MICROSTRUCTURE AND SUPERCONDUCTING PROPERTIES ***M. HERRMANN***[1], *W. HÄßLER*[1], *C. RODIG*[1], *M. SCHUBERT*[1], *A. KARIO*[1], *K. NENKOV*[1], *J. SCHEITER*[1], *L. SCHMOLINGA*[2], *A. AUBELE*[3], *B. SAILER*[3], *K. SCHLENGA*[3], *B. HOLZAPFEL*[1], *L. SCHULTZ*[1]; [1]IFW DRESDEN, [2]BRUKER HTS GMBH, [3]BRUKER EAS GMBH. — DURING THE POWDER-IN-TUBE PREPARATION USING SHEATH MATERIALS, E.G. MONEL OR CUNI ALLOYS, IT IS NECESSARY TO RECOVER THE METALLIC SHEATH IN ORDER TO REDUCE THE WORK HARDENING AND ALLOW FOR FURTHER DEFORMATION. ESPECIALLY IN COMBINATION WITH A MECHANICALLY ALLOYED IN-SITU PRECURSOR THIS INTERMEDIATE HEAT TREATMENT IS A SENSITIVE PROCESSING STEP. DUE TO THE HIGH REACTIVITY OF THE NANOCRYSTALLINE PRECURSOR AN UNINTENDED MgB_2 FORMATION STARTING AT AROUND 350°C IS OBSERVED. WITH ONGOING PHASE FORMATION THE HARDNESS OF THE PRECURSOR IS INCREASING AND THEREFORE LIMITING THE DEFORMABILITY OF THE WIRE.IN ORDER TO ALLOW FOR A RELIABLE WIRE PREPARATION THIS PAPER CONCENTRATES ON THE CHARACTERIZATION OF THE REACTIVITY OF MECHANICALLY ALLOYED PRECURSOR POWDERS USING X-RAY DIFFRACTION STUDIES WITH SUBSEQUENT RIETVELD ANALYSIS. EXPERIMENTAL RESULTS OF TRANSPORT MEASUREMENTS AND MICROSTRUCTURAL INVESTIGATIONS ON MgB_2 BULK SAMPLES, WIRES AND TAPES PREPARED WITH PRECURSOR POWDERS OF DIFFERENT PROCESSING, E.G. VARIATION OF MILLING ENERGY AND CARBON ADDITION, WILL BE DISCUSSED.

5MPE-01

SUPERCONDUCTING PROPERTIES OF BORON DOPED $YBa_2Cu_3O_{7-Y}$ HTS ***N. MARGIANI***[1], *T. MEDOIDZE*[1], *I. METSKHVARISHVILI*[2], *I. MZHAVANADZE*[1], *N. PAPUNASHVILI*[1], *V. ZHGHAMADZE*[1]; [1]INSTITUTE OF CYBERNETICS, [2]IV. JAVAKHISHVILI TBILISI STATE UNIVERSITY. — TWO SERIES OF THE NOMINALLY PURE AND BORON-DOPED $YBa_2Cu_3B_XO_{7-Y}$

HTSS WITH B-DOPING LEVEL X VARYING BETWEEN 0 AND 0.1 WERE PREPARED BY THE SOLID STATE REACTION AT 925^{O}C AND 945^{O}C, RESPECTIVELY. BORON-DOPING OF $YBA_2CU_3O_{7-Y}$ PREPARED AT THE NON-OPTIMUM SYNTHESIS TEMPERATURE, T= 925^{O}C, ACCELERATES THE FORMATION OF Y123 PHASE AND INCREASES THE INTERGRAIN CRITICAL CURRENT DENSITY (FROM 44A CM^{-2} FOR AN UN-DOPED SAMPLE UP TO 104A CM^{-2} FOR X=0.025) AS WELL AS THE ZERO RESISTIVITY TEMPERATURE (FROM 88K UP TO 91K). MOREOVER, LOW LEVEL BORON-DOPING (X=0.025 AND 0.05) SHARPENS THE SUPERCONDUCTING TRANSITION. ON THE OTHER HAND, THE SMALL ADDITIVES OF BORON (X= 0.025 AND 0.05) DOES NOT ESSENTIALLY AFFECT THE CRITICAL TEMPERATURE, T_C=92K, OF THE Y123 HTS PREPARED AT THE OPTIMUM SYNTHESIS TEMPERATURE, T=945^{O}C. THE HIGHER-LEVEL BORON DOPING CAUSES DEGRADATION OF T_C. ADDITION OF B_2O_3 IN THIS SERIES OF $YBA_2CU_3B_XO_{7-Y}$ LEADS TO A SIGNIFICANT IMPROVEMENT IN J_C (FROM 100 A CM^{-2} FOR A CONTROL SAMPLE TO 147 A CM^{-2} FOR A B-DOPED SAMPLE WITH X=0.025). OBTAINED RESULTS INDICATE A POSSIBILITY OF BORON DOPANT TO BE INSERTED EITHER INTO INTERSTITIAL OR INTO SUBSTITUTIONAL SITES OF THE LATTICE.

THIS WORK HAS BEEN FULFILLED BY FINANCIAL SUPPORT OF THE GEORGIA NATIONAL SCIENCE FOUNDATION (GRANT #GNSF/ST09/7-844).

5MPE-02

CORRELATION BETWEEN ENHANCED TC, AC IRREVERSIBILITY LINE AND HEAT TREATMENT IN HTC SUPERCONDUCTORS. ***A. NAFIDI***[1]*, E. Y. EL YAKOUBI*[1]*, M. BRAIGUE*[1]*, R. MORGHI*[1]*, M. D'ASTUTO*[2]*, E. G. MICHEL*[3]*;* [1]GROUP OF CONDENSED MATTER PHYSICS, UNIVERSITY IBN ZOHR, [2]IMPMC, CNRS UMR7590 UPMC, 75015 PARIS, [3]DTO. DE FÍSICA DE LA MATERIA CONDENSADA, UNIVERSIDAD AUTÓNOMA DE MADRID. — WE REPORT HERE ON THE PREPARATION, RESISTIVITY, AC MAGNETIC SUSCEPTIBILITY MEASUREMENTS AND EFFECT OF HEAT TREATMENTS IN $(Y_{1-X}SM_X)(SRBA)CU_3O_{6+Z}$. EACH SAMPLE WAS SUBJECT TO TWO TYPE OF HEAT TREATMENT : OXYGEN ANNEALING [O] AND ARGON ANNEALING FOLLOWED BY OXYGEN ANNEALING [AO]. BELOW T_C, THE SHARP DECREASE IN THE REAL PART KSI'(T) IS A MANIFESTATION OF DIAMAGNETIC SHIELDING WHEREAS THE PEAKS T_P IN THE IMAGINARY PART KSI"(T) REPRESENTS THE A.C. LOSSES. AN ANHANCEMENT OF T_C[AO] WAS OBSERVED FOR X>0.4. IN THE NORMAL STATE, THE [AO] TREATMENT REDUCED THE LINEAR RESISTIVITY PARAMETERS INDICATING A DIMINUTION OF THE INTERACTION OF CARRIER CHARGES WITH PHONONS. AN ENHANCEMENT OF THE AC IRREVERSIBILITY LINE H(T=T_P/T_C) WAS OBSERVED DUE TO [AO] TREATMENT FOR X>0.5 INDICATING AN IMPROVEMENT IN THE PINNING PROPERTIES. THE DATA WERE ANALYZED WITH THE RELATION H=K'(1-T)^{N}. REMARKABLE CORRELATIONS WERE OBSERVED BETWEEN DELTAT$_C$(X) = T_C[AO]-T_C[O] AND DELTAK'(X); AND BETWEEN T_C(X), D[CU(2)-Y/SM](X) DISTANCE AND THE NUMBER P_{SH}(X) OF HOLES BY CU(2)-O_2 SUPERCONDUCTING PLANES. A COMBINATION OF SEVERAL FACTORS SUCH AS DECREASE IN D[CU(1)-(SR/BA)]; INCREASE IN CATIONIC AND CHAIN OXYGEN ORDERING; P_{SH} AND IN-PHASE PURITY FOR THE [AO] SAMPLES MAY ACCOUNT FOR THE OBSERVED DATA.

5MPE-03

CORRELATION BETWEEN ENHANCED TC, THE UNIT CELL VOLUME AND AC MAGNETIC SHIELDING IN ARGON PREHEATED (Y1-XEUX)(SRBA)CU3O6+Z ***A. NAFIDI***[1]*, E. Y. EL YAKOUBI*[1]*, R. MORGHI*[1]*, M. BRAIGUE*[1]*, M. D'ASTUTO*[2]*, E. G. MICHEL*[3]*;* [1]GROUP OF CONDENSED MATTER PHYSICS, UNIVERSITY IBN ZOHR, [2]IMPMC, CNRS UMR7590 UPMC, 140 RUE DE LOURMEL, 75015 PARIS, FRANCE, [3]DTO. DE FÍSICA DE LA MATERIA CONDENSADA, UNIVERSIDAD AUTÓNOMA DE MADRID, 28049 MADRID, SPAIN. — WE REPORT HERE ON THE PREPARATION, X-RAY DIFFRACTION WITH RIETVELD REFINEMENT, RESISTIVITY AND AC SUSCEPTIBILITY MEASUREMENTS OF $(Y_{1-X}EU_X)(SRBA)CU_3O_{6..94}$. EACH SAMPLE WAS SUBJECT TO TWO TYPES OF HEAT TREATMENT: OXYGEN ANNEALING [O] AND ARGON ANNEALING FOLLOWED BY OXYGEN ANNEALING [AO]. FOR EACH X, THE [AO] TREATMENT INCREASES E (FOR $0 \le X \le 1$), T_C (FOR $X \ge 0.45$ AND BY 6 K TO 87 K FOR X=1 [AO][1]) AND THE DISTANCE D[CU(1)-SR/BA] (DECREASE T_C) FOR X<0.4 AND DECREASE IT (INCREASE T_C) FOR X>0.4 DUE TO THE DECREASED CATIONIC DISORDER ALONG C FOR $X \ge 0.5$. IN THE NORMAL STATE, THE [AO] TREATMENT REDUCED THE LINEAR RESISTIVITY PARAMETERS INDICATING A DIMINUTION OF THE INTERACTION OF CARRIER CHARGES WITH PHONONS. THERE WAS A REMARKABLE IMPROVEMENT IN THE SHIELDING EFFECT S (AMPLITUDE OF X'(T)) IN THE CASE OF THE SAMPLES [AO] AT ALL $T < T_C$ AND FOR ANY APPLIED FIELD FOR X > 0.5. FOR EACH X AND HEAT TREATMENT, S(X) DECREASES WHEN H_{DC} AND THE TEMPERATURE INCREASE. REMARKABLE CORRELATIONS WERE OBSERVED BETWEEN T_C(X), D[CU(2)-Y/EU](X), D[BASR-Y/EU](X), THE NUMBER P_{SH}(X) OF HOLES BY CU(2)-O_2 SUPERCONDUCTING PLANES AND THE VOLUME OF THE UNIT CELL V(X); AND BETWEEN $\Delta T_C(X) = T_C[AO]-T_C[O]$ AND ΔE(X). A COMBINATION OF SEVERAL FACTORS SUCH AS DECREASE IN D[CU(1)-(SR/BA)]; INCREASE IN CATIONIC AND CHAIN OXYGEN ORDERING; P_{SH} AND IN-PHASE PURITY FOR THE [AO] SAMPLES MAY ACCOUNT FOR THE OBSERVED DATA.

5MPE-04

EVALUATIONS OF SUPERCONDUCTING PROPERTIES IN REBCO COATED CONDUCTORS HEAT-TREATED UNDER A REDUCED OXYGEN PARTIAL PRESSURE FOR A SUPERCONDUCTING JOINT ***J. LEE***[1]*, H. KIM*[1]*, J. SONG*[1]*, M. AHN*[2]*, K. CHANG*[3]*, T. KO*[3]*, H. LEE*[1]*;* [1]KOREA UNIVERSITY, KOREA, [2]KUNSAN NATIONAL UNIVERSITY, KOREA, [3]YONSEI UNIVERSITY, KOREA. — A SUPERCONDUCTING JOINT OF THE REBCO COATED CONDUCTORS (CCS) BECOMES THE VERY IMPORTANT ISSUE FOR COMMERCIALIZING OF HTS APPLICATIONS. FOR A SUPERCONDUCTING JOINT, A DIRECT JOINING OF TWO SUPERCONDUCTORS THROUGH MELTING IS REQUIRED. IN AMBIENT AIR, A JOINING OF THE REBCO CCS WITHOUT MELTING THE SILVER STABILIZER IS RARELY OBTAINED BECAUSE THE MELTING POINT OF THE REBCO CCS IS HIGHER THAN THE MELTING POINT OF SILVER. HOWEVER, REBCO CCS ARE JOINED TOGETHER UNDER A CONTROLLED OXYGEN PARTIAL PRESSURE (PO_2) WHERE THE MELTING POINT OF THE

REBCO CCS BECOMES LOWER THAN THAT OF THE SILVER STABILIZER LAYER. IN THIS STUDY, WE EVALUATED CHANGES IN THE MICROSTRUCTURE AND SUPERCONDUCTING PROPERTIES OF THE REBCO CCS HEAT-TREATED UNDER A REDUCED PO_2 AND AN ADDITIONAL OXYGENATION ANNEALING PROCESS TO RESTORE THE OXYGEN STOICHIOMETRY FOR A SUPERCONDUCTING JOINT.

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5MPE-05

TEMPERATURE DEPENDENCE OF THERMAL EXPANSION AND INELASTIC PROPERTIES OF YBACUO HTSC ***E. E. SANAIA***[1]*, I. KURASHVILI*[1]*, M. DARCHIASHVILI*[2]*, G. DARSAVELIDZE*[2]*;* [1]ILIA VEKUA SOKHUMI INSTITUTE OF PHYSICS AND TECHNOLOGY, [2]F. TAVADZE INSTITUTE OF METALLURGY AND MATERIAL SCIENCE. — TEMPERATURE DEPENDENCE INTERNAL FRICTION, SHEAR MODULUS AND THERMAL EXPANSION OF YBACUO SUPERCONDUCTOR MATERIALS OBTAINED BY SOLID STATE REACTION ARE STUDIED USING THE METHODS OF LOW FREQUENCY INTERNAL FRICTION AND INDUCTIVE DILATOMETER. IN THE 180-250K TEMPERATURE RANGE STAGGERED DECREASE OF SHEAR MODULUS, INCREASE OF RELATIVE THERMAL EXPANSION AND INTENSITY OF BROADENED INTERNAL FRICTION MAXIMUM ARE REVEALED. INTENSITY OF INTERNAL FRICTION MAXIMUM AND SHEAR MODULUS ARE CHARACTERIZED BY SHARP DEPENDENCE FROM AMPLITUDE OF TORSION OSCILLATION. AFTER ANNEALING IN THE 400-6000C TEMPERATURE RANGE MENTIONED PECULIARITIES OF PHYSICAL PROPERTIES ARE OBSERVED BY 20-30K INCREASED TEMPERATURES. ACCORDINGLY CRITICAL VALUE OF AMPLITUDE OSCILLATION AT WHICH BEGINS SHARP INCREASE INTENSITY OF INTERNAL FRICTION MAXIMUM AND DECREASE OF SHEAR MODULUS INCREASED BY 20-25%. THE CHARACTERS OF REVEALED CHANGES OF PHYSICAL PROPERTIES OF YBACUO HTSC ARE EXPLAINED IN THE MODEL OF INTERACTION OF VARIOUS DISLOCATIONS WITH POINT DEFECTS.

5MPE-06**AGING EFFECT IN DIFFERENTLY COATED BAZRO3-DOPED GDBACUO THIN FILMS** *K. SCHLESIER, H. HUHTINEN,* ***P. PATURI****;* UNIVERSITY OF TURKU. — WE HAVE STUDIED AGING IN LASER ABLATED 2 % BAZRO3 DOPED GABACUO (GBCO) THIN FILMS. THE FILMS WERE COATED WITH GOLD, SILVER, COPPER, PHOTORESIST AND STYCAST. ONE FILM WAS LEFT WITHOUT COATING FOR REFERENCE. THE SUPERCONDUCTING AND STRUCTURAL PROPERTIES WERE FOLLOWED FOR SEVERAL MONTHS. THE CRITICAL TEMPERATURE AND CURRENT DENSITY WERE DETERMINED FROM MAGNETIZATION MEASUREMENTS. THE CHANGES IN STRUCTURE WERE INVESTIGATED WITH X-RAY DIFFRACTION.

5MPE-07**MAGNETIC ORIENTATION OF SUPERCONDUCTORS WITH LAYERED CRYSTAL STRUCTURES** ***S. HORII***[1]*, M. YAMAKI*[2]*, T. MAEDA*[2]*, J. SHIMOYAMA*[3]*;* [1]KOCHI UNIVERSITY OF TECHNOLOGY AND JST-RIP, [2]KOCHI UNIVERSITY OF TECHNOLOGY AND JST-TRIP, [3]UNIVERSITY OF TOKYO AND JST-TRIP. — BOTH CUPRATE- AND IRON-PNICTIDE-BASED SUPERCONDUCTORS SHOW ANISOTROPIC SUPERCONDUCTING PROPERTIES BETWEEN *C*-AXIS AND *AB*-PLANE DIRECTIONS. IN THE CASE OF CUPRATES, IN-PLANE ANISOTROPY DUE TO SYMMETRY OF THE COOPER PAIRS SHOULD BE TAKEN INTO ACCOUNT. ALSO IN THE IRON-PNICTIDES, REQUIREMENT OF IN-PLANE ALIGNMENT HAS BEEN EXPERIMENTALLY REPORTED BY SOME GROUPS. THAT IS, TRI- OR BI-AXIAL ORIENTATION IS PROBABLY NECESSARY FOR IMPROVING HIGH *J*C VALUES.RECENT IMPROVEMENT IN MAGNETO-SCIENCE ENABLES ALIGNMENT OF THE HARD AXIS OF MAGNETIZATION AND TRI-AXIAL ORIENTATION. OUR GROUP HAS ALREADY REPORTED TRI-AXIAL ORIENTATION OF TWIN-FREE Y-BASED CUPRATE POWDER USING A MODULATED ROTATION MAGNETIC FIELD[1] AND UNI-AXIAL ORIENTATION USING A ROTATING MAGNETIC FIELD[2]. THESE TECHNIQUES ARE EXPECTED TO BE USEFUL NOT ONLY FOR PRODUCTION OF TRI-AXIAL-ORIENTED SUPERCONDUCTORS BUT ALSO FOR EVALUATION BY NUCLEAR MAGNETIC RESONANCE. IN THIS WORK, WE ATTEMPTED TO FABRICATE MAGNETICALLY ORIENTED POWDER SAMPLES OF CUPRATES AND PNICTIDES USING STATIC, ROTATION AND MODULATED ROTATION FIELDS. THE CONTROL OF TRI-AXIAL MAGNETIC ANISOTROPY BY THE CHOICE OF RARE-EARTH IONS IN RE-BASED CUPRATES AND TRI- OR UNI-AXIAL ORIENTATION IN PNICTIDES WILL BE REPORTED. [1] FUKUSHIMA, HORII ET AL., APPL. PHYS. EXPRESS 1 (2008) 111703. [2] ISHIHARA, HORII ET AL., APEX 1 (2008) 031701.

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5MPE-08

LOW FIELD MAGNETO RESISTANCE IN RU-1222 SUPERCONDUCTOR *R. MOHAN*[1]*,* ***S. KIM***[2]*, N. K. GAUR*[3]*, S. BHATTACHARYA*[4]*, S. K. GUPTA*[4]*;* [1]DEPARTMENT OF MECHATRONICS ENG. & RESEARCH INSTITUTE OF ADVANCED TECHNOLOGY, JEJU NATIONAL UNIVERSITY, [2]DEPARTMENT OF MECHATRONICS ENG. & RESEARCH INSTITUTE OF ADVANCED TECHNOLOGY,, [3]DEPARTMENT OF PHYSICS, BARKATULLAH UNIVERSITY, BHOPAL-462 026 INDIA, [4]TPPED, BHABHA ATOMIC RESEARCH CENTRE (BARC), MUMBAI 400085, INDIA. — COEXISTENCE OF SUPERCONDUCTIVITY AND FERROMAGNETISM IN A HYBRID RUTHENATE-CUPRATE $RUSR_2GD_{1.4}CE_{0.6}CU_2O_{10-\Delta}$ (RU-1222) WITH LAYERED PEROVSKITE STRUCTURE HAS ATTRACTED A GREAT DEAL OF INTEREST IN THE PROPERTIES OF THIS MATERIAL. HERE WE ARE REPORTING THE LOW FIELD MAGNETORESISTANCE IN $RUSR_2GD_{1.4}CE_{0.6}CU_2O_{10-\Delta}$. THE POLYCRYSTALLINE SAMPLES OF $RUSR_2GD_{1.4}CE_{0.6}CU_2O_{10-\Delta}$ WERE PREPARED THROUGH SOLID STATE REACTION METHOD. THE FOUR-PROBE RESISTIVITY-TEMPERATURE (P-T) MEASUREMENTS SHOW METALLIC NORMAL STATE RESISTIVITY WITH SUPERCONDUCTING TRANSITION AT 25 K. MAGNETIZATION MEASUREMENTS WITH RESPECT TO FIELD AND TEMPERATURE WERE PERFORMED BY USING A SUPERCONDUCTING QUANTUM INTERFERENCE

DEVICE (SQUID) MAGNETOMETER. THE MAGNETIZATION (M)-TEMPERATURE (T) MEASUREMENT REVEALS MAGNETIC TRANSITIONS (T_{MAG}) AT 105 K. THE MAGNETIZATION (M) VS. FIELD (H) HYSTERESIS AT 5 K SHOWED THE FERROMAGNETIC BEHAVIOR OF THE SAMPLES. THE ZERO FIELD COOLED MAGNETIZATION (M_{ZFC}) AND FIELD COOLED MAGNETIZATION (M_{FC}) DIVERGES AT 100 K. MR MEASUREMENTS WERE CARRIED OUT AT DIFFERENT TEMPERATURES (24 K, 50 K, 100 K AND 200 K) BY USING APPLIED MAGNETIC FIELDS IN THE RANGE FROM −7.5 TO +7.5 KOE. A CLEAR HYSTERIS WAS OBSERVED IN THE MAGNETORESISTANCE DATA. THE SAMPLES SHOW NEGATIVE MAGNETO RESISTANCE AT ALL TEMPERATURE EXCEPT IN SUPERCONDUCTING STATE.

5MX-01

(INVITED) **VORTEX LIQUID-GLASS TRANSITION UP TO 60 T IN NANO-ENGINEERED REBCO COATED CONDUCTORS GROWN BY METAL ORGANIC DEPOSITION** ***M. MIURA***[1]*, S. A. BAILY*[1]*, B. MAIOROV*[1]*, L. CIVALE*[1]*, J. O. WILLIS*[1]*, T. IZUMI*[2]*, K. TANABE*[2]*, Y. SHIOHARA*[2]*;* [1]LOS ALAMOS NATIONAL LABORATORY, [2]SUPERCONDUCTIVITY RESEARCH LABORATORY, ISTEC. — HIGHER IRREVERSIBILITY FIELDS (H_{IRR}) INCREASE THE UPPER BOUND FOR APPLICATIONS OF SUPERCONDUCTORS AND COULD EXPAND MARKET PENETRATION. ALSO, THE UNDERSTANDING OF THE MIXED PINNING LANDSCAPES DUE TO A COMBINATION OF VARIOUS DIMENSIONAL DISORDERS IS CRITICAL TO IMPROVE HIRR. WE PRESENT THE STUDIES IN PULSED FIELD (UP TO 60 T) OF SUPERCONDUCTING FILMS ON FLEXIBLE METAL SUBSTRATES. WE INVESTIGATE THE EFFECT OF DISORDER ON HIRR AT DIFFERENT FIELD ORIENTATIONS FOR $YBA_2CU_3O_Y$ AND $BAZRO_3$-NANOPARTICLE DISPERSED $Y_{0.77}GD_{0.33}BA_2CU_3O_Y$ (YGDBCO+BZO) GROWN BY MOD. WE FIND THAT HIRR IS HIGHER FOR YGDBCO+BZO ALONG THE C AXIS AND AT INTERMEDIATE ORIENTATIONS. THE VORTEX MELTING TRANSITION WAS INVESTIGATED USING THE RESISTIVE TRANSITION'S CRITICAL EXPONENT. THE BEHAVIOR CAN BE EXPLAINED BY THE MIXED PINNING LANDSCAPE FROM RANDOMLY DISTRIBUTED BZO NANOPARTICLES AND C-AXIS CORRELATED DISORDER. OUR RESULTS INDICATE THAT NANO-ENGINEERED COATED CONDUCTORS ARE AN ENABLING TECHNOLOGY FOR HIGH FIELD APPLICATIONS.

WE THANK V. ZAPF FOR ASSISTANCE WITH THE MEASUREMENTS IN DC FIELDS. WORK AT LANL WAS SUPPORTED BY THE US DOE, NHMFL-UCGP, AND THE US NSF. A PART OF THIS WORK WAS SUPPORTED BY NEDO AS A COLLABORATIVE RESEARCH.

5MX-02

ANGULAR CRITICAL CURRENT IN YBCO COATED TAPES AT VERY STRONG MAGNETIC FIELDS *A. XU*[1]*, **J. JAROSZYNSKI***[1]*, F. KAMETANI*[1]*, D. LARBALESTIER*[1]*, Y. CHEN*[2]*, Y. XIE*[3]*, V. SELVAMANICKAM*[2]*;* [1]NHMFL, [2]UNIVERSITY OF HUSTON, [3]SUPERPOWER. — YBCO COATED CONDUCTOR (CC) IS THE PRIME CHOICE FOR AN ALL-SUPERCONDUCTING MAGNET TECHNOLOGY TO GO TO 30 T AND BEYOND. A KEY PART OF THE COIL DESIGN DEPENDS ON KNOWING THE DETAILED ANGULAR DEPENDENCE OF THE CRITICAL CURRENT IC SO THAT THE COIL QUENCH DESIGN POINT CAN BE PREDICTED WITH CONFIDENCE. HERE WE PRESENT DETAILED MEASUREMENTS OF THE CRITICAL CURRENT IN DIFFERENT YBCO CC FABRICATED BY SUPER POWER INC. THE MEASUREMENTS WERE PERFORMED IN MAGNETIC FIELDS UP TO 31 T AT 4.2 K SO AS TO BE RELEVANT FOR VERY HIGH FIELD MAGNET DESIGN. MOREOVER, WHILE IT IS WELL ESTABLISHED THAT YBCO CAN INCORPORATE MANY DIFFERENT TYPES OF PINNING CENTERS WITH SIGNIFICANT POSITIVE EFFECT ON JC THE ANGULAR ANISOTROPY OF THE CRITICAL CURRENT DENSITY AND ITS MICROSCOPIC CAUSES ARE STILL POORLY UNDERSTOOD . WE FIND THAT STRONGLY CORRELATED PINS, SUCH AS BAZRO3 (BZO) NANORODS, NOT ONLY YIELD STRONG C-AXIS PEAKS AT 77 K, BUT ALSO SUBSTANTIALLY MODIFY IC(THETA,H) AT 4.2 K. IN PARTICULAR, BZO DOPING MARKEDLY WIDENS THE CUSP-LIKE IC MAXIMA AROUND THE AB PLANE. THUS BZO DOPED CC ARE MORE SUITABLE FOR MAGNET CONSTRUCTION THEN UNDOPED CC, DESPITE THEIR OBSERVED FASTER DECREASE OF IC(H) AWAY FROM THE AB PLANE.

A PORTION OF THIS WORK WAS PERFORMED AT THE NATIONAL HIGH MAGNETIC FIELD LABORATORY, WHICH IS SUPPORTED BY NSF COOPERATIVE AGREEMENT NO. DMR-0654118, BY THE STATE OF FLORIDA, AND BY THE DOE.

5MX-03

MICROSTRAIN, UPPER CRITICAL FIELD ANISOTROPY AND VORTEX PINNING IN YBCO NANOCOMPOSITES ***A. PALAU***[1]*, A. LLORDES*[1]*, T. PUIG*[1]*, P. ABELLAN*[1]*, F. SANDIUMENGE*[1]*, S. RICART*[1]*, A. POMAR*[1]*, X. OBRADORS*[1]*, J. GUTIERREZ*[2]*, G. ZHANG*[2]*, J. VANACKEN*[2]*, V. V. MOSHCHALKOV*[2]*, J. GAZQUEZ*[3]*;* [1]INSTITUT DE CIENCIA DE MATERIALS DE BARCELONA (ICMAB-CSIC), [2]INPAC-INSTITUTE FOR NANOSCALE PHYSICS AND CHEMISTRY, K.U. LEUVEN, BELGIUM, [3]OAK RIDGE NATIONAL LABORATORY, OAK RIDGE, TENNESSEE, USA. — YBCO WITH BAZRO3, Y2O3, BACEO3 NANOPARTICLES (NP) HAVE BEEN GROWN BY USING CHEMICAL SOLUTION DEPOSITION. DEPENDING ON THE SECOND PHASE CRYSTAL STRUCTURE, INTERFACE, STRAIN ENERGY AND GROWTH PROCESS, THE RANDOM ORIENTED VS. EPITAXIAL FRACTION AND CONSEQUENTLY THE INCOHERENT INTERFACES OF THE NPS CAN BE TUNED. WE DEMONSTRATE THAT THE INCOHERENT INTERFACES ARE RESPONSIBLE OF THE LARGE MICRO-STRAIN EXHIBITED BY THE EPITAXIAL MATRIX OF NANOCOMPOSITES, THE STRONG INCREASE OF THE PINNING FORCE AND THE DECREASE OF THE EFFECTIVE ANISOTROPY[1].ADVANCED XRD-METHODOLOGIES HAVE BEEN APPLIED TO QUANTIFY THE MICRO-STRAIN DISORDER, STRAIN-ANISOTROPY AND RANDOMLY ORIENTED NP FRACTION. BRIGHT AND DARK FIELD HRTEM OBSERVATIONS HAVE BEEN UNDERGONE FOR THE MICROSTRUCTURAL ANALYSIS. ANGULAR DEPENDENT JC TRANSPORT METHODOLOGIES HAVE BEEN APPLIED TO DETERMINE VORTEX PINNING CONTRIBUTIONS IN THE H-T DIAGRAM. FINALLY, ANGULAR DEPENDENT RESISTIVITY MEASUREMENTS IN HIGH PULSED FIELDS (UP TO 40T) HAVE RECENTLY ALLOWED US TO DETERMINE THE UPPER CRITICAL FIELD AT DIFFERENT FIELD ORIENTATION GIVING REMARKABLE

RESULTS WITH RESPECT TO THE ANISOTROPY COEFFICIENT.[1] GUTIERREZ ET AL, NAT.MAT 6, 367 (2007)

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5MX-04

ANGULAR DEPENDENCE OF THE IRREVERSIBILITY FIELD IN DOPED *RE*BCO UP TO 45 T ***C. TARANTINI***[1]*, F. KAMETANI*[1]*, J. JAROSZYNSKI*[1]*, A. GUREVICH*[1]*, D. C. LARBALESTIER*[1]*, Y. L. ZUEV*[2]*, D. K. CHRISTEN*[2]*;* [1]APPLIED SUPERCONDUCTIVITY CENTER, NATIONAL HIGH MAGNETIC FIELD LABORATORY, FSU, [2]OAK RIDGE NATIONAL LABORATORY. — YBCO IS A TOP CANDIDATE FOR HIGH FIELD LOW T APPLICATIONS WITH RECORD HIGH CRITICAL CURRENT AND HIGH IRREVERSIBILITY FIELDS. HOWEVER THERE IS NOTORIOUS PROBLEM WITH ITS HIGH ANISOTROPY WHICH LIMITS THESE APPLICATIONS. SEVERAL APPROACHES HAVE BEEN FOLLOWED TO DECREASE THE ANISOTROPY, E.G. DOPING AND INTRODUCTION OF NANOPARTICLES OR NANORODS. HERE WE INVESTIGATE THE ANGULAR DEPENDENCE OF THE IRREVERSIBILITY FIELD $H_{IRR}(\Theta)$ OF *RE*BCO SAMPLES WITH BZO NANORODS UP TO 45T AS A FUNCTION OF TEMPERATURE. WE OBSERVE THAT AT HIGH TEMPERATURE THE ANISOTROPY IS SIGNIFICANTLY REDUCED ($\Gamma\sim3$) IN COMPARISON TO THE EXPECTED MASS ANISOTROPY DUE TO A STRONG C-AXIS PINNING. HOWEVER THE EFFECTIVENESS OF THE PINNING DECREASES WITH DECREASING TEMPERATURE ALLOWING THE MORE NORMAL ELECTRONIC MASS ANISOTROPY Γ TO BE RESTORED ($\Gamma>5$). THE CORRELATION BETWEEN PINNING AND SAMPLE MICROSTRUCTURE HAS BEEN INVESTIGATED BY HRTEM.

THIS WORK IS SUPPORTED BY U.S. DOE OFFICE OF ELECTRICITY DELIVERY AND ENERGY RELIABILITY - SUPERCONDUCTIVITY PROGRAM FOR ELECTRIC POWER SYSTEMS ADVANCED CABLES AND CONDUCTORS

5MX-05

IN-FIELD, CRITICAL CURRENT ANISOTROPY MEASUREMENTS OF HIGH JC 12MM WIDE $YBA_2CU_3O_{7-\Delta}$ COATED CONDUCTOR FOR HEP MAGNETS APPLICATIONS *E. BARZI, V. LOMBARDO,* ***D. TURRIONI****, A. V. ZLOBIN;* FERMILAB. — THE FINAL BEAM COOLING STAGES OF A MUON COLLIDER MAY REQUIRE DC SOLENOID MAGNETS WITH MAGNETIC FIELDS IN THE RANGE OF 40-50 T AND HYBRID HELICAL SOLENOIDS FEATURING FIELD LEVELS IN EXCESS OF WHAT IS DELIVERABLE WITH TRADITIONAL LOW TEMPERATURE SUPERCONDUCTORS (LTS) SUCH AS NB_3SN AND NBTI. PRESENTLY THE USE OF HIGH TEMPERATURE SUPERCONDUCTORS (HTS) IS THE ONLY SUPERCONDUCTING OPTION AVAILABLE FOR ACHIEVING SUCH FIELD LEVELS. $YBA_2CU_3O_{7-\Delta}$ COATED CONDUCTORS ALLOW FOR VERY HIGH CRITICAL CURRENT DENSITIES AND ADVANCED MECHANICAL PROPERTIES OVER REASONABLY LONG PRODUCTION LENGTHS, PAVING THE WAY FOR APPLICATIONS IN THE FIELD RANGE OF INTEREST. COMMERCIALLY AVAILABLE $YBA_2CU_3O_{7-\Delta}$ COATED CONDUCTORS COME IN TAPES AND SHOW NOTICEABLE ANISOTROPIC EFFECTS WITH RESPECT TO FIELD ORIENTATION, WHICH NEEDS TO BE ACCOUNTED FOR DURING MAGNET DESIGN. IN THE PRESENT WORK, CRITICAL CURRENT TEST RESULTS ARE PRESENTED FOR A 12MM WIDE $YBA_2CU_3O_{7-\Delta}$ TAPES UP TO 14 T, ASSESSING THE LEVEL OF ANISOTROPY AS A FUNCTION OF FIELD ORIENTATION AND TEMPERATURE FROM 4.2K TO 33K.

5MX-06

SYSTEMATIC STUDY OF EFFECTS OF BZO NANORODS ON THE J_C OF YBCO FILMS AT BROAD TEMPERATURE AND MAGNETIC FIELDS REGIME ***A. XU***[1]*, J. JAROSZYNSKI*[1]*, F. KAMETANI*[1]*, D. LARBALESTIER*[1]*, S. WEE*[2]*, A. GOYAL*[2]*;* [1]NATIONAL HIGH MAGNETIC FIELD LABORATORY, [2]OAK RIDGE NATIONAL LABORATORY. — VERY HIGH FIELD MAGNET APPLICATION AT 4 K FOCUS ATTENTION ON PINNING OPTIMIZATION IN THE LOW THERMAL FLUCTUATION REGIME, WHILE GENERATOR AND MOTOR APPLICATIONS AT 30-40 K AND 2-3 T FALL TOWARDS A STRONGER THERMAL FLUCTUATION REGIME. WE REPORT A WIDE-RANGE J_C CHARACTERIZATION (4-77 K AND 0-31 T) OF THICK PLD FILMS WITH 0-4 VOL.% BZO NANORODS. AT 77 K ALL THE BZO FILMS SHOW SHARP C-AXIS PEAKS WHICH ARE ABSENT AT 4 K, EVEN THOUGH J_C(4 K) ALONG C-AXIS INCREASES LINEARLY WITH %BZO AND REACHES THE VERY HIGH VALUES OF 47 MA/CM^2 (SELF FIELD) AND 4 MA/CM^2 AT 29 T. AT 30 K THE J_C ANISOTROPY IS 1.5-2 IN THE RANGE 1-4 T, SMALL REMNANTS OF A C-AXIS PEAK ARE VISIBLE AND J_C REACHES 4 MA/CM^2 AT 4 T AND 10.5 MA/CM^2 AT 1 T, ALL VALUES FOR 4 %BZO. IT THUS APPEARS THAT BZO NANORODS INDUCE STRONG SMALL-SCALE DISORDER THAT PINS VERY EFFECTIVELY AT 4 K BUT SOME PINS ARE THERMALLY DEPINNED AT 30 K. AT 4 K, THE FILMS CAN ACHIEVE THE PHENOMENALLY HIGH I_C OF 2.25 KA IN A 4 MM WIDTH DUE TO THE STRONG BZO AND BACKGROUND PINNING, WHICH IS ESPECIALLY VALUABLE IN BROADENING $J_C(\Theta)$ AROUND THE AB-PLANE. BZO NANORODS ARE THUS VERY EFFECTIVE AT ALL DOMAINS OF *T*, *H* AND Θ STUDIED.

WORK AT ORNL WAS SPONSORED BY THE U.S. DOE OFFICE OF ELECTRICITY DELIVERY AND ENERGY RELIABILITY - ADVANCED CABLES AND CONDUCTORS AND AT NHMFL BY NSF-DMR.

5MY-01

SEEDED INFILTRATION AND GROWTH OF BULK (RE)BCO NANO-COMPOSITES ***N. HARI BABU***[1]*, Y. SHI*[2]*, A. DENNIS*[2]*, S. PATHAK*[2]*, D. CARDWELL*[2]*;* [1]BRUNEL UNIVERSITY, [2]CAMBRIDGE UNIVERSITY. — THE SEEDED INFILTRATION AND GROWTH (SIG) TECHNIQUE OFFERS NEAR-NET SHAPE PROCESSING OF BULK SUPERCONDUCTORS WITH SIGNIFICANT IMPROVEMENT IN REDUCED RE_2BACUO_5 (RE-211) INCLUSION SIZE, REDUCED SHRINKAGE, REDUCED POROSITY AND IMPROVED CURRENT DENSITY WHEN COMPARED TO SAMPLES FABRICATED BY TOP SEEDED MELT GROWTH. $RE_2BA_4CUMO_{12}$ PHASES WHERE M = NB, MO, W, TA, ETC., HAVE BEEN SHOWN TO FORM NANO-SCALE INCLUSIONS IN THE $REBA_2CU_3O_Y$ (RE-123) PHASE MATRIX AND TO CONTRIBUTE TO ENHANCED MAGNETIC FLUX PINNING IN THESE MATERIALS. IN THIS PAPER, WE DESCRIBE THE INTRODUCTION OF SUCH NANO-SCALE INCLUSIONS INTO

BULK SUPERCONDUCTORS PROCESSED BY SIG. VARIOUS YBCO, GDBCO AND SMBCO SINGLE GRAIN, BULK SUPERCONDUCTORS CONTAINING $(RE)_2BA_4CUNBO_Y$ NANO-SCALE INCLUSIONS HAVE BEEN FABRICATED SUCCESSFULLY BY THIS TECHNIQUE IN AN AIR ATMOSPHERE. A RELATIVELY UNIFORM T_C WAS OBSERVED THROUGHOUT THE BULK OF THESE SAMPLES WITH SHARP TRANSITION WIDTH (<1 K), EXCEPT IN THE IMMEDIATE VICINITY OF THE SEED. J_C, IN EXCESS OF 10^5 A/CM^2 AT 77.3 K IN SELF-FIELD IS OBSERVED FOR THE SAMPLES CONTAINING RE-2411. THE PAPER PRESENTS DETAILS OF THE SIG FABRICATION PROCESS, THE MICROSTRUCTURAL FEATURES (PARTICULARLY THE SPATIAL VARIATION OF RE-2411 CONCENTRATION) AND THE CORRELATION BETWEEN MICROSTRUCTURE AND J_C. DEVELOPMENT OF THE SIG PROCESS FOR ACHIEVING IMPROVED J_C IN THE MID-FIELD (1-3T) RANGE IS ALSO PRESENTED.

5MY-02

THE JC ENHANCEMENT OF SINGLE DOMAIN YBCO BULK BY UTILIZING ZNO-NANORODS GROWN PRECURSOR IN TSMTG PROCESS ***C. WANG***[1]*, S. HUANG*[1]*, C. CHU*[1]*, S. WANG*[1]*, I. CHEN*[1]*, M. WU*[2]*;* [1]DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING, NATIONAL CHENG KUNG UNIVERSITY, TAINAN, TAIWAN, [2]INSTITUTES OF PHYSICS, ACADEMIA SINICA, TAIPEI, TAIWAN. — THE BULK OF HIGH TEMPERATURE COPPER OXIDE SUPERCONDUCTORS (HTSCS) REQUIRES HIGH CRITICAL CURRENT DENSITY (JC) TO PERFORM HIGH MAGNETIC TRAPPING FIELD FOR PRACTICAL APPLICATIONS. THE ZNO DOPED YBCO SUPERCONDUCTOR WAS REPORTED TO CONTRIBUTE TO JC ENHANCEMENT BECAUSE ZN^{2+} IONS SUBSTITUTE THE IN-PLANE CU SITES [CU(2)] TO FORM WEAK SUPERCONDUCTIVITY PHASE. IN THIS STUDY, WE PRESENT THE NEW TECHNIQUE OF GROWING ZNO NANORODS ON YBCO PRECURSOR POWDER BY CVD(CHEMICAL VAPOR DEPOSITION) PROCESS. WE UTILIZE THESE NANORODS-INCLUDED PRECUSOR TO FABRICATE SINGLE DOMAIN YBCO BULK TO OBTAIN HIGHER JC. IN OTHER WORDS, WE DOPED ZNO NANORODS(1-DIMENSION) INSTEAD OF TRADITIONAL ZNO PARTICLES (0-DIMENSION) IN YBCO TO INDUCE MORE EFFICIENT CHEMICAL AND COLUMNAR DEFECTS. THEORETICALLY, 1-DIMENSION COLUMNAR DEFECTS CAN BE CONSIDERED AS STRONGER PINNING CENTERS THAN 0-DIMENSION ONES. OUR RESULTS PROVE THAT, ZNO NANORODS DOPED SAMPLES PERFORM HIGHER JC THAN ZNO NANOPARTICLES DOPED ONES. ITS JC CAN REACH C.A. 55,000 A/CM^2 IN 0.1WT% ZNO NANORODS DOPED SAMPLE AT 77K WITHOUT ANY OTHER ADDITION(CEO_2 OR PT...ETC) AND ALSO SHOWS THE PEAK EFFECT AT 2 TESLA APPLIED FIELD.

THIS STUDY WAS SUPPORTED BY THE NATIONAL SCIENCE COUNCIL, TAIWAN, REPUBLIC OF CHINA, UNDER CONTRACT NSC 96-2112-M-006-012-MY3

5MY-03

MASS PRODUCTION OF LOW-COST GDBACUO BULK SUPERCONDUCTORS USING A NOVEL SEED IN THE BATCH PROCESS ***M. MIRYALA****, K. SUZUKI, Y. FUKUMOTO, A. ISHIHARA, M. TOMITA;* RAILWAY TECHNICAL RESEARCH INSTITUTE. — HIGH-T_C SUPERCONDUCTING MAGNETS PROMISE A VARIETY OF INDUSTRIAL, MEDICAL, PUBLIC, AND RESEARCH APPLICATIONS. HOWEVER, THE POTENTIAL LARGE-SCALE APPLICATIONS OF THESE MATERIALS NEED EXCELLENT AND UNIFORM PROPERTIES AND A CHEAP PRODUCTION. THE BATCH PROCESS DEVELOPED FOR FABRICATION OF LRE-$BA_2CU_3O_Y$ (LRE: ND, SM, EU, GD) PELLETS IN AIR FULFILS ALL THESE REQUIREMENTS. WE ESTABLISHED A BATCH PROCESS FOR $GDBA_2CU_3O_Y$ GROWN IN AIR, USING A NOVEL THIN FILM ND-123 SEEDS GROWN ON MGO CRYSTALS. IN THIS WAY WE ARE ABLE TO FABRICATE MATERIALS WITH ENHANCED PINNING DUE TO NANOMETER SIZE PRECIPITATES, WITH GOOD QUALITY, AND *DRAMATICALLY REDUCED COST*. THE SUPERCONDUCTING AND MAGNETIC PERFORMANCE OF THE PELLETS WAS CHECKED ON SEVERAL SMALL TEST SAMPLES CUT OUT AT VARIOUS STANDARD POSITIONS WITHIN THE BULK. THE SELF-FIELD J_C OF 70 KA/CM^2 WAS ACHIEVED AT 77 K, *H//C*-AXIS IN VARIOUS POSITIONS OF THE PELLET. THE TRAPPED FIELD MEASUREMENTS SHOWED THAT IN THE WHOLE BATCH THE SAMPLES WERE SINGLE-DOMAIN AND OF GOOD PINNING PERFORMANCE. THE TRAPPED FIELD NEARLY 1T WAS OBSERVED IN THE BEST 24 MM SINGLE-GRAIN PUCK, WHICH IS THE HIGHEST VALUE REPORTED SO FAR. ON BASIS OF THE PROGRAM RESULTS THE PRICE, PERFORMANCE, ENLARGEMENT OF THE GRAIN SIZE OF GD-123 MATERIAL WILL BE DISCUSSED WITH RESPECT TO USE IN VERITY OF INDUSTRIAL APPLICATIONS.

5MY-04

PEAK EFFECT IN BULK Y-BA-CU-O SUPERCONDUCTORS WITH CEO_2-DOPING BY INFILTRATION GROWTH METHOD ***P. CHEN***[1]*, S. CHEN*[2]*, I. CHEN*[1]*, M. WU*[3]*;* [1]DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING, NATIONAL CHENG KUNG UNIVERSITY, TAINAN, TAIWAN, [2]DEPARTMENT OF POLYMER ENGINEERING, NATIONAL TAIWAN UNIVERSITY OF SCIENCE AND TECHNOLOGY, TAIPEI, TAIWAN, [3]INSTITUTES OF PHYSICS, ACADEMIA SINICA, TAIPEI, TAIWAN. — THE CEO_2-DOPED Y-BA-CU-O BULK SUPERCONDUCTORS WERE SUCCESSFULLY GROWN BY INFILTRATION GROWTH (IG) METHOD WITH A SMALL SM-BA-CU-O CRYSTAL AS SEED IN ORDER TO OBTAIN SAMPLES WITH ENHANCED SUPERCONDUCTOR PROPERTIES. A SUPERIOR JC (H, T) WITH A PEAK EFFECT WHICH WAS NOT USUALLY OBSERVED IN YBCO SYSTEM APPEARS IN CEO_2 DOPED IG-YBCO SAMPLES. MAGNETIC SUSCEPTIBILITY MEASUREMENTS BY SQUID SHOWED THE JC (3T, 65K) OF IG-YBCO SAMPLE WITH 1.5 WT% CEO_2 ADDITION COULD REACH 10^5 A/CM^2, WHICH IS TWO TIMES HIGHER THAN THAT OF CEO_2 DOPED TOP SEEDED MELT TEXTURED (TSMT) YBCO SAMPLE. WE SUPPOSED THAT SMALL AMOUNT OF SM DISSOLVED FROM SMBCO SEED DIFFUSED INTO THE BULK TO FORM COMPOSITIONAL FLUCTUATIONS (Y,SM)BCO AND THAT WAS CORRELATED TO THE EFFECTIVE PINNING AT HIGH FIELD (OR PEAK EFFECT) TO IMPROVE THE JC (H, T) AT HIGH FIELD. COMPOSITIONAL ANALYSIS OF SM IN SAMPLES MEASURED BY THE INDUCED COUPLED PLASMA MASS SPECTROMETRY (ICP-MS), WHICH SHOWED THAT THERE WAS AT LEAST 0.2 MOL% SM IN CEO_2 DOPED IG-YBCO SAMPLES. HOWEVER, THE SM IN TMST-YBCO BOTH SAMPLES WITH OR WITHOUT CEO_2 ADDITION WERE AROUND 0.02 MOL%. WITH HIGHER

AMOUNTS OF SM, AN ENHANCEMENT OF JC IN HIGH FIELD REGIONS WAS OBSERVED, OF WHICH ΔTC PINNING IN ACTIVE. THE ΔTC PINNING CAN BE ATTRIBUTED TO THE EXISTENCE OF COMPOSITIONAL FLUCTUATIONS OF (Y,SM)BCO. IN ADDITION, THE EPMA RESULTS SHOWED THE HOMOGENOUS DISTRIBUTION OF SM IN THE MATRIX OF CEO_2 DOPED IG-YBCO SAMPLE.

THIS STUDY WAS SUPPORTED BY THE NATIONAL SCIENCE COUNCIL, TAIWAN, REPUBLIC OF CHINA, UNDER CONTRACT NSC 96-2112-M-006-012-MY3.

5MY-05

MAGNETIC FIELD TRAPPING IN MGB_2 BULKS AND INSERTS ***E. PERINI***[1]*, G. GIUNCHI*[1]*, L. SAGLIETTI*[1]*, A. FIGINI ALBISETTI*[1]*, A. MATRONE*[2]*, V. CAVALIERE*[2]*;* [1]EDISON SPA, [2]C.R.I.S.. — IN ORDER TO REALIZE SUPERCONDUCTIVE PERMANENT MAGNETS TO BE USED IN POWER APPLICATIONS LIKE THE MAGNETIC LEVITATION OR THE ELECTRICAL MOTORS, WE HAVE STUDIED THE MAGNETIC FIELD TRAPPING CAPABILITY OF MGB_2 DISCS OF DIFFERENT SHAPES, AT TEMPERATURES > 10K. IN PARTICULAR WE HAVE COMPARED MGB_2 BULK DISCS WITH MGB_2 SUPERCONDUCTIVE INSERTS IN METALLIC SUBSTRATES (SIMS) OF DIAMETERS OF 70 MM. BOTH SUPERCONDUCTIVE DEVICES HAVE BEEN PRODUCED BY THE REACTIVE MG LIQUID INFILTRATION MG-(RLI) PROCESS. THE MAGNETIZATION WAS PERFORMED BY THE APPLICATION AND REMOVAL OF AN EXTERNAL MAGNETIC FIELD UP TO 2 T, PRODUCED BY A SUPERCONDUCTING MAGNET, OR BY FIELD COOLING OF THE SUPERCONDUCTIVE DEVICES NEARBY NDFEB PERMANENT MAGNETS. THE SIMS DEVICES SHOWS AN HIGHER STABILITY OF THE TRAPPED FIELDS WITH RESPECT TO THE BULK DISCS. TYPICAL TRAPPED FIELDS, MEASURED AT 1 MM FROM THE SURFACE OF THE DEVICE, ARE OF THE ORDER OF 1T. THE DENSITY DISTRIBUTION OF THE SUPERCURRENTS HAS BEEN ESTIMATED BY MEASURING THE TRAPPED FIELD AT VARIOUS TEMPERATURES UP TO T_C AND PERFORMING MAGNETIC LEVITATION FORCES MEASUREMENTS.

5MY-06

HIGH-PRESSURE SYNTHESIZED NANOSTRUCTURAL MGB_2-BASED MATERIALS WITH HIGH SC PERFORMANCE FOR FAULT CURRENT LIMITATION AND OTHER CRYOGENIC APPLICATIONS ***T. PRIKHNA***[1]*, W. GAWALEK*[2]*, Y. SAVCHUK*[1]*, V. SOKOLOVSKY*[3]*, M. EISTERER*[4]*, M. SERGA*[1]*, V. TKACH*[1]*, N. DANILENKO*[5]*, M. WENDT*[2]*, J. DELLITH*[2]*, H. WEBER*[4]*, M. TOMPSIC*[6]*, S. DUB*[1]*, A. SHAPOVALOV*[1]*, V. MOSHCHIL*[1]*, N. SERGIENKO*[1]*, V. MEEROVICH*[3]*, T. HABISREUTHER*[2]*, D. LITZKENDORF*[2]*, C. SCHMIDT*[2]*, V. MELNIKOV*[1]*, P. NAGORNY*[1]*, V. SVERDUN*[1]*;* [1]INSTITUTE FOR SUPERHARD MATERIALS OF THE NATIONAL ACADEMY OF SCIENCES OF UKRAINE, [2]INSTITUT FÜR PHOTONISCHE TECHNOLOGIEN, JENA, GERMANY, [3]BEN-GURION UNIVERSITY OF THE NEGEV, BEER-SHEVA, ISRAEL, [4]ATOMINSTITUT, VIENNA, AUSTRIA, [5]FRANTSEVICH INSTITUTE FOR PROBLEMS OF MATERIALS SCIENCE NATIONAL ACADEMY OF SCIENCE OF UKRAINE, [6]HYPERTECH RESEARCH INC., COLUMBUS, OH, USA. — THE MAIN ADVANTAGES OF THE USE OF HIGH-PRESSURE SYNTHESIS AND SINTERING (0.5-2 GPA, 600- 1050 ^{O}C, 1 H) TO MANUFACTURE POLYCRYSTALLINE MGB_2 ARE THE POSSIBILITY TO GET ALMOST THEORETICALLY DENSE (99 %) NANOSTRUCTURAL (AROUND 20 NM AVERAGE GRAIN SIZES) MATERIALS WITH EXTREMELY HIGH CRITICAL CURRENT DENSITIES, FIELDS OF IRREVERSIBILITY, UPPER CRITICAL FIELDS, THERMOCONDUCTIVITY AND MECHANICAL CHARACTERISTICS. IN THE MATERIALS SYNTHESIZED FROM MG AND B TAKEN IN MGB_2 STOICHIOMETRY AT 20 K J_C=1.0·10^6 A/CM^2 IN 0 T AND J_C=10^3 A/CM^2 IN 8 T FIELD; AT 35 K J_C=1.5·10^5 A/CM^2 0 T FIELD; AT 22 K H_{C2}=15 T HAVE BEEN ATTAINED. THE COMPLEX SEM AND TEM STUDY OF THE STRUCTURE OF MGB_2 MATERIALS WITHOUT AND WITH ADDITIONS OF TI, TA, ZR, SIC SUPPORTS THE VIEW OF THE PRIMARY IMPORTANCE OF THE DISTRIBUTION OF OXYGEN, HIGHER BORIDES, HYDROGEN, AND CARBON ADMIXTURES IN THE STRUCTURE FOR SC CHARACTERISTICS OF THE MATERIALS. MATERIALS WITH NEAR MGB_{12} STOICHIOMETRY OF MATRIX AND WITH NANOSIZED RANDOMLY DISTRIBUTED MGB_2 INCLUSIONS CAN HAVE TC=37 K AND AT 20 K J_C=6·10^4 A/CM^2 AT 0 T AND HIRR=5T. DUE TO HIGH DENSITY THE MATERIALS ARE STABLE FROM FAST DEGRADING (FOR AT LEAST 5-6 YEARS EVEN IF HIGH-PRESSURE MANUFACTURED MATERIALS ARE KEPT IN AIR). THE MODEL TESTS OF THE MGB_2 RINGS FROM HIGH-PRESSURE SYNTHESIZED MATERIALS SHOWED THAT THEIR USE IN INDUCTIVE FAULT CURRENT LIMITERS AND OTHER CRYOGENIC DEVICES HOLDS MUCH PROMISES.

5MY-07

(INVITED) **EXPLORING THE LIMITS OF BC2 AND DOPANT SOLUBILITY IN MGB2 USING HIGH TEMPERATURE AND HIGH PRESSURE PROCESSING** ***S. BOHNENSTIEHL****, M. D. SUMPTION, E. COLLINGS;* OHIO STATE UNIVERSITY. — MUCH OF THE RESEARCH ON MGB2 HAS BEEN LIMITED TO HEAT TREATMENT TEMPERATURES OF 1100-1200 C DUE TO THE VOLATILITY OF MG WHICH LEADS TO DECOMPOSITION OF MGB2 INTO MGB4 AND MG VAPOR. THIS DECOMPOSITION HAS ALSO CONSTRAINED DOPING STUDIES SINCE MANY OF THE MOST INTERESTING DOPANTS (METAL DIBORIDES) HAVE EXTREMELY HIGH MELTING POINTS (>2000 C) THUS MAKING IT DIFFICULT TO OBTAIN HOMOGENOUS SAMPLES. IN ORDER TO ADDRESS THESE DIFFICULTIES, WE HAVE CONSTRUCTED AN INDUCTION HEATER WHICH CAN REACH TEMPERATURES GREATER THAN 2000 C USING RF POWER INJECTED INTO A HIGH PRESSURE VESSEL AT 1500 PSI (100 BAR) IN ORDER TO SUPPRESS MG VOLATILITY. THE SAMPLE IS CONTAINED IN A MGO CRUCIBLE HEATED WITH A GRAPHITE SUSCEPTOR. BY USING THIS TECHNIQUE, WE CAN SYNTHESIZE DENSE MGB2 WITH HIGH CONNECTIVITY AND ALSO DOPED MGB2 WITH UNIFORM DOPING. INITIAL RESULTS OF MGB2 PROCESSED AT THESE TEMPERATURES WILL BE PRESENTED ALONG WITH MICROSTRUCTURAL AND SUPERCONDUCTING PROPERTY MEASUREMENTS. ADDITIONAL RESULTS ON DOPED MGB2 WILL FOCUS ON TRANSITION METAL DIBORIDE DOPANTS TO ADDRESS THE ACTUAL SOLUBILITY OF SOME OF THESE DOPANTS AND THEIR EFFECT ON THE UPPER CRITICAL FIELD.

5MZ-01

(INVITED) **IMPACT OF FORMING, WELDING, AND ELECTROPOLISHING ON SURFACE FINISH OF NIOBIUM COUPONS AND SUPERCONDUCTING RF CAVITY EQUATOR REGIONS** ***L. D. COOLEY****, C. M. THOMPSON, D. T. HICKS, D. BURK, R. SCHUESSLER, A. ROMANENKO, G. WU;* FERMILAB. — NIOBIUM SUPERCONDUCTING RADIO FREQUENCY (SRF) CAVITIES ARE SOMETIMES LIMITED BY QUENCHES ASSOCIATED WITH VISIBLE DEFECTS NEAR CAVITY EQUATOR WELDS. THIS PROBLEM REDUCES MANUFACTURING YIELD OF CAVITIES WITH HIGH ELECTRIC FIELD GRADIENT, AND THE MECHANISMS OF DEFECT FORMATION ARE NOT KNOWN. HERE, WE REPORT COUPON ELECTROPOLISHING EXPERIMENTS WHERE FORMING, WELDING, AND ELECTROPOLISHING PARAMETERS WERE SYSTEMATICALLY STUDIED. COLD WORKING AND ELECTROLYTE TEMPERATURE WERE FOUND TO INCREASE TENDENCIES FOR PIT FORMATION, EVEN THOUGH COLD-WORKED COUPONS SHOWED VERY HIGH GLOSS AND SMOOTH SURFACES. SMALL RATIOS OF ALUMINUM CATHODE AREA TO NIOBIUM ANODE AREA PRODUCED GRAIN CONTRAST LIKE THAT SEEN IN CAVITIES AND UNLIKE THAT PRODUCED BY DIFFUSION-LIMITED ELECTROPOLISHING. ESPECIALLY, THIS OCCURRED AT TEMPERATURES (40 TO 50 °C) LIKE THOSE RECORDED ON THE SURFACE OF CAVITY CELLS DURING ELECTROPOLISHING. SINCE CURRENT DENSITY IS CONCENTRATED NEAR THE CATHODE, UNINTENDED CHEMICAL REACTIONS BECOME POSSIBLE, WHICH MAY CONTRIBUTE A SECONDARY ETCHING ACTION ON THE NIOBIUM SURFACE AND REVEAL GRAIN BOUNDARIES. WE DISCUSS IMPLICATIONS FOR SRF CAVITY PROCESSING, AND WE ALSO PRESENT SURFACE SCIENCE STUDIES OF THE ELECTROPOLISHED COUPONS WITH ATTENTION TO TOPOGRAPHY AND SUB-SURFACE CHEMISTRY.

WORK SUPPORTED BY THE U.S. DEPARTMENT OF ENERGY UNDER CONTRACT NO. DE-AC02-07CH11359

5MZ-02

SUPPRESSED SUPERCONDUCTIVITY ON THE SURFACE OF SRF QUALITY NIOBIUM FOR PARTICLE ACCELERATING CAVITIES ***Z. H. SUNG****[1], A. A. POLYANSKII[1], P. J. LEE[1], A. GUREVICH[1], D. C. LARBALESTIER[1], E. ZELDOV[2], Y. MYASOEDOV[2], M. POLAK[3];* [1]ASC/NHMFL/FSU, [2]THE WEIZMANN INSTITUTE OF SCIENCE, ISRAEL, [3]THE SLOVAK ACADEMY OF SCIENCE, SLOVAKIA. — DEGRADATION IN THE PERFORMANCE OF SUPERCONDUCTING RF(RADIO FREQUENCY) NIOBIUM CAVITIES FOR PARTICLE ACCELERATOR IS ASSOCIATED WITH THE BREAKDOWN OF SUPERCONDUCTING STATE ON THE SURFACE DURING STRONG RF OPERATION. THIS BREAKDOWN IS INITIATED BY LOCALIZED MULTI-SCALE DEFECTS LYING WITHIN THE 40NM PENETRATION DEPTH, WHICH MIGHT BE GRAIN BOUNDARIES OR OTHER NANOMETER SCALE DEFECTS, SEVERE SURFACE ROUGHNESS, OR FABRICATION DEFECTS SUCH AS WELDING PITS IN THE ELECTRON-BEAM WELD ZONE. BY COMBINING MULTIPLE MICROSCOPY AND PHYSICAL PROPERTY MEASUREMENT TECHNIQUES, INCLUDING MAGNETO-OPTICAL (MO) IMAGING, TRANSMISSION ELECTRON MICROSCOPY, AND DIRECT TRANSPORT MEASUREMENT, WE HAVE OBSERVED EVIDENCE FOR SUPPRESSED SUPERCONDUCTIVITY AT NB GRAIN BOUNDARIES. WE FOUND THAT PINNING OF VORTICES ALONG GBS IS WEAKER THAN PINNING OF VORTICES IN THE GRAINS, WHICH MAY INDICATE A SUPPRESSED SUPERFLUID DENSITY ON GBS. IN ORDER TO EXTRACT THE DEPAIRING CURRENT DENSITY FROM THE LINEAR FLUX FLOW RESISTANCE SEEN IN THE GBS, WE MEASURE THE TRUE LOCAL MAGNETIC FIELDS AT THE GBS USING MICRO HALL PROBE ARRAYS. WE HAVE ALSO EXTENDED THESE TECHNIQUES TO THE STUDY OF WELDING PITS WHICH OFTEN COINCIDE WITH THERMAL BREAKDOWN EVENTS.

THIS WORK WAS SUPPORTED BY THE US DOE UNDER GRANTS DE-FG02-07ER41451, FNAL PO 570362, AND THE STATE OF FLORIDA.

5MZ-03

NONLINEAR NEAR-FIELD MICROWAVE MICROSCOPY OF NB SURFACES ***T. TAI****, S. M. ANLAGE;* CENTER FOR NANOPHYSICS AND ADVANCED MATERIALS, DEPARTMENT OF PHYSICS, UNIVERSITY OF MARYLAND, COLLEGE PARK, MD 20742-4111 USA. — NIOBIUM-BASED SUPERCONDUCTING RADIO FREQUENCY (SRF) CAVITY PERFORMANCE IS SENSITIVE TO LOCALIZED DEFECTS THAT GIVE RISE TO QUENCHES AT HIGH ACCELERATING GRADIENTS. IN ORDER TO IDENTIFY THESE MATERIAL DEFECTS IN BULK NB SURFACES AT THEIR OPERATING FREQUENCY AND TEMPERATURE, IT IS IMPORTANT TO DEVELOP A NEW KIND OF WIDE BANDWIDTH MICROWAVE MICROSCOPY WITH LOCALIZED HIGH-RF MAGNETIC FIELDS. BY TAKING ADVANTAGE OF MAGNETIC WRITER TECHNOLOGY WIDELY USED IN THE MAGNETIC RECORDING INDUSTRY, ONE CAN OBTAIN ~200 MT RF MAGNETIC FIELDS ON SUB-MICRON LENGTH SCALES ON NB SUPERCONDUCTOR SURFACES. WE DISCUSS OUR EFFORTS TO INDUCE THE NONLINEAR MEISSNER EFFECT AND FIND LOCALIZED DEFECTS ON BULK NB SURFACES AND THIN FILM COATINGS OF INTEREST FOR ACCELERATOR APPLICATIONS.

THIS WORK IS SUPPORTED BY DOE/HEP

5MZ-04

MAGNETIC IMPURITIES AS A POSSIBLE ORIGIN FOR DISSIPATION IN NIOBIUM SUPERCONDUCTING RF CAVITIES ***T. PROLIER****[1], J. ZASADZINSKI[2], J. A. KLUG[1], M. PELLIN[1], J. ELAM[1], L. COOLEY[3], A. GUREVICH[4];* [1]ARGONNE NATIONAL LABORATORY, [2]ILLINOIS INSTITUTE OF TECHNOLOGY, [3]FERMI NATIONAL ACCELERATOR LABORATORY, [4]NATIONAL HIGH MAGNETIC FIELD LABORATORY, FSU. — THE PERFORMANCE OF SUPERCONDUCTING RF CAVITIES ARE LIMITED BY DISSIPATION MECHANISM OCCURRING IN THE FIRST 40 NM OF THE SURFACE. UP TO NOW NO CONSENSUS HAVE BEEN REACHED ON THE ORIGIN OF SUCH DISSIPATION. FOR INSTANCE THE ORIGIN OF THE SURFACE IMPEDANCE SATURATION AT LOW TEMPERATURE REMAINS A MYSTERY. WE WILL PRESENT RECENT MEASUREMENTS THAT STRONGLY SUGGEST THE PRESENCE OF MAGNETIC IMPURITIES AT THE SURFACE OF THE NIOBIUM CAVITIES-GRADE SAMPLES ALONG WITH A THEORETICAL MODEL THAT CAN EXPLAIN THE RESIDUAL RESISTANCE.

RESEARCH SUPPORTED BY THE U.S. DEPARTMENT OF ENERGY, OFFICE OF HIGH ENERGY PHYSICS, DIVISION OF UNDER AWARD DE-PS02-09ER09-05

5MZ-05

MODEL FOR INITIATION OF QUALITY FACTOR DEGRADATION AT HIGH ACCELERATING GRADIENTS IN SUPERCONDUCTING RADIO-FREQUENCY CAVITIES BASED ON A CONFORMAL MAPPING TECHNIQUE ***A. DZYUBA**, A. ROMANENKO, G. WU, L. COOLEY;* FERMI NATIONAL ACCELERATOR LABORATORY. — SURFACE ROUGHNESS AND SUB-SURFACE CHEMISTRY ARE THOUGHT TO PLAY CRUCIAL ROLES IN DETERMINING THE ONSET OF DISSIPATION AND LOSS OF QUALITY FACTOR *Q* AT HIGH ELECTRIC FIELD GRADIENTS IN SUPERCONDUCTING RADIO-FREQUENCY (SRF) CAVITIES. WHILE ROUGHNESS IS ACCESSIBLE BY VISUAL INSPECTION AND PROFILOMETRY OF REPLICAS, SUB-SURFACE CHEMISTRY IS OFTEN NOT ACCESSIBLE DUE TO THE NEED TO DESTROY THE CAVITY TO CONDUCT SURFACE SCIENCE. THUS, THE RELATIVE IMPORTANCE OF THESE EFFECTS IS NOT KNOWN. HERE, WE MODEL THESE EFFECTS AT THE SCALE OF THE PENETRATION DEPTH LAMBDA, WHICH CONTROLS THE ONSET OF FLUX PENETRATION AND THEREFORE THE ONSET OF DISSIPATION. THE VORTEX PENETRATION FIELD H_{PEN} WAS DETERMINED USING A CONFORMAL TRANSFORMATION METHOD TO INCLUDE KNOWN EXPRESSIONS FOR THE SURFACE BARRIER AS A FUNCTION OF SURFACE ANGLE (I.E. ROUGHNESS) AND GINZBURG-LANDAU PARAMETER KAPPA (I.E. SUB-SURFACE CHEMISTRY). CALCULATIONS SHOW COMPARABLE REDUCTIONS OF H_{PEN} FOR ANGLE AS FOR KAPPA, INDICATING THAT BOTH CONTRIBUTIONS HAVE APPROXIMATELY EQUAL WEIGHT. THE MODEL WAS THEN APPLIED TO A CAVITY WITH KNOWN *Q(E)* BEHAVIOR AND TO NIOBIUM SAMPLES WITH THE SAME TREATMENT AND GRAIN SIZE AS THAT CAVITY IN ORDER TO OBTAIN A ROUGHNESS PROFILE AND SURFACE ANALYZES. A GOOD FIT TO DATA WAS OBTAINED ONLY FOR $\mu_0 H_{PEN}$ = 0.165 T, BELOW THE 0.180 T OF PURE BULK NIOBIUM, CONFIRMING A SUBSTANTIAL ROLE OF SUB-SURFACE CHEMISTRY IN CAVITY DISSIPATION.

WE THANK H. PADAMSEE FOR STIMULATING DISCUSSIONS. WORK SUPPORTED BY THE U.S. DEPARTMENT OF ENERGY UNDER CONTRACT NO. DE-AC02-07CH11359.

5MZ-06

PROGRESS IN DEVELOPMENT OF SUPERCONDUCTING RF CAVITY TECHNOLOGY FOR THE ILC *C. ADOLPHSEN[1], H. CARTER[2], S. FUKUDA[3], R. GENG[4], H. HAYANO[3],* ***J. KERBY**[2], C. NANTISTA[1], N. OHUCHI[3], T. PETERSON[2], T. SHIDARA[3], A. YAMAMOTO[3];* [1]SLAC, [2]FERMILAB, [3]KEK, [4]JEFFERSON LAB. — THE INTERNATIONAL LINEAR COLLIDER (ILC) IS PLANNED AS THE NEXT ENERGY-FRONTIER ELECTRON-POSITRON ACCELERATOR. THE MAIN LINACS ARE BASED ON SUPERCONDUCTING RADIO-FREQUENCY (RF) CAVITY TECHNOLOGY, AND WILL ACCELERATE ELECTRON AND POSITRON BEAMS UP TO 250 + 250 GEV AT THE CENTER-OF-MASS ENERGY. BASED ON THE REFERENCE DESIGN REPORT (RDR) ISSUED IN EARLY 2007, THE TECHNICAL DESIGN PHASE (TDP) IS IN PROGRESS. THIS PAPER DESCRIBES THE STATUS OF THE DESIGN, R&D EFFORTS, AND FURTHER PLANS OF THE SUPERCONDUCTING RF CAVITY DEVELOPMENT AND ASSOCIATED TECHNOLOGIES FOR THE ILC.

THIS WORK IS SUPPORTED BY THE ILC GLOBAL DESIGN EFFORT, ALL OF THE PARTICIPATING LABORATORIES, AND WORLDWIDE FUNDING AGENCIES.

5PL-01

FRIDAY OPENING REMARKS. ***M. OSOFSKY**;* NRL. — INTRODUCTORY COMMENTS FOR FRIDAY'S PLENARY SPEAKERS WILL BE PRESENTED.

5PL-02

SCIENCE, SOCIETY, AND SUPERCONDUCTIVITY ***S. E. KOONIN**;* U.S. DEPARTMENT OF ENERGY. — (ADMIN) DR. KOONIN WILL PROVIDE A HIGH-LEVEL OVERVIEW OF APPLIED SUPERCONDUCTIVITY IN U.S. SCIENCE AND POLICY.

5PL-03

US NAVY'S SUPERCONDUCTIVITY PROGRAMS: SCIENTIFIC CURIOSITY TO FLEET UTILITY ***D. U. GUBSER**;* NAVAL RESEARCH LABORATORY. — THE US NAVY'S INTEREST IN SUPERCONDUCTIVITY BEGAN SHORTLY AFTER WORLD WAR II WHEN PROGRAMS AT THE NAVAL RESEARCH LABORATORY (NRL) AND THE OFFICE OF NAVAL RESEARCH (ONR) BEGAN EXPLORING THE SCIENCE OF SUPERCONDUCTING MATERIALS. THROUGHOUT THE 1950'S AND 1960'S THESE PROGRAMS DISCOVERED NEW SUPERCONDUCTING MATERIALS AND ADDED MUCH TO THE BASIC UNDERSTANDING OF THE PHENOMENA. TECHNOLOGY DEVELOPMENT PROGRAMS BEGAN IN THE LATE 1960'S WITH MAJOR EFFORTS AND ONR, NRL, AND THE NAVY'S WARFARE CENTERS. DEVELOPMENT OF SUPERCONDUCTING QUANTUM INTERFERENCE DEVICES (SQUIDS) USED TO DETECT UNDERWATER MINES AND SUBMARINES BEGAN AT THE WARFARE CENTER IN PANAMA CITY, FL IN 1969. AT THE SAME TIME SCIENTISTS AND ENGINEERS AT THE WARFARE CENTER IN ANNAPOLIS, MD BEGAN THEIR OWN TECHNOLOGY EFFORTS TO DEVELOP QUIET, HIGH POWER DENSITY SHIP PROPULSION MOTORS. ONR AND NRL EXPANDED THEIR PROGRAMS TO INCLUDE SUPERCONDUCTING ELECTRONICS AS WELL AS EFFORTS TO DEVELOP TECHNOLOGICALLY USEFUL MATERIALS (FILMS AND WIRES) FOR THE NAVY'S TECHNOLOGY PROGRAMS.THE NAVY'S SUPERCONDUCTIVITY EFFORTS ACCELERATED RAPIDLY AFTER THE DISCOVERY OF HIGH TEMPERATURE SUPERCONDUCTING (HTS) MATERIALS. A MAJOR EFFORT LED BY NRL DEVELOPED AND LAUNCHED HTS ELECTRONIC DEVICES AND SUBSYSTEMS INTO SPACE. THE NAVY WARFARE CENTER IN SAN DIEGO AND ONR/NRL BEGAN PROGRAMS DEVELOPING LOW LOSS FILTERS FOR ELECTRONIC COMMUNICATIONS AS WELL AS THE DEVELOPMENT OF FAST, LOW POWER SUPERCONDUCTING DIGITAL DEVICES. NAVY SCIENTISTS LED INDUSTRIAL PROGRAMS FOR DEVELOPMENT OF FULL SCALE HTS SHIP PROPULSION MOTORS AND HTS FILTERS FOR COMMUNICATION SYSTEMS.AS THE 21ST CENTURY BEGAN,

THE NAVY STARTED TO DEVELOP SUPERCONDUCTING SYSTEMS FOR FLEET IMPLEMENTATION. THE FIRST SHIP TO USE A SUPERCONDUCTING SYSTEM WAS THE USS HIGGINS THAT USES SUPERCONDUCTING CABLES IN A DEGAUSSING SYSTEM (2008). THIS TALK WILL REVIEW ASPECTS OF THESE PROGRAMS AND THE PEOPLE WHO WERE INSTRUMENTAL IN THEIR SUCCESS.A PLAQUE COMMEMORATING THE SUCCESSFUL OPERATION OF THE HTS SYSTEM ON THE HIGGINS WILL BE PRESENTED AT THE END OF THIS TALK.

5PL-04

SUPERCONDUCTIVITY AND HIGH ENERGY PHYSICS-A STUDY IN SYMBIOSIS ***B. STRAUSS***[1]*, S. ST.LORANT*[2]*;* [1]U.S. DEPARTMENT OF ENERGY, [2]SLAC NATIONAL LABORATORY (RETIRED). — FOLLOWING THE DEVELOPMENT OF NB_3SN AND NIOBIUM BASED SOLUTION ALLOYS IN 1961 THE FIELD OF HIGH ENERGY PHYSICS HAS WITNESSED A CONTINUAL DEVELOPMENT OF MAGNETS AND DEVICES FOR THE GENERATION, BEAM HANDLING AND ANALYSIS OF PARTICLE BEAMS AND THEIR INTERACTIONS. THIS PAPER WILL EXAMINE THE TECHNOLOGY DEVELOPMENT OF THESE DEVICES FROM THE EARLIEST BUBBLE CHAMBERS THROUGH THE DEVELOPMENT OF THEORIES OF STABILITY AND ON TO THE CONSTRUCTION OF SUPERCONDUCTIVITY BASED PARTICLE ACCELERATORS AND THEIR ASSOCIATED DETECTORS. THE LATEST ADVANCES IN SUPERCONDUCTING RADIO FREQUENCY ACCELERATING CAVITIES WILL BE CONSIDERED WITHIN THIS R&D MODEL. THIS DEVELOPMENT OF TECHNOLOGY WAS ACCOMPLISHED BY UNIVERSITIES, NATIONAL LABORATORIES AND INDUSTRY WORKING IN A MOST COOPERATIVE WAY.

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