SYMPOSIUM C

Recent Advances in Superconductivity–Materials Synthesis, Multiscale Characterization, and Functionally Layered Composite Conductors

March 29 - April 1, 2005

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* Invited paper

SESSION C1: New Materials
Chairs: Terry Holesinger and Dean Miller
Tuesday Morning, March 29, 2005
Room 2000 (Moscone West)

8:30 AM *C1.1
A Novel Superconducting State in the Superconducting Ferromagnetic Rutheno-Cuprates. Paul C.W. Chu, [1]Texas Center for Superconductivity, University of Houston, Houston, Texas; [2]Lawrence Berkeley National Laboratory, Berkeley, California; [3]Hong Kong University of Science and Technology, Kowloon, Hong Kong.

One salient feature of a superconductor is the expulsion of magnetic flux below its transition temperature T_c. A Type II superconductor will be in the Meissner state (MS) with an equilibrium diamagnetic moment M_s=-H/4π when H is smaller than its lower critical field (H_{c1}). A distinct $dM_s/dH>0$, on the other hand, is expected either under higher H or in the spontaneous vortex state (SVS), which has been predicated when superconductivity and ferromagnetism coexist and the internal field is greater than the H_{c1}. The magnetic properties of powder samples of different particle sizes and a single crystal of rutheno-cuprates have been systematically examined. Here we report the observation of a novel superconducting state in the polycrystalline and single crystalline superconducting ferromagnetic rutheno-cuprates below T_c, where: (1) magnetic field expulsion does exist, albeit the effect is very small, (2) the spontaneous vortices occur; (3) dM_s/dH is negative and H-independent up to an apparent H_{c1}, reminiscent of the MS; and (4) this H_{c1} does not depend on T but varies with the particle size of the single-grain powders. These are in strong contrast to what is typically expected of either MS or SVS. We attribute these to the combination of the anisotropic superconductivity, the fine granularity of the compounds, and the unusually long penetration depth, which make the polycrystalline and single crystalline rutheno-cuprates a naturally occurring mesoscopic superconducting system with device implications.

9:00 AM C1.2
On the Origin of Modulated Structures in the YBCO Superconductor. Didier deFontaine[1] and Vidvuds Ozolins[2]; [1]Materials Science, Univ. California Berkeley, Berkeley, California; [2]Dept. of Materials Science, Univ. Calfornia Los Angeles (UCLA), Los Angeles, California.

Recent diffraction studies have shown the existence of lattice modulations in yttrium barium cuprates (YBCO). We show that these modulations are caused by the ordering of O-Cu-O- chains in the CuO planes. Remarkable agreement is illustrated in the case of underdoped YBCO between experimental diffraction patterns of diffuse intensity and satellite intensity obtained from ab initio electronic structure calculations. It is suggested that the "stripe" structure of magnetic excitations observed by inelastic neutron scattering originates in the underlying oxygen order.

9:15 AM C1.3
Structure and Superconducting Properties of Bi-2223 and Bi,Pb-2223 Single Crystals. Enrico Giannini[1], Alexandre Piriou[1], Nicholas Clayton[1], Nicolas Musolino[1], Roman Gladyshevskii[2] and Rene Flukiger[1]; [1]DPMC, University of Geneva, Geneva, Switzerland; [2]Ivan Franko National University of Lviv, Lviv, Ukraine.

The structure and superconducting properties of both Pb-free and Pb-doped Bi-2223 single crystals have been investigated. Large and high-quality crystals were grown by using the newly developed Vapour-Assisted Travelling Solvent Floating Zone method, which allowed us to grow crystals containing volatile doping elements, like Pb. The homogeneity of the crystals was enhanced by post-annealing under high pressure of O2 (up to 40 MPa at T = 500°C). Sharp superconducting transitions (as high as 111 K and as sharp as ΔTc $\cong$ 1 K) were obtained in crystals having a sizes up to 3 x 2 x 0.1 mm^3. The structure of both Pb-free and Pb-doped Bi-2223 was refined for the first time from single-crystal X-ray diffraction (XRD) data. The unit cell of the average structure is pseudo-tetragonal with a = 5.4210(7), b = 5.4133(6) and c = 37.010(7) Å, and a = 5.395(1), b = 5.413(1) and c = 37.042(11) Å, for the Pb-free and the Pb-doped phase, respectively. An incommensurate modulation in the direction of one of the short cell vectors has been defined (q ~ 0.21 a*), however, the structure can be conveniently described in a supercell with a 5-fold volume (a = 27.105(4))Å. With respect to the ideal average structure, one additional oxygen atom for ten initial O was found to be inserted into the BiO layers. The Ca sites were found to be partially occupied by Bi atoms, the amount of the substitution achieving ~8% and ~5% in the Pb-free and Pb-doped Bi-2223 phase, respectively. The magnetic properties of the superconducting state were widely investigated. The superconducting anisotropy was found to be ~50, more than three times as lower as in Bi-2212. As a consequence, the irreversibility fields are higher and the magnetic relaxation tares are lower than in the Bi-2212 phase. The lower critical field, the irreversibility field and the second peak affect were measured as a function of the temperature and the vortex phase diagram of Pb-free Bi-2223 was traced. The effect of changing the oxygen doping by annealing under various oxygen partial pressures was investigated. Preliminary results on the structural and superconducting features of underdoped and overdoped Bi-2223 crystals are presented. The Bi-2223 phase was found to be much less sensitive to the post-annealing atmosphere than the other compounds of the same family, Bi-2201 and Bi-2212.

9:30 AM C1.4
Growth and Investigation of Single Crystals of some New Double Perovskite Ruthinates Exhibiting Magnetism and Superconductivity. Muralidhara Rao Sistla[1], M. K. Wu[1,2], J. K. Srivastava[3], T. R. Chen[1], B. H. Mok[1], H. Y. Lin[4], H. Y. Tang[4] and H. L. Liu[5]; [1]Institute of Physics, Academia Sinica, Taipei, Taiwan; [2]Department of Physics and Materials Science Center, National Tsing Hua University, Hsinchu, Taiwan; [3]N. S. Group, Tata Institute of Fundamental Research, Mumbai 400 005, India; [4]Department of Applied Chemistry, National Chi Nan University, Nantou, Taiwan; [5]Department of Physics, National Taiwan Normal University, Taipei, Taiwan.

Single crystals of A_2(Ba, Sr)Re(Y, Pr, Ho)Ru_{1-x} Cu_xO_6 have been grown from high temperature solutions of a mixture of PbO and PbF_2. Influence of additives like B_2O_3 and growth conditions such as temperature and environmental conditions on the size and morphology of these crystals are presented. The compositional homogeneity of the crystals is investigated with SEM, EDS and powder x-ray diffraction. The crystals grow as hexagonal plates or with a polyhedral habit depending on the solvent composition. While the parent compounds i. e. x = 0 are antiferromagnetic insulators, in the presence of Cu they exhibit superconductivity as seen from the magnetic measurements. The results are explained. The incorporation of Cu in the crystals was also confirmed by neutron activation analysis and Raman Spectroscopy.

10:15 AM *C1.5
High Field Magnet Prospects for MgB2. David Larbalestier, University of Wisconsin, Madison, Wisconsin.

MgB2 is in some important ways distinctively different from both the low temperature and the high temperature superconductors. Several companies worldwide have fabricated kilometer-length wires that make useful prototype magnets feasible. Already 1-2 Tesla solenoids have been made. Amongst the most important attributes of MgB2 are the lack of weak-linked grain boundaries making round wire conductors feasible, a Tc value that is twice as high as Nb3Sn, and Jc values that can attain 106 A/cm2 at low H and T and 105 A/cm2 at 6-9T at 4.2K. But Nb-Ti and Nb3Sn are both strongly entrenched and in spite of their much lower Tc they attain Jc values of about 105 A/cm2 at fields of 8.5 and 15T at 4.2K. Understanding the alloying behavior that controls the upper critical field Hc2 and the connectivity of bulk forms is key to making MgB2 a truly credible challenger to Nb-base magnets. A further dream is to address some markets only accessible by HTS materials. Development of fine-filament, round-wire conductors with high Jc might address magnet applications where the wide tape geometry of coated conductors poses real drawbacks. In short there are strong reasons for development of MgB2. MgB2 is certain to strongly and broadly impact superconducting magnet technology if its full potential Tc values of 35-40K, perpendicular Hc2 values over 40T, parallel Hc2 values over 70T and Jc values up to almost 107 A/cm2 can be achieved in bulk wire form.

10:45 AM *C1.6
MgB_2 Superconducting Wires and Tapes: Present Status and Applications. Giovanni Grasso, Andrea Malagoli, Valeria Braccini, Andrea Tumino and Sergio Siri; LAMIA Dept., INFM, Genova, Italy.

The present status of the development of MgB_2 superconducting wires and tapes will be presented. The recent achievements in terms of manufactured lengths, critical currents, and upper critical fields will be reported. Enphasis will be given to the possible applications foreseen for such conductors in the next future. So far, magnetic resonance imaging magnets and fault current limiters are the immediate targeted devices, but improvements in the $H_c{}^2$ values should allow for a wider range of applications. Recent progresses achieved at Columbus Superconductors for the fabrication of km-long multifilamentary, internally stabilized MgB_2 conductors will be finally discussed.

11:15 AM *C1.7
Effect of Sintering Temperature on J_c, H_{c2} and H_{irr} in SiC Doped MgB_2 Wires. S. X. Dou[1], S. Soltanian[1], D. Sumption[2], E. W. Collings[2] and M. Tomsic[3]; [1]Institute for Superconducting and Electronic Materials, University of Wollongong, Wollongong, New South Wales, Australia; [2]LASM, Materials Science & Engineering

Dept, Ohio State University, Columbus, Ohio; [3]Hyper Tech Research Inc, Columbus, Ohio.

We report a systematic study on the effect of sintering temperature on the phase formation, critical current density, upper critical field and irreversibility field of nano SiC doped MgB_2. Bulk and Fe sheathed wires doped with different nano-SiC particle sizes have been made and heat treated at temperatures ranging from 580°C to 1000°C. A systematic correlation between the sintering temperature, normal state resistivity, RRR, J_c, H_{c2} and H_{irr} has been found in all samples of each batch. Samples sintered at lower temperature have a very fine and well consolidated grain structure while samples sintered at high temperature contain large grains with easily distinguishable grain boundaries. Low temperature sintering resulted in a higher concentration of impurity precipitates, larger resistivity, higher J_c up to 15 T and lower T_c values. These samples show higher Hc_2 and H_{irr} at T near T_c but lower H_{c2} in low temperature regime. Nano-precipitates were the dominant mechanism responsible for higher H_{c2} at T near Tc while impurity scattering due to C substitution for B is responsible for higher H_{c2} in the low temperature regime for samples sintered at higher temperature. In addition to high H_{c2}, it is also proposed that the large number of nano impurities serve as pinning centres and improve the flux pinning, resulting in higher J_c values at high magnetic fields.

11:45 AM C1.8
Effect of Impurities in MgB2 on Thermodynamic Properties. Lawrence L. Cook, Ralph Klein and Winnie Wong-Ng; Ceramics, NIST, Gaithersburg, Maryland.

In the course of a thermodynamic study of MgB2, we have measured vapor pressures over several samples using the Knudsen effusion vacuum thermogravimetric technique, and measured the standard enthalpies of formation on the same samples using isoperibol solution calorimetry. While we found a large variation in the measured enthalpies, vapor pressure differences between the samples were much less. Second phase impurities in the samples were at low levels, and ranged from absent to barely detectable by powder x-ray diffraction. Certain of the samples, after partial vaporization, showed presence of substantial MgO, in addition to the presence of the expected MgB4. In order to explain such features, together with the wide variation in enthalpies, and the relatively small differences in vapor pressures, we propose entry of oxygen into MgB2 as a solid solution under certain circumstances. The current status of this hypothesis, and the latest experimental data will be discussed.

SESSION C2: Fundamental Issues for Coated Conductors
Chairs: Paul C. W. Chu and David Larbalestier
Tuesday Afternoon, March 29, 2005
Room 2000 (Moscone West)

1:30 PM *C2.1
Progress and Barriers in Developing High Temperature Superconductor Wires. Dean E. Peterson, Superconductivity Technology Center, Los Alamos National Laboratory, Los Alamos, New Mexico.

Most power applications of High Temperature Superconductors (HTS) depend on production of wires with appropriate properties and costs. Tremendous progress has been made during the past 15 years towards viable conductors. First generation BSCCO tapes are already commercially available for prototype power applications. Second generation coated conductors are now being fabricated in hundred meter lengths that exhibit critical currents in excess of 100 amps at 77 K. Several technical barriers remain to be solved before these new YBCO tapes will be produced in kilometer lengths with appropriate properties for large scale power applications. This review will summarize the status of high temperature superconducting wire development and discuss promising technical approaches as well as research opportunities. The presentation will focus on Los Alamos IBAD Coated Conductors to exemplify development of these scientifically and technologically important materials.

2:00 PM *C2.2
Progress of Long Length PLD-YBCO Coated Conductor and IBAD/PLD-CeO2 Substrate, and Jc Improvement in a Magnetic Field. Yutaka Yamada[1], Tomonori Watanabe[1], Kazuhiro Takahashi[1], Masaya Konishi[1], Takemi Muroga[1], Seiki Miyata[1], Akira Ibi[1] and Yuh Shiohara[2]; [1]Nagoya Coated Conductor Center, ISTEC-SRL, Nagoya, Aichi, Japan; [2]Division of Superconducting Tape and Wire, ISTEC-SRL, Tokyo, Japan.

Activity at SRL-Nagoya Coated Conductor Center (NCCC) is presented for the production of a 100 m class long buffered substrate and a few tens meters YBCO coated conductor using reel-to-reel IBAD and PLD systems. A 220 m long IBAD and a 100 m long CeO2 caped substrate have been successfully and stably produced. Furthermore, the PLD-CeO2 method succeeded in obtaining a high degree of 3 degrees of bi-axial texturing, which is close to a single crystal level and is considered to increase an Ic. A new PLD system called MPT-PLD (Multi-Plume and Multi-Turn PLD) also successfully achieved a 46m long YBCO conductor with a high Ic over 180A. The production rate was so rapid that each run of YBCO deposition was carried out at 12m/h for 4 times deposition. Also, Ic and Jc in a magnetic field are being improved by the study of thickness dependence on a magnetic field and RE-BCO materials. This study made it clear that Ic in a magnetic field has a crossover for the thickness and, then, it showed an optimum thickness for Ic in a given magnetic field. Furthermore, RE element such as Gd has a superior magnetic field dependence of Ic, compared to YBCO. These efforts are considered to help us efficiently develop a high Ic conductor used in a magnetic field.

2:30 PM C2.3
Continuous Preparation of Pulsed Laser Deposited YBCO on IBAD-MgO for Coated Conductor Applications. Brady J. Gibbons, Paul Dowden and Vladimir Matias; MST-STC, Los Alamos National Laboratory, Los Alamos, New Mexico.

The Superconductivity Technology Center at the Los Alamos Research Park has focused on continuous processing of second generation coated conductors. Our process includes steps for continuous electropolishing of Hastelloy C276 substrate tape (1 cm × 0.1 mm), continuous ion-beam assisted deposition (IBAD) of a biaxially textured MgO template layer, and continuous pulsed laser deposition (PLD) of oxide buffer layers and the superconductor ($YBa_2Cu_3O_7$). We are currently producing YBCO-based coated conductors using a 50 nm thick $LaMnO_3$ (LMO) buffer layer. The in-plane texture improves from $6-8°$ in the MgO to less than 3° in YBCO. We have attained YBCO performance of over 350 A (at 75 K) in lengths over 1 m (for a 3 μm thick YBCO film). YBCO is deposited in a multi-zone heater that allows for an engineered heating power profile as the YBCO film is deposited. The premise is to account for the change in the emissivity of the tape surface as the YBCO film becomes thicker. Using this heater we are able to grow thicker YBCO layers and attain higher critical currents. More detailed studies of using this "engineered" profile will be presented. This work is funded by the Department of Energy Office of Electric Transmission and Distribution.

3:15 PM *C2.4
Realization of High Performance Coated Conductors by Advanced TFA-MOD Process. Teruo Izumi[1], Hiroshi Fuji[1], Yuji Aoki[1], Ryo Teranishi[1], Koichi Nakaoka[1], Junko S. Matsuda[1], Sukeharu Nomoto[1], Yutaka Kito[1], Yutaka Yamada[1], Akimasa Yajima[2], Takashi Saitoh[3] and Yuh Shiohara[1]; [1]SRL-ISTEC, Koto-ku, Tokyo, Japan; [2]Asahi Denka Kogyo K.K., Arakawa-ku, Tokyo, Japan; [3]Fujikura Ltd., Koto-ku, Tokyo, Japan.

The TFA-MOD process is expected to be suitable as a low cost one due to its simple process and high performance. However, in order to produce the coated conductors for the applications, the several factors such as higher Ic, long tape etc. should be realized. In this paper, the recent progresses in our group on R&D of coated conductors by TFA-MOD process are reviewed. In order to obtain high Ic, the optimization of the growth conditions both for calcinations and crystallization steps was investigted. Through the investigations, it was clarified that a low heating rate in the calcination step and high PH2O with a low heating rate in the crystallization step are important for a high Ic value in thick films. The extremely high Ic value of 413 A was obtained by applying the above results on highly textured buffered substrates. On the other hand, the gas flow was controlled precisely by using a simulation technique for a uniform long tape processing. In the case of the low gas flow rate in our reel-to-reel system which has a transverse gas flow system, it was predicted by the calculation that the stagnant gas region with high HF concentration exists in the leeward part in the furnace. This could be a reason for the non-uniform reaction not only in the width direction but in the longitudinal one. Then, the long tape fabrication was carried out in the high gas flow condition, and the uniform performance with the high Ic value of 119A as an end-to-end one was realized in the 8.9m long tape. This work was supported by the New Energy and Industrial Technology Development Organization (NEDO) as Collaborative Research and Development of Fundamental. Technologies for Superconductivity Applications.

3:45 PM *C2.5
Progress in Scale Up of Applications-Ready Coated Conductors at Superpower. Venkat Selvamanickam, Yi-Yuan Xie, Allan Knoll, Yimin Chen, Yijie Li, Xuming Xiong, Jodi Reeves, Yunfei Qiao, Ping Hou, Tom Salagaj and Ken Lenseth; SuperPower

Inc., Schenectady, New York.

SuperPower is scaling up coated conductors for use in HTS device applications. In addition to high critical currents over 100 m lengths, our program is focused on developing applications-ready coated conductors. All steps of our coated conductor manufacturing process are conducted in pilot-scale facilities capable of producing minimum piece lengths of 100 m. Achievement of high throughput in every process stage is an important focus of our program. Linear speeds of at least 10 m/h are used in every process step. High-field performance has been substantially improved using rare-earth substitution. Lower ac losses have been achieved by producing multifilamentary conductors using an industrial photolithography process. Conductors are produced in practical 4 mm widths by slitting, where the critical current has been unaffected. A unique surround stabilizer structure, wherein a copper layer is electroplated completely around the conductor, has been developed. Over-current measurements show the effectiveness of the surround copper stabilizer structure. Superior bend strain, tensile strain, and tensile stress properties have been measured in our 4 mm wide conductors with surround stabilizer. A 1 m long cable was fabricated for the first time ever with 4 mm wide conductor. AC losses measured in this cable show very low values, which are substantially lower than that measured in cables made with first-generation HTS conductors. Pancake coils and racetrack coils have been fabricated with our coated conductor for magnet and rotating machinery applications. This work was partially supported by the U.S. Air Force through funds from Title III, AFRL, and AFOSR and the U.S. Department of Energy. This work was partially conducted under CRADAs with Los Alamos National Laboratory and Air Force Research Laboratory at Wright Patterson Air Force Base.

4:15 PM *C2.6

Status of 2G Wire Development at American Superconductor. Martin Rupich, Urs Schoop, Darren T. Verebelyi, Cees L.H. Thieme, Xiaoping Li, Wei Zhang, Thomas Kodenkandath, David Buczek and Yibing Huang; American Superconductor, Westborough, Massachusetts.

The Second Generation (2G) YBCO Coated Conductor wire development effort at American Superconductor has transitioned from demonstration of the technical feasibility and evaluation of potential manufacturing processes to development of a commercially viable 2G YBCO wire manufacturing technology. Ten meter lengths of 2G wire with critical currents exceeding 200 A/cm-width (77 K, self-field) have been available from AMSC for the past year. The current homogeneity and the mechanical robustness of AMSC's 2G wire has enabled its successful testing in prototype demonstrations, including coils and cables. AMSC's 2G manufacturing approach, based on the RABiTS/MOD-YBCO technology, is now focused on increasing the processing width and length to enable the high-rate, low-cost manufacturing of 2G wire that meets the electrical, mechanical, thermal and environmental requirements of targeted commercial and military applications. The RABiTS/MOD-YBCO manufacturing approach allows us to tailor the performance of the wire for specific customer applications. In addition the MOD YBCO process allows the controlled introduction of defects into the YBCO, enabling optimization of the wire performance for applications with different temperature and magnetic field requirements. In this presentation we will review the performance and properties of AMSC's RABiTS/MOD-YBCO 2G wires in relation to requirements for targeted commercial applications and discuss the progress of AMSC's 2G Pilot scale manufacturing effort.

4:45 PM C2.7

Development of Multi-plume and Multi-turn (MPT) PLD for YBCO Coated Conductor. Tomonori Watanabe[1], Reiji Kuriki[1], Takemi Muroga[1], Seiki Miyata[1], Akira Ibi[1], Yutaka Yamada[1], Yuh Shiohara[2], Takeharu Kato[3] and Tsukasa Hirayama[3]; [1]Nagoya Coated Conductor Center, ISTEC-SRL, Nagoya, Japan; [2]Division of Superconducting Tapes & Wires, ISTEC-SRL, Tokyo, Japan; [3]Japan Fine Ceramics Center, Nagoya, Japan.

Enlargement of deposition area is one of the problems to be solved to achieve high rate deposition of $YBa_2Cu_3O_{7-x}$ (YBCO) layer by pulsed laser deposition (PLD) for long coated conductor fabrication. We introduced a reel-to-reel PLD system, in which the optical system was designed so that the laser beam scanned YBCO targets during deposition and produced plural and discrete plumes (multi-plume) to enlarge the deposition area along the tape substrate transferring direction. Reel-to-reel tape transferring system was designed so that the substrate was transferred through multi-turn loops, and turns around a substrate heater for 3 times (multi-turn), to enlarge the deposition area across the substrate transferring direction. Using this multi-plume and multi-turn (MPT) PLD system, we have investigated a high rate deposition of YBCO with high critical current (I_c) on the "self-epitaxial" PLD-CeO_2 cap layer, which indicates drastic improvement of the in-plane grain alignment, on the ion beam assisted deposition (IBAD)-$Gd_2Zr_2O_7$ (GZO) buffered Hastelloy tape. Multi-plume, which used in this study were 4 plumes with laser repetition frequency of 40 Hz each, was able to combine the high critical current density (J_c) obtained by 40 Hz-deposition with the high deposition rate by 160 Hz one. We also found that raising the referential deposition temperature, according to the YBCO layer growth, was effective to suppress a-axis oriented grains and increase I_c. Adding this temperature adjustment to the MPT-PLD, an I_c as high as 260 A was attained in a 10 cm long conductor. Furthermore, We applied MPT-PLD, with deposition temperature adjustment, to prepare long YBCO coated conductor. Then, a 45.8 m long YBCO layer was succeeded in deposition and its end-to-end I_c reached 182 A. The multiplication of I_c and length achieved high value of 8.34 kA m. Our efforts to fabricate longer YBCO coated conductor will be reported. This work was supported by New Energy and Industrial Technology Development Organization (NEDO) as Collaborative Research and Development of Fundamental Technologies for Superconductivity Applications.

SESSION C3: Functionally Textured Metal/Oxide Coated Conductor Composite Templates
Chairs: Tolga Aytug and Teruo Izumi
Wednesday Morning, March 30, 2005
Room 2000 (Moscone West)

8:30 AM *C3.1

YBCO/IBAD MgO Coated Conductors - Functionality of Template Architecture and Recent Processing Improvements. Paul Arendt, Steve Foltyn, Quanxi Jia, Raymond DePaula, James Groves, Terry Holesinger, Liliana Stan, Igor Usov and Haiyan Wang; Los Alamos National Lab., Los Alamos, New Mexico.

The Los Alamos second-generation coated conductor architecture utilizes superconducting YBCO thick films on a biaxially oriented MgO template produced by ion-beam-assisted deposition (IBAD) on polycrystalline metal substrates. YBCO films grown using this architecture have been shown to exhibit transport critical current properties equivalent to films grown on single crystal substrates.[1] When compared with other IBAD materials, MgO displays superior texture vs. thickness properties. However it has been criticized for requiring ancillary layers not required by the other IBAD materials. In this talk, we discuss the functionality of these layers and how they fulfill and improve upon roles played by the other, much thicker, alternate IBAD materials. Radiation damage anisotropy experiments of MgO will also be described. The results imply a mechanism for the formation of biaxially textured IBAD MgO. They also suggest possible IBAD improvements, which when tested, proved to broaden the IBAD processing window. [1] S. R. Foltyn, P. N. Arendt, Q. X. Jia, H. Wang, J. L. MacManus-Driscoll, S. Kreiskott, R. F. DePaula, L. Stan, J. R. Groves, and P. C. Dowden, App. Phys. Lett., 82 4519 (2003).

9:00 AM *C3.2

Isolating the Effect of the Out-of-Plane Misorientation on J_c in RABiTS Through c-Axis Tilted Epitaxial Growth of TiN Seed Layers. Claudia Cantoni[1], Amit Goyal[1], John D. Budai[1], Albert A. Gapud[1], Matthew Feldmann[2], Nick Nelson[2], Keith J. Leonard[1], Mariappan P. Paranthaman[1] and David K. Christen[1]; [1]Oak Ridge National Laboratory, Oak Ridge, Tennessee; [2]Applied Superconductivity Center, University of Wisconsin, Madison, Wisconsin.

It is presently recognized that a sharp substrate texture is key for obtaining critical current densities approaching single-crystal values in coated conductors. Nevertheless, many questions remain about the evolution of grain boundaries from substrate to buffer layers to superconductor, and the effect on J_c of particular types of misorientations. In RABiTS, each substrate grain boundary can be regarded as the superimposition of a [001]-tilt, a [100]-tilt, and a [100]-twist boundary, and the global texture is commonly described through the in-plane and out-of-plane components. Although the majority of buffer layers deposited on textured metal substrates by various techniques duplicate more or less faithfully the substrate grain alignment, some materials have been found to develop a much sharper out-of-plane texture. These materials offer the opportunity to distinguish the effects of the out-of-plane and in-plane texture on J_c. When a TiN seed layer is employed, the out-of-plane misorientation of the buffer layers XRD FWHM decreases down to $\sim$ 3 degrees, while the in-plane misorientation remains equal to the substrate value of $\sim$ 7 degrees. We will report on the growth and structural characterization of TiN-based buffer architectures deposited by PLD that have consistently shown tilting of the c-axis towards the direction of the sample surface normal. We will address the extent and the mechanism of such tilt, as well as the modifications of the grain boundary distribution, using x-ray microbeam measurements and electron backscattering diffraction maps in which in-plane and out-of-plane components of the local misorientation are separated. We will also discuss the effect of such texture improvement on J_c. Research sponsored by the U.S. Department of Energy under contract DE-AC05-00OR22725 with the Oak Ridge National Laboratory, managed by UT-Battelle, LLC.

9:30 AM C3.3
Influence of the Substrate Temperature on the Texture of MgO Films Grown by Ion Beam Assisted Deposition. Liliana Stan, Paul N. Arendt, Raymond F. DePaula, Igor Usov and James R. Groves; Superconductivity Technology Center, Los Alamos National Laboratory, Los Alamos, New Mexico.

The variation in substrate temperature during the ion beam assisted deposition (IBAD), which employs the use of energetic ions to bombard the growing film, could influence quality of the crystalline texture of the MgO films. Therefore, the investigation of the texture dependence on substrate temperature is necessary to determine the optimum temperature for MgO growth. Also, determining the ion to molecule ratio window (the acceptable deviation from the optimum ion to molecule ratio) for different substrate temperatures establishes the optimum MgO deposition conditions. For each fixed deposition temperature, a set of samples was produced by varying the ion assist beam current from sample to sample while keeping the deposition rate constant. In this way, the ion to molecule ratio was modified and the range for achieving well textured films was determined. The investigation of the MgO texture dependence on the substrate temperature reveals that the best in-plane alignment is obtained at ~25 °C. At this temperature, MgO films with in-plane orientation distribution as low as 3.7° full width at half maximum (FWHM) have been attained. MgO films deposited at temperature higher than 100 °C have broad in-plane alignment. Although, the deposition at the lowest temperature (-150 °C) did not improve the in-plane texture, the ion to molecule ratio deposition window for achieving biaxially textured films was the largest. As a trend, the ion to molecule ratio deposition window decreases with increasing substrate temperature. This is especially important for continuous IBAD MgO depositions where less restrictive conditions are desired.

10:15 AM *C3.4
The Atomic Scale Properties of Interfaces in High-Tc Materials and Layered Composites. Nigel D. Browning[1,2], Rolf Erni[1], James P. Buban[3], Robert F. Klie[4], Stephen J. Pennycook[5,6], Sokrates T. Pantelides[5,6] and Alberto Franceschetti[5]; [1]Chemical Engineering and Materials Science, University of California, Davis, California; [2]National Center for Electron Microscopy, Lawrence Berkeley National Laboratory, Berkeley, California; [3]Institute of Engineering Innovation, University of Tokyo, Tokyo, Japan; [4]Center for Functional Nanomaterials, Brookhaven National Laboratory, Upton, New York; [5]Condensed Matter Sciences Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee; [6]Department of Physics and Astronomy, Vanderbilt University, Nashville, Tennessee.

Grain boundaries have long been known to play a critical role in determining the transport properties of high-Tc superconducting materials. With the introduction of layered oxide composite systems for the next generation of wires, other interfaces have also begun to assume similar levels of importance. For both the highly studied grain boundaries and the newer hetero-interfaces, characterizing atomic scale properties such as the interface structure (e.g. the formation of interface phases), composition (e.g. segregation and diffusion), and local bonding (electronic properties) is the key to understanding the overall transport properties as a function of processing conditions. The ability to perform this characterization is afforded by the combination of atomic resolution Z-contrast imaging and electron energy loss spectroscopy (EELS) in the scanning transmission electron microscope (STEM). The recent technical innovations of aberration correction (higher spatial resolution) and monochromation (higher energy resolution) have extended modern STEMs to the point where direct correlation of the experimental results with density functional theory is now possible. Through a combined experiment and theory approach to characterizing interfaces, the basic foundations of crystal chemistry (doping) and the transport models for interfaces in high-Tc materials can be examined. In this presentation, the latest developments in microscopy for the characterization of interfaces high-Tc materials will be presented. These techniques will be applied to analyze the morphology of interfaces in a layered composite and used at the highest spatial and energy resolution to discuss segregation and doping affects at undoped and Ca-doped YBa2Cu3O7-d grain boundaries.

10:45 AM *C3.5
Crystal Chemistry of Interfaces Formed Between Two Dissimilar Structures. Fred F. Lange and David Andeen; Materials, UCSB, Santa Barbara, California.

Without a doubt, when one crystalline material is allowed to nucleate and grow on another, special crystallographic relations are discovered that would not be predicted with any current theory. There are many examples. For identical structures with different lattice spacing, the misfit strain when one lattice is made to fit that of the substrate, can be conceptually related to the excess strain energy associated with the interface. This conceptual relation is not apparent for different structures, and thus differential lattice parameters can not be used to explain special crystallographic relations. Recently, the authors have discovered that the two simple rules of crystal chemistry can be used to understand some special crystallographic relations between two dissimilar structures. The first rule states that the charge associated with the cations and anions within a space that describes the structure (usually known as the unit cell), must balance. The second rule states that the cations are coordinated by a specific number of anions, and that this coordination number depends on the size ratio of the cations to anions. These two rules are commonly used to understand how a stable of different cations and anions can substitute for one another to form specific structures. These same two rules will be used to explain special orientation relations between two dissimilar structures. The examples chosen are ZnO (wurtzite) that epitaxies on (111) MgAl2O4 (spinel), TiO2 (anatase) on (100) LaAlO3 (perovskite) and TiO2 (rutile) on (R-plane) Al2O3 (sapphire), ZrO2 (fluoride) on basal plane Al2O3 (sapphire), and SiO2 (Cristobalite) on basal plane Al2O3 (sapphire) . In addition to these basic concepts, methods for experimentally discovering special relations, and geometrical methods for searching for explaining special orientations that minimize the misfit strain will be discussed.

11:15 AM C3.6
Study of Chemically Deposited Buffer Layers for YBCO Coated Conductors. Md. S. Bhuiyan[1,2], M. Paranthaman[1], S. Sathyamurthy[1], D. Lee[1], S. Kang[1], A. Goyal[1] and K. Salama[2]; [1]Oak Ridge National Laboratory, Oak Ridge, Tennessee; [2]University of Houston, Houston, Texas.

It is extremely important to develop a low-cost coated conductor fabrication method for electric-power applications. We have developed a chemical solution deposition (CSD) process, to deposit oxide buffer layers on biaxially textured Ni-W (3 at.%) substrates. CeO_2 and Y_2O_3 seed layers were grown by MOD technique and in the case of CeO_2 sharper out-of-plane and in-plane textures were achieved compared to the underlying texture of the Ni-W substrate. A new series of single rare earth niobate, RE_3NbO_7 (RE = La, Ce, Nd, Sm, Eu, Gd, Ho, Y, and Yb) buffer layers have been developed for the growth of superconducting $YBa_2Cu_3O_{7-\delta}$ (YBCO) films. Using CSD, smooth, crack-free and epitaxial RE3NbO7 films were grown on cube textured Ni-W substrate. YBCO films with critical current densities exceeding 1 MA/cm^2 at 77 K and self-field were achieved on these solution buffers using pulsed laser deposition. This demonstration promises a route for producing low-cost all-solution buffers for second generation YBCO coated conductors.
This work will be presented as part of Bhuiyan Ph.D. dissertation. Research supported by the Department of Energy, Office of Electric Transmission and Distribution, and Air Force Office of Scientific Research. This research was performed at the Oak Ridge National Laboratory, managed by UT-Battelle, LLC for the USDOE under contract DE-AC05-00OR22725

11:30 AM C3.7
Chemical Solution Deposition of Perovskite Buffers Layers for Superconducting Applications. Scott Fillery[1], Quanxi Jia[2] and Frederick F. Lange[1]; [1]Materials Department, University of California Santa Barbara, Santa Barbara, California; [2]Superconductivity Technology Center, Los Alamos National Laboratory, Los Alamos, New Mexico.

Chemical solution deposition of Lanthanum Manganite (LMO) thin films has been achieved on Ion Beam Assisted Deposition (IBAD) MgO substrates provided by Los Alamos National Laboratory. Solutions of Lanthanum acetate and Manganese acetate were refluxed in acetic acid and methanol to produce a spin-able precursor of varying concentration. Heat treatments at between 1000 and 1100 deg. C included water vapor, measured at between 0.5 and 0.9 mL/hr, to allow LMO film stability and inhibit Ni oxidation. Suppression of Mg(OH)2 at temperatures below 400 deg. C was achieved by delaying water input to higher temperatures. X ray diffraction shows epitaxy of (020) Lanthanum Manganite thin films on the (002) IBAD MgO substrates. LMO film thicknesses were measured at 90 nm using a profilometer on channels formed by stamping self assembled Octadecyltrichlorosilane (OTS) monolayers prior to film deposition. Similar perovskite structures have also been investigated on IBAD MgO substrates and will be discussed in conjunction with the above research.

11:45 AM C3.8
Solution Deposition and ex-situ Vacuum Conversion of Epitaxial YBCO//$SrTiO_3$//NiW RABiTS Coated

Conductors. Paul Clem, Jacob J. Richardson, James A. Voigt, Donald L. Overmyer and Michael P. Siegal; Sandia National Laboratories, Albuquerque, New Mexico.

A variety of solution deposition routes have been reported for processing epitaxial YBCO film coated conductors on metal tape substrates. We report here an extension of these methods toward long length, epitaxial film all-solution deposition routes to enable biaxially-oriented $YBa_2Cu_3O_{7-x}$ (YBCO) coated conductors. Recent results are presented detailing an all solution deposition approach to coated conductors with critical current densities J_c (77K) > 1 MA/cm^2 on rolling-assisted, biaxially textured, (200) oriented Ni-W alloy tapes, using $SrTiO_3$ (STO) or $SrTi_{0.96}Nb_{0.04}O_3$ (Nb:STO) buffer layers. Processing regimes to enable growth of STO on NiW without formation of NiO or WO_x will be discussed, as well as defect chemistry approaches to limit oxygen diffusion in STO and Nb:STO. Recent results with J_c values up to 1.7 MA/cm^2 have been obtained using American Superconductor Corporation (AMSC) solution-deposited YBCO on $SrTiO_3$//NiW, with I_c = 139 A/cm-width. Current limitations to all-solution deposition processes will be discussed, including the influence of substrate quality and buffer layer/substrate lattice mismatch. Kinetics of vacuum conversion will be discussed for 0.25-1.0 micron thickness YBCO films. Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

SESSION C4: Interface Dynamics in Layered Heteroepitaxial Oxide Films
Chairs: Claudia Cantoni and Paul Clem
Wednesday Afternoon, March 30, 2005
Room 2000 (Moscone West)

1:30 PM *C4.1
Abstract Withdrawn

2:00 PM *C4.2
Influence of Substrate−Film Interface Engineering on the Superconducting Properties of YBa2Cu3O7. Guus Rijnders and Dave H. A. Blank; Science & Technology, University of Twente, Enschede, Netherlands.

The atomic stacking sequence at the substrate−film interface plays an essential role in the heteroepitaxial growth of REBa2Cu3O7. During initial growth, the interface configuration influences the surface morphology and structural properties of the film, due to the formation of antiphase boundaries (APBs) by coalescence of islands with different stacking sequences. In this study, the interface configuration is accurately controlled by both the terminating atomic layer of the SrTiO3 substrate and the stoichiometry of the first unit cell layer. Using this capability the network of APBs and, therefore, the in-plane ordering is tuned, allowing the study of its influence on the structural and electrical properties of the YBa2Cu3O7 film. The critical temperature Tc is depressed by increase of the in-plane ordering, which strongly indicates that the presence of APBs in the sample favors the oxygen in-diffusion. Furthermore, the correlation between the vicinal properties of SrTiO3 (001) substrates and the twinning in YBa2Cu3O7 thin films grown by pulsed-laser deposition is studied using x-ray diffraction with reciprocal space mapping. The vicinal properties, i.e., angle and in-plane orientation, play a significant role in the anisotropic strain starting at the interface between substrate surface and film, and affect the twin behavior of YBa2Cu3O7. On substrates having an <110> in-plane orientation of the step edges, a completely preferred twin pair is observed if the vicinal angle (α) is increased to 0.6°. Whereas on substrates having their step edges oriented along one of the crystallographic axis, the films exhibit a detwinning as the vicinal angle increases. For α =1.10° a maximum detwinned, i.e., monocrystalline film is obtained.

2:30 PM C4.3
Coordinated Characterization of Coated Conductors. Dean J. Miller[1], Susana Trasobares[1], Jon M. Hiller[1], Kenneth E. Gray[1], Vitali K. Vlasko-Vlasov[1], Helmut Claus[1], Victor A. Maroni[1], K. Venkataraman[1] and Jodi Reeves[2]; [1]Argonne National Laboratory, Argonne, Illinois; [2]SuperPower, Inc., Schenectady, New York.

We have established a coordinated set of characterization methods that can be applied to coated conductor specimens to help identify the underlying causes of poor performance. The key to this approach is to utilize complementary techniques that measure local superconducting properties, phase composition, microstructure, and texture. We have used the coordinated application of magneto-optical imaging (MOI), Raman microscopy, and site-specific microstructural characterization using focused-ion-beam (FIB) sectioning and transmission electron microscopy (TEM) to study meter-length coated conductor tapes. These studies have pinpointed specific microstructural and chemical defects that can be correlated with poor Ic performance in these tapes. The key aspects of this coordinated characterization approach will be outlined and detailed studies that illuminate the role local defects play on transport properties will be presented and discussed. Work at Argonne National Laboratory was supported by the U. S. Department of Energy, Offices of Science and of Electric Transmission and Distribution under Contract W-31-109-ENG-38. Electron microscopy was carried out in the Electron Microscopy Center at Argonne National Laboratory, which is supported by the Office of Science.

3:15 PM *C4.4
A New Approach using Artificial Substrates for Growth of High-Quality Precipitate-Free HTS Thin Films, Toward Electronic Device Applications. Kazuhiro Endo[1], Petre Badica[2,3], Hiroshi Sato[4] and Hiroshi Akoh[4]; [1]Nanoelectronics Research Institute (NeRI), National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan; [2]Institute for Materials Research, Tohoku University, Sendai, Japan; [3]National Institute of Materials Physics (INCBFM), Bucharest, Romania; [4]Correlated Electron Research Center (CERC), National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan.

For successful fabrication of electronic devices, high quality thin films are required; controlled and uniform thickness and properties, certain morphology and alignment, low and uniform roughness, device fabrication area completely without precipitates are several key limitative parameters. All of them are even more important for sandowitch-type structures and superlattices exibiting through the stacked layers certain effects, (e.g. Josephson or magnetoresistance tunneling, other) and/or for integrated devices. In particular, the last criterion is increasingly difficult to be realized for ultra thin films and/or films of multi-component materials showing segregation problems. For the first time, we have succeeded in the growth of high-quality thin films with clean and completely precipitate-free surface, suitable for device applications, by applying a new concept and method to the substrates. The concept consists in generation of artificial steps of controlled heght and width, and desired shape on the surface of the substrate. The width of the step is chosen so that it is equal to the double of the migration length of the atomic species in the growth process of the film. If precipitates occur, they will be selectively gathered to the step edge where the free energy is lowest. Using this new approach, we have successfully obtained by MOCVD high-quality precipitate-free Bi-2223 and Bi-2223/Bi-2212-superlattice thin films on (001) SrTiO3 substrates with artificial steps of controlled width and height. These as-grown films have been further used to fabricate patterned intrinsic Josephson junctions, which are not only instructive models for future artificial SIS junctions, but also good candidates for high frequency applications in the THz region. Completely precipitate-free films offer a strong advantage for integration, and generate new possibilities for the device fabrication.

3:45 PM *C4.5
Transmission Electron Microscopy Studies of YBCO Films on Biaxially Textured Buffer Layer Deposited by Pulsed Laser Deposition. Takeharu Kato[1], Hirokazu Sasaki[1], Tomonori Watanabe[2], Akira Ibi[2], Hiroyuki Iwai[2], Yasuhiro Iijima[3], Kazuomi Kakimoto[3], Yasunori Sutoh[3], Takemi Muroga[2], Seiki Miyata[2], Yutaka Yamada[2], Takashi Saitoh[3], Teruo Izumi[4], Yukichi Sasaki[1], Tsukasa Hirayama[1], Yuh Shiohara[4,2] and Yuichi Ikuhara[1]; [1]Materials Research and Development Laboratory, Japan Fine Ceramics Center, Nagoya, Japan; [2]SRL-Nagoya Coated Conductor Center, ISTEC, Nagoya, Japan; [3]Material Technology Laboratory, Fujikura Ltd., Koto-ku, Tokyo, Japan; [4]SRL-Division of Superconducting Tapes and Wires, ISTEC, Koto-ku, Tokyo, Japan.

Thick YBCO films with high Jc values were deposited by pulsed-laser deposition (PLD) on Hastelloy with buffered biaxially textured layer. Both cross-sectional and plan-view TEM specimens of the YBCO films were prepared, and then the microstructural characterization of the films was examined by transmission electron microscopy (TEM). The YBCO films less than 1μm thick were predominantly composed of c-axis oriented grains, however, a-axis oriented grains were occasionally found. Since screw dislocations perpendicular to the substrate were observed in the c-axis oriented grains, the grains were considered to grow spirally. It was found that the a-axis oriented grains nucleated on the biaxially textured buffer layer, and grew larger with the increasing thickness of the YBCO film. We found that c-axis and a-axis oriented grains coexisted in the thick YBCO films beyond about 1μm from the buffer layer and formation of many gaps between the YBCO grains. In addition, both Y-rich phases and cupper oxides were formed at the interface between a-axis and c-axis oriented grains. Since those phases or the gaps are considered to reduce the Jc values of the YBCO film, it is, therefore, important to find out the optimum process conditions to suppress both the nucleation of a-axis grains, Y-rich phases or cupper oxides and the formation of the porous structure. Acknowledgment: This work was supported by the New Energy and Industrial Technology Development Organization (NEDO) as the Collaborative Research and Development of Fundamental Technologies for Superconductivity Applications.

4:15 PM C4.6
Microstructures of EuBa2Cu3O7 Films on SrTiO3 Substrates with Different Seed Layers. Yuan Lin, Haiyan Wang, B. Maiorov, L. Civale, Yuan Li, J. L. MacManus-Driscoll, S. R. Foltyn and Q. X. Jia; Materials Science and Technology Division, Los Alamos National Lab., Los Alamos, New Mexico.

EuBa2Cu3O7 (Eu123) films show some unique properties such as an excellent surface morphology, a high transition temperature, and an interesting field-dependent critical current density, which are important for thin film devices and coated conductor applications. In our earlier studies, we found that by inserting a certain REBa2Cu3O7 (RE123, RE = Y, Dy,etc.) seed layer, the processing window for high performance Eu123 can be significantly expanded. In this presentation, we report our comparative studies of the microstructures of Eu123 films on SrTiO3 substrates with different seed layer RE123 materials. We have used high-resolution X-ray diffraction (HRXRD) to investigate the micro-domains and dislocation densities of the films. We will also discuss the effect of the microstructures on the superconducting properties of Eu123 films.

4:30 PM C4.7
Electrical Self-Stabilization of High-Temperature Superconducting Wires for Power Applications using Iridium-Based Conductive Architectures. Tolga Aytug[1,2], Parans M. Paranthaman[1], H. Y. Zhai[1], K. J. Leonard[1], A. A. Gapud[1], P. M. Martin[1], C. Cantoni[1], R. Feenstra[1], A. Goyal[1], D. K. Christen[1] and J. R. Thompson[2]; [1]Oak Ridge National Laboratory, Oak Ridge, Tennessee; [2]Physics and Astronomy, University of Tennessee, Knoxville, Tennessee.

For power applications of YBCO coated conductors, it is necessary to electrically stabilize the conductor. An economic way to achieve this that benefits the engineering Je, is to grow conductive buffer layers directly on textured Cu or Ni surfaces. However, due to poor oxidation resistance and high reactivity/diffusivity of Cu or Ni, an insulating oxide layer usually forms at the metal/substrate interface. The oxide layers degrade the electrical connectivity of the entire architecture. To overcome this problem we have developed a new conductive, non-magnetic buffer layer architecture composed of bilayer La0.7Sr0.3MnO3/Ir on both Ni- and Cu-based substrates. The key feature is the Ir layer, which serves as a barrier to both inward diffusion of oxygen and outward diffusion of metal substrate cations during fabrication. Using PLD to grow YBCO, we demonstrate ideal electrical coupling to both Ni and Cu-based substrates. Electron microscopy shows a complete absence of unwanted oxide interfaces or intermixing of the individual layers. Critical current (Ic) values for 1 m thick YBCO coatings exceed 100 A/cm at 77 K on a Ni-W RABiTS template. Using a CeO2 cap layer directly on Ir, the standard 3-layer buffer stack was simplified and made compatible with the BaF2 ex situ process, yielding Ic > 150 A/cm (77 K) for a 1 m thick YBCO coating. In addition, mechanisms related to interdiffusion of Ir-Ni are addressed through detailed post-annealing studies and characterizations.

4:45 PM C4.8
Reliable Fabrication Methods for High-Tc Superconductor SNS Junction Nano-Devices. Sungwook Kim and John McDevitt; University of Texas at Austin, Austin, Texas.

Although the superconductor/normal metal (SN) interface is the most important controlling factor in determining the performance of superconductor/normal metal/superconductor (SNS) junctions, controlling the SN interface still remains difficult. The in situ deposit techniques have been widely used to cope with this problem, but it limits the types of SNS junctions that can be explored. Soft chemistry etching methods and new annealing methods were developed and applied to fabricate the YBCO/Au/YBCO and TX-YBCO/Au/TX-YBCO SNS junction nano-devices with ex situ deposit. The planar SNS junctions controlled by such methods exhibited good transport properties effects well above 80 K with less than 10-8 ?-cm2 contact resistivity. The current state of the suitable fabrication methods of SNS nano-devices will be described with experiment results.

SESSION C5: Poster Session:
Wednesday Evening, March 30, 2005
8:00 PM
Salons 8-15 (Marriott)

C5.1
Techniques for Substrate Temperature Monitoring and Control during Stationary and Continuously Processed Ion Beam Assisted Deposited Magnesium Oxide.
Raymond F. DePaula, Paul N. Arendt, James R. Groves, Liliana Stan and Igor Usov; MST/STC, Los Alamos National Lab, Los Alamos, New Mexico.

Previous experiments investigated the effects of substrate temperature on in-plane texture of Ion Beam Assisted Deposition (IBAD) Magnesium Oxide (MgO)(1). Depositions were made on different substrate materials over a wide range of temperatures and assist beam parameters. Findings concluded that maintaining a lower (∼25 C) substrate temperature during deposition improved the quality of the in-plane texture. Maintaining the appropriate temperature at the substrate surface during processing is crucial. Substrate temperature was monitored at some distance from the substrate in a cooling block. Initially, it was assumed that there was good thermal contact between the substrate and the cooling block and that the substrate surface was at the same temperature as the block. However, a careful investigation showed that the substrate surface temperature can be substantially (∼100 C) different. Techniques used to monitor the substrate temperature and improve the cooling efficiency will be discussed. (1) see L Stan et.al. Influence of the Substrate Temperature on the Texture of MgO Films Grown by IBAD. This symposium.

C5.2
Evolution of Biaxial Texture during Ion-Beam Assisted Deposition of MgO. Vladimir Matias, Alp T. Findikoglu and Terry G. Holesinger; MST-STC, LANL, Los Alamos, New Mexico.

We examine the evolution of biaxial texture during ion-beam assisted deposition (IBAD) of MgO using reflection high-energy electron diffraction (RHEED), in situ ion scattering, x-ray diffraction and transmission electron microscopy. The IBAD-MgO templates on metal tape are used for second generation high-temperature superconducting wire, also known as coated conductors. We find that the texture development is very sensitive to the nucleation surface conditions, both chemical species and surface morphology. In the best cases an in-plane texture of 3.5 degrees and an out-of-plane texture of 1.5 degrees are attainable. We are utilizing a methodology of presenting data in terms of IBAD texture contour plots where we collect data as a function of ion-to-molecule ratios and film thickness. The striking conclusion from the data is that the texture development for different ion-to-molecule ratios can be scaled with the cumulative ion damage normalized to deposited MgO material. We discuss the results in terms of possible mechanisms for IBAD-MgO biaxial texturing and relationship to other IBAD texturing processes. This work is funded by the Department of Energy Office of Electric Transmission and Distribution.

C5.3
Textured Oxidation Protection Coatings on Copper and Copper-Alloy Substrates to be used in Coated Conductor Applications. Chakrapani Varanasi[1,2], Paul N. Barnes[2], Nicholas A. Yust[2], Andrew D. Chaney[2] and Srinivas Sathiraju[3,2]; [1]Univeristy of Dayton Research Institute, Dayton, Ohio; [2]PRPG, AFRL, Wright-Patterson AFB, Ohio; [3]National Research Council, National Academy of Sciences, Washington DC, District of Columbia.

Copper or copper based alloys are an attractive, less costly alternative to Ni-based alloys as substrate materials for $YBa_2Cu_3O_{7-x}$ (YBCO) coated conductor applications. Use of a thermally conductive copper substrate will have the benefit of conducting the heat away from a localized hot spot and hence acting as a quench protection stabilization component of the coated conductor when used with suitable buffer layers. If the YBCO layer is electrically connected to the copper substrate via conducting buffer layers, then the addition of a copper current shunt can be avoided. These advantages can make copper a superior substrate for the dc conductor. In addition, copper substrates are non magnetic and useful for reducing ferromagnetic losses resulting from transient fields, although eddy current losses may be a competing factor. As cubic texture can be developed in copper or copper-iron substrates with good lattice match with buffer layers and YBCO, the rolling-assisted biaxial textured substrates (RABiTs) approach can be used to process coated conductors. However, the oxidation of copper and copper-alloy substrates has been a problem to process long length YBCO coated conductors successfully. Deposition of oxidation protection layers on copper is an attractive approach to address this problem. However, the protective layer should have a good lattice match, provide oxidation protection, remain effective (diffusion into copper considerations), and should be non-magnetic. In this study, non magnetic Ni-20% Cr, and Pt coatings have been applied onto cubic textured Cu and Cu-Fe alloy substrates by DC magnetron sputtering to develop substrates with good texture and high oxidation resistance. Texture development and oxidation protection were investigated for films deposited at different deposition conditions and the results obtained it this study will be presented.

C5.4

Chemical and Microstructural Evaluation of Europium Niobate Buffer Layers for YBCO Coated Conductors.
Manisha V. Rane[1], Harry Efstathiadis[1], Hassa Bakhru[1], Frank Ramos[1], Pradeep Haldar[1], M. S. Bhuiyan[2], Amit Goyal[2] and M. Parans Paranthaman[2]; [1]Albany NanoTech, Albany, New York; [2]Oak Ridge National Laboratory, Oak Ridge, Tennessee.

The low cost all solution technique has been employed to synthesize textured Europium niobate, Eu_3NbO_7 (ENO) based buffer layers, for growing thick superconducting YBCO films, on biaxially textured metal substrate. In this first part of our study, the chemical and microstructural properties of ENO films have been evaluated using various characterization techniques such as X-ray Diffraction (XRD), Focused Ion Beam (FIB), Scanning Electron Microscopy (SEM), Rutherford Backscattering (RBS), and Secondary Ions Mass Spectroscopy (SIMS). This work summarizes the observations, and proposes future directions for process optimization to make the buffer viable.
Research supported by the Department of Energy, Office of Electric Transmission and Distribution. This investigation was performed under the contract USDOE contract DE-FC07-03ID14515 at Albany NanoTech at University at Albany, SUNY, and at the Oak Ridge National Laboratory, managed by UT-Battelle, LLC for the USDOE under contract DE-AC05-00OR22725.

C5.5

Development of Electrodeposited Iridium as Buffer Layer for YBCO Superconductors. Priscila Delega Spagnol[1], Tapas Chaudhuri[2,1], Raghu Bhattacharya[1] and Sovannary Phok[2,1]; [1]Basic Science-Superconductivity Group, National Renewable Energy Laboratory (NREL), Golden, Colorado; [2]Physics, University of Colorado, Boulder, Colorado.

Electrodeposition (ED) is a potentially low-cost, non-vacuum, high-rate deposition process that can easily deposit uniform film on large non-planar substrates. In this paper we are reporting successful biaxially textured electrodeposition of Ir on Ni and Ni-W substrates. Ir metal is well know for its excellent oxidation and corrosion resistance among platinum group elements, and also the lattice mismatch of cubic Ir is very close to that of CeO_2 and Ni. Our main goal is to simplify the buffer layer architecture by using electrodeposited Ir. The films were deposited in a vertical cell in which the electrodes (both working and counter) were suspended vertically from the top of the cell. The ED experiments were performed at 65^oC without stirring the solution. The ED precursors were prepared at about -1.2 V from 2 to 15 minutes on both Ni and Ni-W 3at.% where the Pt counter and Pt pseudo-reference were shorted together. To qualify the quality of the electrodeposited Ir buffer layer, initially $CeO_2/YSZ/CeO_2$ buffer structure and later on simplified YSZ/CeO_2 buffer structure were deposited on ED Ir coated Ni and Ni-W substrates by PLD. The ED Ir/metal substrates were first heated to 800^oC in 0.5 mTorr of forming gas and then a CeO_2 seed layer was deposited in 180mTorr forming gas. Subsequently, YSZ and CeO_2 layers were deposited sequentially in 0.1mTorr oxygen. The XRD studies revealed that the YC layers are bi-axially textured with phi = 6.5^o and omega = 8^o.

C5.6

Superconducting YBCO Films Prepared by Electrodeposition and Spray Pyrolysis. Sovannary Phok, Priscilia Spagnol, Tapas Chaudhuri and Raghu N. Bhattacharya; NREL, Golden, Colorado.

Bi-axially textured YBa2Cu3O7-δ films have been fabricated by non-vacuum electrodeposition and spray pyrolysis techniques. Electrodeposited YBCO was prepared on sputtered copper/single crystal substrates. Electrodeposition was carried out at constant voltage and the deposition was completed only in few minutes. The thickness of the as-deposited films was in the range of 0.5 to 1 μm. The optimized sputtered copper layer thickness was about 200$\AA$ on SrTiO3. In spray pyrolysis method, the solution is sprayed directly on LaAlO3 substrates. The substrate temperature is about 100 °C. The thickness of the as-deposited films was in the range of 0.24 to 0.31 μm. The electrodeposited and spray deposited films were annealed at temperatures ranging from 800 °C to 920 °C under various flowing gas mixture. XRD analysis revealed that processed electrodeposited and spray deposited films were bi-axially textured where YBCO grains were well oriented along c-axis and in the (a,b) plane. $\Delta\omega$, deduced from rocking curve on (005) reflection was as low as 0.34°. Δphi, deduced from phi-scan on (103) reflection was as low as 0.6°. The critical current density for these type of films already reached 0.5 MA/cm2 at 77 K and 0 T.

C5.7

Preparation and Characterization of Oxide Superconducting Particles by a Metal-Chelate Decomposition Method.
Hiroki Fujii[1], Kiyoshi Ozawa[2], Takayuki Nakane[1], Hiroaki Kumakura[1] and Hitoshi Yamaguchi[3]; [1]SMC, NIMS, Tsukuba, Japan; [2]MEL, NIMS, Tsukuba, Japan; [3]MAS, NIMS, Tsukuba, Japan.

Colloidal Y-Ba-Cu particles of different compositions were prepared by a metal-chelate decomposition method. The solution of each metal-acetate was mixed with NTA (nitrilotriacetic acid) solution. After mixing these solutions and subsequent stirring, these metal-chelates were decomposed by H_2O_2 at 60 °C or 70 °C. The composition of the precipitates depended on the initial composition of the solution and the reaction temperature. The composition of the precipitates was closer to that of the solutions when reacted at 70 °C. The precipitates with the compositions of Y:Ba:Cu=1:2:3 and 1:2:4 were obtained when the compositions of the solution were Y:Ba:Cu=1:2.2:3.1 and 1:2.2:4.15 at 70 °C. In the as-precipitated state, uniform particles of 20 nm were obtained, and only $BaCO_3$ phase was indentified as a crystalline phase. Heat treatment at 600 °C in air induced the crystallization of the remnant. When heat-treated at 850 °C in air, $YBa_2Cu_3O_z$ (Y-123) was formed as a single phase, and its particle size was $\sim$200 nm. The particle size reached $\sim$500 nm when heat-treated at 900 °C. On the other hand, $YBa_2Cu_4O_8$ (Y-124) phase was formed by the heat treatment at 810 °C in a flow of oxygen. The critical temperatures of the Y-123 and Y-124 were 91 and 80 K, respectively.

C5.8

Identification of Intermediate Phases and Growth Mechanism TFA Derived YBCO Films. Juan Carlos Gonzalez[1], Jaume Gazquez[1], Teresa Puig[1], Narcis Mestres[1], Felip Sandiumenge[1], Xavier Obradors[1] and Marie Jo Casanove[2]; [1]Materials Superconductors, ICMAB-CSIC, Bellaterra, Spain; [2]CEMES, Toulouse, France.

The preparation of YBCO films using TFA metal-organic precursors is a very promising chemical, low cost and scalable methodology which has been probed to achieve excellent superconducting properties. However, the knowledge acquired on the growth mechanisms, participating intermediate phases and their role in the final microstructure is still limited. In this work, we present complementary analysis by micro-Raman spectroscopy, TEM and X-ray diffraction of a series of YBCO films prepared at intermediate growth conditions. The use of the three techniques has enabled us to identify the intermediate precursor phases (Y2O3, Y2Cu2O5, BaF-O, BaO, and CuO). It is remarkably surprising the degree of phase segregation and the large mobility that different metal atoms need to achieve prior to YBCO conversion, possibly induced by the laminar growth mode characteristic of the TFA processes. In view of the obtained results, we propose that not a unique route of phase transformations occurs in the YBCO conversion and we identify several competing routes.

C5.9

Rare-Earth (Nd, Sm) Substitutions in YBa2Cu3O7-x Films Deposited by Trifluoroacetate Process. Brandon Craig Harrison, C. Varanasi and P. N. Barnes; Air Force Research Labs, WPAFB, Ohio.

The Trifluroacetate-Metal Organic Deposition (TFA-MOD) method is a strong candidate for utilization in the scale up of YBa2Cu3O7-x (YBCO) coated conductor production, since it is a low cost, non-vacuum process that can achieve YBa2Cu3O7-x superconductor tapes with high critical current density. However, for applications that require coated conductors to operate in magnetic fields greater than self-field, the TFA-MOD process must be modified to incorporate flux pinning centers into the YBCO films. Moreover, if the conductors are to be used in generators, transformers, etc. these pinning centers should be randomly distributed in the films to provide enhanced Jc in all directions of applied field. To achieve this result Nd and Sm were substituted in for Y within the film by adding small amounts of the corresponding rare-earth trifluoroacetates to the precursor solution. Samples were fabricated by spin coating onto non-buffered single crystal LaAlO3. Process conditions were then optimized to achieve phase separation; producing dispersed nanoparticles. The dependence of current density and microstructure of the film on the processing conditions and fractional substitution will be presented.

C5.10

Investigation of the Calcination Conditions for the Advanced TFA-MOD Process. Koichi Nakaoka[1], Junko Matsuda[1], Hiroshi Fuji[1], Ryo Teranishi[1], Yuji Aoki[1], Yutaka Kito[1], Teruo Izumi[1], Yuh Shiohara[1], Yutaka Yamada[2], Tomotaka Goto[3] and Akimasa Yajima[3]; [1]SRL-ISTEC, Tokyo, Japan; [2]ISTEC-SRL Nagoya Coated Conductor Center, Nagoya, Japan; [3]Asahi Denka Co., Ltd., Tokyo, Japan.

The metal organic deposition (MOD) process using the precursor solution containing trifluoroacetate (TFA) salts of Y, Ba, and Cu could easily affords $YBa_2Cu_3O_{7-y}$ (YBCO) films with high Jc.

However, this TFA-MOD process requires long time (over 10 hours) especially in the calcination process for each single coating. In our previous work, in order to shorten the calcination time, we developed a new precursor solution that consisted of yttrium- and barium-trifluoroacetates, and copper naphthenate. We call the process using this new precursor solution as an "advanced TFA-MOD process." The production rate in the advanced TFA-MOD process was achieved to be 25 times faster than the conventional process, maintaining a high Jc property. In this work, we have investigated the calcination process on both microstructures and superconducting properties for optimization of the advanced TFA-MOD process. Increase of the heating rate makes the surface microscopic morphologies of the precursor films rougher, and Jc values lower. In the case of the high heating rate, formation of large pores and segregation of Cu atoms were observed in the precursor films. The maximum values of the HF gas generation rate during calcination became high as the heating rate was increased. The crystallinities of the YBCO films decreased with increasing the heating rate in the calcination. Consequently, it became clear that the increase of the heating rate caused the rapid HF gas generation leading to degradation of the surface macroscopic morphologies, formation of pores. Both morphological differences could be a reasons for lower crystallinities, and reduction of Jc values. Additionally, the effects of Cu-segregation were also investigated. This work was supported by the New Energy and Industrial Technology Development Organization (NEDO) as Collaborative Research and Development Fundamental Technologies for Superconductivity Applications.

C5.11

Fabrication of Long Length YBCO Coated Conductors by Advanced TFA-MOD Process. Yuji Aoki[1], Ryo Teranishi[1], Koichi Nakaoka[1], Yutaka Kito[1], Hiroshi Fuji[1], Jyunko Matsuda[1], Sukeharu Nomoto[1], Teruo Izumi[1], Yuh Shiohara[1], Yutaka Yamada[2] and Akimasa Yajima[3]; [1]Superconductivity Research Laboratory, International Superconductivity Technology Center, Tokyo, Japan; [2]Superconductivity Research Laboratory, Nagoya Coated Conductor Center, International Superconductivity technology Center, Nagoya, Japan; [3]Asahi Denka Kogyo Co., Ltd., Tokyo, Japan.

A metal organic deposition (MOD) method is one of the promising processes to realize a low cost process since any special expensive high vacuum equipment is not required. Additionally, it has been well confirmed that this process has an advantage to provide a high Jc film of an MAcm-2 class on the metal substrate. We have been developing the TFA-MOD process for the superconducting layer using a continuous reel-to-reel system with appropriate heat-treatment, and successfully produced uniform tapes with high performance. In our previous work, the optimized conditions for the heat-treatment were applied to the growth of Y-123 films on CeO2(PLD)/Gd2Zr2O7(IBAD)/Hastelloy tapes and the Ic value of 340 A was achieved in the 1.60 mm in thickness. In the large scale equipment for a continuous long tape process by the reel-to-reel system, the influence of the gas flow velocity, flow direction and a slight curving along the width direction of the tape during the heat-treatment process were investigated. Particularly, when a longer tape has tried to produce, it was difficult to obtain the uniform reaction along the long direction. To solve this problem, a higher gas flow rate during YBCO growth was applied in order to decrease the concentration of HF gas in the leeward stagnant region. Actually, relatively uniform performance was obtained the end-to-end Ic value of 119 A was achieved in the 8.6 m long tape. The product of Ic and length was 1,029 Am. We will present results on the preparation of 30 m class coated conductor. This work is supported by the New Energy and Industrial Technology Development Organization(NEDO) as Collaborative Research and Development of Fundamental Technologies for Superconductivity Applications.

C5.12

Improvements in Critical Current with Second Phase Additions to MgB2. Soo Kien Chen[1,2], Zainovia Lockman[1], Clare Dancer[1], Bartek Glowacki[1,2] and Judith L. MacManus-Driscoll[1,2]; [1]Materials Science and Metallurgy, University of Cambridge, Cambridge, United Kingdom; [2]Interdisciplinary Research Centre in Superconductivity, University of Cambridge, Cambridge, United Kingdom.

Various oxide and nitride secondary phases have been added to MgB2. Bulk polycrystalline MgB2 samples were prepared via in situ solid state reaction using short annealing in Ar/H2. Several of the dopants have yielded improvements in magnetic critical current density, Jc by a factor of 4 at 6K and 20K, 2T. The improvements in Jc are mainly as a result of microstructural modification and increased sample densification. Hence, the main advantage of the dopant additions is to reduce the dependence on expensive mechanical methods for forming fine grains (e.g. mechanical milling) and for densifying them (e.g. high pressure isostatic pressing).

C5.13

Microstructure and Jc Property of a Novel High-Tc Superconducting Films and Wires. Jae Joon Chang[1], Byeong Hyeok Sohn[1], Eue Soon Jang[1], Man Park[1], Seung Jin Ryu[1] and Jin Ho Choy[2]; [1]School of Chemistry, Seoul National University, Seoul, South Korea; [2]Nanoscience, Ewha Womans University, Seoul, South Korea.

A systematic application of intercalation technique to layered superconducting oxides enables us to open a new chapter in the development of nano-hybrid with various functions. Recently, we were successful in preparing a novel high-Tc superconducting micro-wires and films from the nano-hybrid exfoliated superconducting colloid by electrophoretic deposition method (EPD). In order to prepare superconducting colloidal suspension, the high-Tc bismuth cuprate superconductor, Bi2Sr2CaCu2O8+y or Bi2Sr2Ca2Cu3O10+y, should first be intercalated with mercury iodide molecules and subsequently with organic salt intercalates. Exfoliation of Bi-based superconductor has been achieved from organic salt intercalates. In order to study the successful exfoliation of layered high-Tc superconductors, powder X-ray diffraction (XRD), transmission electron microscopy (TEM), and atomic force microscopy (AFM) analyses were accomplished. Moreover, we found that the surface charge of the resulting nanosheets in acetone solvent is slightly positive with a potential of 25mV. Such a surface property allowed us to apply these colloidal particles as a novel precursor to the fabrication of superconducting thin, and thick films. As a great advantage, the present exfoliated nanoparticles are not limited to shape and scale of substrate thanks to its nanoscale dimension. As a point of this view, high-Tc superconducting thin films and micro-wires on silver substrate were fabricated by EPD method. Directional growth along c-axis and connectivity between grains were remarkably improved by subsequent heat treatment. Such a epitaxial growth was further confirmed by field-emission scanning electron microscopy (FE-SEM), and TEM. Consequently, the resulting films and wires show reasonable critical current density (Jc) and their thickness can be controlled in proportion to the regulation of time.

C5.14

Behavior Tc and Hc2 Near the Metal/Insulator Transition. Michael Osofsky[1], Robert J. Soulen[1], Gerald T. Woods[2] and William F. Egelhoff[3]; [1]Code 6361, Naval Research Laboratory, Washington, District of Columbia; [2]University of South Florida, Tampa, Florida; [3]National Institute of Standards and Technology, Gaithersburg, Maryland.

The search for new materials with enhanced superconductive transitions, Tc, has been, and is still, carried out for the most part without the benefit and guidance of a firm theoretical framework. Instead, various empirical correlations have been noted and used with moderate success. Alternatively, band theory can be used to estimate Tc on a case-by-case basis. We demonstrate empirically that several disparate classes of superconductors whose only common feature is proximity to a metal/insulator transition (MIT), share a common phase diagram Tc(r). Here r is a coordinate characterizing the disorder and is completely defined in terms of measurable quantities. This remarkable phase diagram may be plausibly explained by explicitly incorporating an enhancement of the electron screening length, which occurs near the MIT, into the BCS equation for Tc. Just recently we have studied Hc2 as a function of proximity to the MIT for several thin film and wire systems and find a similar common phase diagram for Hc2(r). Again, we find that the shape of the phase diagram may be explained by introducing an enhancement of the electron screening length into the GLAG equation for Hc2.

C5.15

A Study of the Electronic Structure and the Effects of Oxygen on the Superconducting Properties of MgB_2 by Electron Energy Loss Spectroscopy. Juan Carlos Idrobo[1], Serdar Ogut[1] and Nigel D. Browning[2,3]; [1]Physics, University of Illinois at Chicago, Chicago, Illinois; [2]Chemical Engineering and Materials Science, University of California, Davis, California; [3]National Center for Electron Microscopy, Lawrence Berkeley National Laboratory, Berkeley, California.

The discovery of superconductivity in MgB_2 with a transition temperature of 40 K has attracted the attention of the scientific community for two main reasons: the technological applications of this material and the new insights that such a simple structure could bring to superconductivity theory. Efforts to improve the superconductivity properties of MgB_2 have included doping with elements such as Y, Zr, C, Al, Cu and Ag, but the results varied for different groups. An explanation for this behavior is that the transport properties of MgB_2 have a strong dependence on the sample preparation conditions, and in particular, the incorporation of impurities such as oxygen. Different phases of oxygen precipitates have been characterized and it has been found that the presence of oxygen in MgB_2 systematically changes the electronic structure of the boron atoms. From the different phases of oxygen precipitates found in MgB_2, those forming coherent superlattice structures of MgB_2-MgB_xO_y were studied in more detail by first-principles calculations. This kind of precipitate, in contrast to the other phases of oxygen precipitates, has been reported to increase the upper critical fields and critical current density but without decreasing the critical temperature of MgB_2. This effect is reflected by the low critical temperatures calculated for coherent oxygen precipitates with different concentrations of oxygen using density functional theory. These low critical temperatures explain the behavior of the oxygen precipitates as pinning centers and highlights the importance of oxygen on the superconducting properties of MgB_2. Additionally, due to the presence of two carrier species given by the boron and magnesium states in MgB_2, a low energy plasmon mode was proposed theoretical. This work presents the first experimental evidence of this plasmon mode, which has a quadratic dispersion, $\omega_P \alpha q^2$.

C5.16

MgB2 Bulk Samples Obtained by High Gas Pressure Annealing and High Gas Pressure Ultrasonic Cavitation of the Nano-size Starting Components Immersed in the Viscous Gas Medium. Andrzej Jacek Morawski[1], Tomasz Lada[1], Adam Presz[2], Andrzej Zaleski[3], Ryszard Diduszko[4], Silvia Bodoardo[5], Valeria Dellarocca[5] and Kazimierz Przybylski[6]; [1]Superconducting Material Department, Institute for High Pressure Physics, Warszawa, Warsaw, Poland; [2]Nanotechnology Department, Institut For High Pressure Physics, Warszawa, Warsaw, Poland; [3]Institute of Low Temperature and Structure Research, Wroclaw, Wroclaw, Poland; [4]Institute of Electronic Materials Technology, Warsaw, Warsaw, Poland; [5]Dipartimento di Scienze dei Materiali e Ingegneria Chimica, Politecnico di Torino, Torino, Italy; [6]Faculty of Materials Science and Ceramics, University of Science and Technology, Krakow, Poland.

As nanostructure doping is crucial for homogeneous, dense pinning centers enabling to increase the pinning force, and therefore to increase Jc and Hc2, we attempt to use a novel high gas pressure ultrasonic method enabling us to promote the cavitations effect obtained under extremely dense and viscous argon or helium gas medium. Powder was mixed and milled by new high gas pressure ultrasonic device. This method was accordingly used at the same time to clean and melange the nano-powder size batches. The syntheses have been made on the cylindrical samples of 3 mm in diameter and 5 to 10 mm long. The samples were obtained by uniaxial pressing at 1.5 GPa. Except of carbon, the other most interesting doping agent currently investigated is nano-powder of SiC and diamond. We investigated the effect of the nano-powder SiC doping of two average grades: 6 nm and 18 nm, with the content up to 18 at. % for the commercial MgB2 powder made by Alfa Aesar. Synthesis were performed at an inert gas at pressure of up to 1 GPa at temperature from 1500 K to 1550 K, in the high pressure gas trap system, with the equilibrium magnesium vapor made by melting of Mg chips inside close vessels. As obtained samples were all superconducting with Tc over 39K and the highest Tc = 42.6 K of the bulk samples was recorded for the sample doped with 1.5 at. % of the 6nm SiC, which form a nanolayer on the MgB2 surface . The XRD examinations indicated the MgB2 phase and a very low addition of Mg, Si and C composites and/or SiC as well as Mg2Si nano-crystallites. The compositions of the additional phase were strictly dependent of the nano-size grains dimensions, their solubility and quantity. SEM, EDX and superconducting properties Hc2, Tc, Jc are presented and discussed. The probably effect of tangential strain caused by nano-inclusion of thin amorphous or crystalline SiC layer between the pure or carbon doped MgB2 larger grains are considered for increasing the Tc of our samples.

C5.17

Development of the HPCVD Process for MgB_2 Film Fabrication. Alexej V. Pogrebnyakov[1,2], Abhishek Jain[1], Daniel Lamborn[3], Joan Redwing[1] and Xiaoxing Xi[1,2]; [1]Department of Materials Science and Engineering, The Pennsylvania State University, University Park, Pennsylvania; [2]Department of Physics, The Pennsylvania State University, University Park, Pennsylvania; [3]Department of Chemical Engineering, The Pennsylvania State University, University Park, Pennsylvania.

Insitu growth of high quality MgB_2 films was demonstrated using Hybrid Physical-Chemical Vapor Deposition in which evaporated Mg and thermally decomposed diborane gas (B_2H_6) serve as precursors. Using this method, epitaxial MgB_2 films were fabricated, which have residual resistivity values as low as 0.26 $\mu\Omega$cm and critical temperature, T_c, values exceeding those of bulk and other film samples. Epitaxial multilayer structures were also grown comprising MgB_2 and other conducting and insulating films. In the present implementation of the HPCVD system, the Mg source is placed around the substrate on an inductively-heated susceptor and both are heated to $\sim$700^{o}C which is needed to provide a sufficient Mg vapor pressure. This configuration imposes limitations on the substrate size, and prohibits independent control of substrate and source temperatures. A new HPCVD reactor design was implemented which includes a separately heated Mg source boat and substrate holder in a vertical geometry. The effect of substrate temperature on the growth rate and superconducting properties was investigated. In the deposition temperature interval studied (550 - 720^{o}C), the growth rate increases exponentially with decreasing temperature, and the T_c values of MgB_2 films on SiC substrates remain over 41 K.

C5.18

In-situ Synchrotron Radiation Study of Reaction Kinetics for Bulk MgB_2 Synthesis. John DeFouw[1], John Quintana[1,2] and David Dunand[1]; [1]Dept. Materials Science and Engineering, Northwestern University, Evanston, Illinois; [2]Advanced Photon Source DND-CAT Synchrotron Research Center, Argonne National Laboratory, Argonne, Illinois.

The bulk synthesis of the superconducting compound MgB_2 is studied between 700 and 1025 °C, using Mg in liquid or vapor form and B in powder or fiber form. The formation of the MgB_2 phase is monitored as a function of time *insitu* by scattering of high-energy synchrotron x-rays. Reaction rates vary significantly depending on the form of the boron (fibers vs. powders), but show little differences when using Mg as liquid or as vapor. These reaction rates are much faster than those published for reaction between Mg vapor and B thin films, which may be due to the increases in surface area created by cracks from the large volume expansion during formation of MgB_2 on the macroscopic boron fibers or powders.

C5.19

Substitution of Zr and Nb in MgB2 Bulk Superconductor. Mohit Bhatia, Michael D. Sumption, Xuan Peng and Edwards W. Collings; Materials Science and Engineering, The Ohio State University, Columbus, Ohio.

The effects of zirconium diboride (ZrB2) and niobium diboride (NbB2) doping on the microstructure and superconducting properties of bulk MgB2 superconductor have been investigated. The samples were prepared by powder compaction and in-situ sintering of pure Mg and B doped with 7.5 mol% of ZrB2 and NbB2 respectively. Although additions of ZrB2 and NbB2 have been found to decrease the critical temperature (Tc) by about 2 K a profound increase in the upper critical field Hc2 and the irreversibility field Hirr have been observed suggesting that small amounts of Nb and Zr have substituted for Mg in the bulk composition leading, it has been suggested, to relative changes in electronic diffusivities in the sigma and pi electronic bands. High resolution TEM studies were performed to confirm the substitution. Along with the increase in Hc2 and Hirr a consistent increase in critical current density over the entire superconducting temperature range (up to 36K) has also been observed, indicating also the presence of significant increase in the density of flux pinning sites. This observation was confirmed by pinning force calculations (Fp) and the XRD studies, which showed the presence of small second phase ZrB2 and NbB2 precipitates.

C5.20

Abstract Withdrawn

C5.21

Electric-Field-Induced Modulation of the Magnetic Penetration Depth of Underdoped Superconducting $La_{2-x}Sr_xCuO_4$ Ultrathin Films. Alain Rufenacht[1,2], Jean-Pierre Locquet[2], Jean Fompeyrine[2], Daniele Caimi[2] and Piero Martinoli[1]; [1]Institut de Physique, Universite de Neuchatel, CH-2000 Neuchatel, Switzerland; [2]IBM Research Division, Zurich Research Laboratory, CH-8803 Rueschlikon, Switzerland.

A study of the electric-field-induced change of the in-plane magnetic penetration depth λ_{ab} of an underdoped $La_{2-x}Sr_xCuO_4$ (LSCO) ultrathin superconducting film is reported for the first time. Using MBE, a two unit-cell (UC) thick superconducting (x $\approx$ 0.1) LSCO film was grown epitaxially on a 12 UC thick normal (x = 0.4) LSCO buffer layer deposited on a monocrystalline $SrLaAlO_4$ (SLAO) substrate. This almost homoepitaxial deposition method minimizes degradation of the film structure at the interface, thereby allowing a considerable reduction of the minimal thickness needed to observe superconductivity in LSCO films [1]. This is essential to achieve a significant carrier modulation in a electric-field-effect device. A capacitor structure was then photolithographically patterned after growing on top of the superconducting film a 15 nm thick HfO_2 insulating layer with a dielectric constant $\epsilon \approx 15$ and a Pt gate electrode. After processing a superconducting transition (zero resistance) at $T_c \approx 11$K was observed. The inverse kinetic inductance $1/L_k \propto 1/\lambda_{ab}{}^2$ of the LSCO superconducting film was inferred from the mutual change of a drive-receive two-coil system caused by the screening currents flowing in the film [2] in response to an ac excitation of 30 kHz. Both the temperature (down to 0.5 K) and magnetic-field (up to 9 Tesla) dependences of $1/L_k$ were investigated by applying gate voltages corresponding to electric fields ranging from $E_- = -6.7 \times 10^7$ V/m to $E_+ = +6.7 \times 10^7$ V/m. For the largest electric-field modulation ($\Delta E \equiv E_+ - E_-$) a relative change $\Delta L_k^{-1}/L_k^{-1} \equiv [L_k^{-1}(E_+) - L_k^{-1}(E_-)]/L_k^{-1} \approx 8\%$ was observed at low temperature in good agreement with the theoretical estimate $\Delta L_k^{-1}/L_k^{-1} = 2\epsilon\epsilon_0 \Delta E/ed_s n_s$ (where $e = 1.6 \times 10^{-19}$ C and d_s = 2.6 nm are, respectively, the electronic charge and the thickness of the superconducting film) using $n_s \approx 10^{21}$ cm^{-3} for the (bulk) carrier density corresponding to $x \approx 0.1$. With rising temperature $\Delta L_k^{-1}/L_k^{-1}$ increases, reaching a maximum value of $\sim$ 25% at the temperature corresponding to the largest slope of the L_k^{-1} vs T curve, a behavior which can be explained, at least qualitatively, by a simple model. The data allow also to extract the effective mass m^* of the carriers which is found to lie in the range $m^* = (3\text{-}5)m_e$, where m_e is the electron mass. [1] A. Rüfenacht, P. Chappatte. S. Gariglio, C. Leemann, J. Fompeyrine, J.-P.Locquet, and P. Martinoli, Solid-State Electronics 47, 2167 (2003). [2] B. Jeanneret, J.L. Gavilano, G.-A. Racine, Ch. Leemann, and P. Martinoli, Appl. Phys. Lett. 55, 2336 (1989).

C5.22
Electronic Structures of YNi2-xCoxB2C Superconductors Studied by Photoemission and Photoabsorption Spectroscopy.
Li-Shing Hsu[1] and M.-D. Lan[2]; [1]Department of Physics, National Chang-Hua University of Education, Chang-Hua, Taiwan; [2]Department of Physics, National Chung Hsing University, Taichung, Taiwan.

The electronic structures of five polycrystalline YNi2-xCoxB2C (x=0, 0.05, 0.1, 0.15, and 0.2) borocarbide superconductors were studied by photoemission and photoabsorption spectroscopy. The resonant photoemission spectroscopy (RESPES) around the Ni 2p3/2 absorption edge is used to study the 6-eV valence-band (VB) satellite of Ni. The Ni and Co K-edge x-ray absorption near edge spectra (XANES) for these intermetallic compounds are compared with those of Ni and Co powder and foil, respectively. One can see clearly the transition from photoemission- to Auger-like behavior around the Ni 2p3/2 absorption threshold. The Ni and Co p partial DOS's for these five compounds locate at 4-6 eV higher energy above the Fermi level than those for the corresponding elements, which was also confirmed by theoretical calculation.

SESSION C6: Buffer Layer Processing for Metal/Oxide Coated Conductor Composites
Chairs: Jan Evetts and Fred Lange
Thursday Morning, March 31, 2005
Room 2000 (Moscone West)

8:30 AM *C6.1
Chang-Beom Eom

Abstract Not Available

9:00 AM C6.2
Thickness Effects of $SrTiO_3$ Buffer Layers on Superconducting Properties of $YBa_2Cu_3O_{7-\delta}$ Coated Conductors.
Haiyan Wang[1], Stephen R. Foltyn[1], Paul N. Arendt[1], Quanxi Jia[1], Judith L. MacManus-Driscoll[3,1] and Xinghang Zhang[2]; [1]Los Alamos National Lab, Los Alamos, New Mexico; [2]Materials Science Division, Los Alamos National Lab, Los Alamos, New Mexico; [3]Dept. of Materials Science and Metallurgy, Univ. of Cambridge, Cambridge, United Kingdom.

A thin layer of $SrTiO_3$ has been successfully used as a buffer layer to grow high quality superconducting $YBa_2Cu_3O_{7-\delta}$ (YBCO) thick films on polycrystalline metal substrates with a biaxially oriented MgO template produced by ion-beam-assisted deposition (IBAD). Using this architecture, 1.5 μm-thick-YBCO films with an in-plane mosaic spread in the range of 2.5°\$$\sim$ 4° in full width at half maximum and critical current density over 2×10^6A/cm^2 in self-field at 75 K have been achieved routinely. We have demonstrated that the pulsed laser deposition growth conditions of $SrTiO_3$ buffer layers, such as growth temperature and oxygen pressure, have strong effects on the superconducting properties of YBCO.[1] In this talk, the interesting thickness effects of $SrTiO_3$ buffer layers on the properties of YBCO are discussed in detail. The critical current density of YBCO films increases dramatically when the thickness of the $SrTiO_3$ buffer layer reaches optimum. Microstructure studies including transmission electron microscopy (TEM) and scanning electron microscopy (SEM) were used to explore the microstructure and growth mechanisms of $SrTiO_3$ thin films deposited at different thickness and to further understand their effects on the growth and properties of YBCO films. Cross-sectional TEM studies reveal that $SrTiO_3$ has a good lattice match with YBCO and clean and sharp interfaces with both MgO and YBCO, which further proves that $SrTiO_3$ is a promising candidate as the buffer layer for high performance superconductor coatings. [1] H. Wang, S. R. Foltyn, P. N. Arendt, Q. X. Jia, J. L. MacManus-Driscoll, X. Zhang and P. C. Dowden, *J.Mater.Res.*, **19**, 1869 (2004).

9:15 AM C6.3
Pulsed Laser Deposition of Bi-axially Textured YSZ/CeO2 Films on Electrodeposited Ir/Ni-W Tapes for YBCO Superconductors.
Tapas Chaudhuri, Priscila Spagnol, Raghu Bhattacharya and Sovannary Phok; Basic Science Center, National Renewable Energy Laboratory, Golden, Colorado.

Ir film is a potential candidate for conducting buffer layer on Ni-W tapes used for YBCO superconductor. We have developed in our laboratory electrodeposited Ir coating as buffer layer on Ni-W substrates. To complete the buffer structure it was imperative that bi-axially textured YSZ/CeO2 layers be grown on these substrates. This paper reports the deposition of YSZ/CeO2 layers by PLD on Ni-W tapes electroplated with Ir. The PLD system consisted of a standard chamber (Neocera) and an excimer KrF laser (Lambda Physik, ?=248 nm) operated at 260 mJ with a fluence of 2-3 MJ/cm2 at the target kept at 8 cm from the substrate holder. Layers of YSZ and CeO2 were deposited sequentially on Ir/Ni-W substrates. Two different approaches were investigated: in one the substrate temperature and in another the environment for $\sim$ 50 nm seed layer of YSZ was varied. The layers were characterized by XRD and AFM. When YSZ and CeO2 layers were deposited on Ir/Ni-W at 775 to 850 oC in 10-4 Torr of oxygen, the layers had both (111) and (200) oriented growth. The (111) orientation was more pronounced at and above 825oC while (200) orientation dominated below it. There was marked change when a seed layer of YSZ was deposited prior to optimum YSZ/CeO2 layers. In this case deposition temperature was fixed at 800 oC and different seed layers were first deposited in H2/Ar (0.2 Torr), O2 (10-4 Torr) and vacuum ($\sim$ 10-6 Torr). The H2/Ar produced YSZ films with (111) with a small (200), O2 gave films with mixed (111) and (200) while YSZ films grown in vacuum was (200) oriented. The XRD studies revealed that the YC layers are bi-axially textured with phi = 6.5o and omega = 8o. The surface roughness measured by AFM is about 5 nm.

9:30 AM C6.4
Development of Ho-123 Coated Conductors.
Munetsugu Ueyama, Shuji Hahakura, Katsuya Hasegawa and Kazuya Ohmatsu; Electronics & Materials R&D Laboratories, Sumitomo Electric Industries, Ltd., Osaka, Japan.

We have been developing Ho-123 thin films by using pulsed laser deposition (PLD) method. Ho-123 shows high Jc up to 5MA/cm^2 in the case deposited on single crystal substrates such as sapphire and LAO. In this work, based on our PLD technique, Ho-123 coated conductors have been developed on flexible metal tape substrates. Oxide buffer layers such as YSZ and CeO_2 have been deposited on textured Ni-alloy tapes. A basic technique of the formation of buffer layer was investigated, and hetero-epitaxial buffer layer of CeO_2 / YSZ/ CeO_2 showed excellent in-plane alignment with the delta phi value in the range of 5 to 7 degrees. Surface roughness (Ra) was several nm and the surface was almost flat with few particles. Ho-123 film deposition was conducted on the buffer layers by PLD method. Sample less than 0.2 μm in thickness showed Jc (77.3 K, 0T) over 2 MA/cm^2. Sample with 1.4 μm in thickness showed Jc (77.3 K, self field) over 1MA/cm^2. In another sample, Ic was 190A/cm-w. X-ray (103) pole figure of Ho-123 shows in-plane texture of approximately 6 degree. This demonstrated fine epitaxial Ho-123 growth on CeO_2 /YSZ / CeO_2 textured Ni-alloy tape. SEM photograph of Ho-123 layer revealed relatively smooth film morphology with some particles. Furthermore, Jc-B characteristics at 4.2 K under the high magnetic field up to 30 Tesla were evaluated. Ic (4.2 K, 30 T) was 1,310A/cm-w when the external magnetic field was applied parallel to the tape surface. Concerning the results of the long length conductors, high Ic of 110 - 175 A/cm-w was achieved for 35 m conductor by using multi-layer formation of superconducting layer. High production speed was also achieved by using industrial large scale excimer laser. A part of this work was supported by NEDO as Collaborative Research and Development of Fundamental Technology for Superconductivity Applications. The authors would like to thank Dr. T. Takeuchi and Dr. N. Banno of NIMS for Ic measurement under low temperature and high magnetic field.

10:15 AM *C6.5
Chemical Solution Deposition of Functional Buffers for YBCO Coated Conductors.
Mariappan Parans Paranthaman[1], Srivatsan Sathyamurthy[1], Md. Shafiq Bhuiyan[1], Amit Goyal[1], Thomas Kodenkandath[2], Xiaoping Li[2], Wei Zhang[2], Cees Thieme[2], Urs Schoop[2], Darren Verebelyi[2] and Martin Rupich[2]; [1]Oak Ridge National Laboratory, Oak Ridge, Tennessee; [2]American Superconductor Corporation, Westborough, Massachusetts.

Buffer layers play a key role in second generation $YBa_2Cu_3O_{7-\delta}$ (YBCO) coated conductors. The purpose of the buffer layers is to provide a continuous, smooth and chemically inert surface for the growth of the YBCO film, while transferring the biaxial texture from the substrate to the superconductor layer. Important buffer layer characteristics are to prevent metal diffusion from the substrate into the superconductor, as well as, to act as oxygen diffusion barriers. The most commonly used RABiTS architectures consisting of a starting template of biaxially textured Ni-W substrate with a seed layer of Y_2O_3, a barrier layer of YSZ, and a CeO_2 cap. In this three layer architecture, all the buffers were deposited using physical vapor deposition (PVD) techniques. We have developed a low-cost, non-vacuum, chemical solution deposition process to grow highly aligned oxide buffers on textured Ni-W substrates. Using an all solution buffer architecture comprising of $La_2Zr_2O_7$ and CeO_2, we demonstrated the growth of high performance YBCO films with an I_c (critical current) of 140 A/cm-width. This process could potentially decrease the overall cost of the conductors. We will report in detail about results achieved on all solution buffers.
Supported by the U.S. DOE, Division of Materials Sciences, Office of Science, and Office of Electric Transmission and Distribution. The research was performed at the Oak Ridge National Laboratory, managed by UT-Battelle, LLC for the USDOE under contract DE-AC05-00OR22725

10:45 AM *C6.6
Interface Control in All MOD Coated Conductors: Influence on the Critical Currents. Alberto Pomar, M. Coll, A. Cavallaro, J. Gazquez, F. Sandiumenge, J. C. Gonzalez, N. Mestres, T. Puig and X. Obradors; Institut de Ciencia de Materials de Barcelona, Bellaterra-08193, Spain.

Ex-situ growth techniques are the subject of an intense research in order to get low-cost high-critical-current $YBa_2Cu_3O_{7-x}$ (YBCO) coated conductors (CC). In particular, the main goal is to obtain an all chemical CC where superconducting YBCO is grown by the so-called trifluoroacetates route (TFA) and the buffer layers are grown by metalorganic deposition (MOD). To that end, several oxides have been successfully grown by MOD that can be potentially used as intermediate (as for example, $La_2Zr_2O_7$, $BaZrO_3$, ...) or cap (CeO_2, $SrTiO_3$) buffer layers. On the other hand, progresses made on the optimization of TFA-YBCO growth have been impressive in the last years and the critical currents reported on single crystals or on vacuum buffer layers largely exceed the target value of 1 MA/cm^2 at 77K in self-field. Most of the studies have been focused on improving the in-plane texture of both the YBCO and the buffer layers. However, there is still a lack of studies on the role of the interface quality between the different MOD layers and the final superconducting properties of the CC. For example, it is known that several buffer properties can dramatically affect the critical current as for example, surface roughness or lattice matching with YBCO. These properties can be tuned by modifying the processing conditions of buffer layers but, for the optimization of their microstructure it is important to fully understand the relationship between the different parameters. In this work we will report recent progress in the control of the interface quality between buffer layers and TFA-YBCO thin films and how it influences the critical current of the CC. For this, TFA-YBCO processing has been adapted for each buffer layer. We have mainly focused on MOD fluorite-like CeO_2 buffer layers and on MOD perovskite $SrTiO_3$ buffer layers. Normal state resistivity and critical currents J_c of the superconducting films have been taken as figures of merit to optimize the growth conditions of the different buffer layers structures. We will show the dependence of J_c on the microstructural evolution of these buffer layers under different processing conditions, as for example, growth temperature and reacting atmospheres and the modification of the interface quality through post-annealing treatments. We will compare also with our results on vacuum deposited CeO_2 buffer layers on RABiT and IBAD metallic substrates. Microstructure of the samples has been characterized by TEM, SEM, AFM and micro-Raman measurements. We will also analyze the magnetic field dependence of the critical current and the possible influence of buffer layer microstructure on the pinning abilities of YBCO thin films will be discussed. This work has been supported by the European Union through the Growth project SOLSULET (G5RD-CT-2001-00550).

11:15 AM C6.7
Non-Vacuum Deposition of Buffer Layer and YBCO Superconductor. Raghu N. Bhattacharya, Priscila Spagnol, Sovannary Phok and Tapas Chaudhuri; National Renewable Energy Laboratory, Golden, Colorado.

In this meeting we will report on non-vacuum deposition of buffer layers and YBCO superconductor. Electrodeposition process is used for buffer layer deposition of Ir, CeO_2, and Y_2O_3. Both electrodeposition and spray deposition are used to prepare YBCO superconductor. We choose Ir as buffer layer because of its excellent oxidation and corrosion resistance properties among platinum group elements, and also the lattice mismatch of cubic Ir is very close to that of CeO_2 and Ni. Our main goal is to simplify the buffer layer architecture by using electrodeposited Ir. We are also depositing electrodeposited CeO_2, and Y_2O_3 buffer layer to replace existing vacuum technology. To qualify the quality of the electrodeposited Ir buffer layer, initially PLD CeO_2/YSZ/CeO_2 buffer structure and later on simplified PLD YSZ/CeO_2 buffer structure were deposited on ED-Ir coated Ni and Ni-W substrates. Bi-axially textured CYC and YC layers on electrodeposited Ir/Ni-W were prepared successfully. $YBa_2Cu_3O_7$ (YBCO) films with thickness ranging from 0.15 μm to 1 μm have been fabricated by non-vacuum electrodeposition and spray pyrolysis deposition techniques. We already obtained a critical current density of about 0.5 MA/cm^2 at 77 K and zero field using these type of non-vacuum deposited films. We are expecting to obtain >1 MA/cm^2 current density by further optimization.

11:30 AM C6.8
Growth Mechanism and Optimization of MOD CeO2 Buffer Layers for TFA YBa2Cu3O7/CeO2 Multilayers.
Felip Sandiumenge, Andrea Cavallaro, Mariona Coll, Jaume Gazquez, Teresa Puig, Alberto Pomar, Neus Roma, Narcis Mestres and Xaxier Obradors; Materials Superconductors, ICMAB-CSIC, Bellaterra, Spain.

The development of low cost coated conductors requires the use of multilayered structures where a high texture is preserved between the different layers. CeO2 layers have been a widely extended choice as cap layer because it has a low lattice mismatch with YBa2Cu3O7. However because of its high reactivity with BaO, growth of YBa2Cu3O7 layers on it by the Trifluoroacetate (TFA) route remains a delicate problem. In this work we initially report on the growth conditions of MOD CeO2 layers and we characterize them by TEM and AFM. In a second term, the growth of YBa2Cu3O7-TFA films on these MOD cap layers and on CeO2 buffer layers deposited by sputtering on YSZ single crystals have been investigated and their superconducting properties have been compared with those leading to optimized films on LaAlO3 single crystals. Critical currents up to 1.6 MA/cm2 at 77 K have been demonstrated in YBa2Cu3O7/CeO2 multilayers. SEM, ?-Raman and TEM have been used to study the microstructure while inductive critical current and resistivity measurements have been carried out to study the superconducting properties.

11:45 AM C6.9
Phase Equilibria for Coated-Conductor Research.
Winnie Kwai-Wah Wong-Ng[1], Lawrence Cook[1], Zhi Yang[1], Igor Levin[1], Julia Frank[1] and Ron Feenstra[2]; [1]Ceramics Division, NIST, Gaithersburg, Maryland; [2]Solid State Sciences, ORNL, Oak Ridge, Tennessee; [3]Solid State Sciences, ORNL, Oak Ridge, Tennessee.

Continued global research in high Tc superconductors has lead to the promise of a wide variety of industrial applications, including power distribution, energy storage, and advanced motors and magnets. To implement these applications, the availability of low-cost, long-length, and high performance wire/tape and cable is critical. Phase diagrams are commonly regarded as road maps for the optimization of processing. We have focused our efforts on phase equilibria studies of Ba2RCu3O6+x (R=lanthanides and Y) for coated conductor applications. This talk will highlight our results in three areas: (1) Phase diagrams for the BaO-R2O3-CuOx (R=Nd, Sm, Eu, Gd, Ho, Y, Er, and Yb) systems under atmospheric-controlled conditions to match used in coated conductor processing. A comparison of these phase diagrams will be discussed. (2) Phase equilibria of the multi-component system representing the interfacial reactions of Ba2YCu3O6+x with buffer layer of CeO2. Phase equilibria data assist in the interpretation of TEM images of the associated interfacial reaction products. (3) The occurrence of low temperature melts in the Ba-Y-Cu-O-F-H2O system as related to the BaF2 process for long-length coated conductor processing. Recent results on phase equilibrium studies of the Ba-Y-Cu-O-F-H2O system will be summarized.

SESSION C7: Recent Advances in RE-123 Film Epitaxy
Chairs: Judith L. MacManus-Driscoll and Winnie Wong-Ng
Thursday Afternoon, March 31, 2005
Room 2000 (Moscone West)

1:30 PM *C7.1
Overcoming the Barrier to 1000 A/cm-width Coated Conductors. Stephen R. Foltyn[1], H. Wang[1], Q. X. Jia[1], P. N. Arendt[1], L. Civale[1], B. Maiorov[1], J. L. MacManus-Driscoll[2,1], Y. Li[1] and M. P. Maley[1]; [1]Los Alamos National Laboratory, Los Alamos, New Mexico; [2]University of Cambridge, Cambridge, United Kingdom.

As YBCO-based coated conductors approach the commercialization phase, a few long-standing issues have become prominent, one of which is the rapid decrease in critical current density (Jc) as the coating is grown thicker. This problem creates a "diminishing returns" effect that has generally limited critical current (Ic) for centimeter-wide tapes to a few hundred amperes at liquid nitrogen temperature. We have analyzed this problem and have developed a simple model for the variation of current density within a thick film that produces excellent agreement with experimental results. One aspect of the model - that Jc is abnormally high near the YBCO-substrate interface - predicts that additional interfaces within the YBCO would significantly raise the average Jc of a coating. We have tested this hypothesis by alternately depositing YBCO and thin CeO2 interlayers to create a multilayer structure with multiple heteroepitaxial interfaces. Our test samples used nickel-alloy substrates and a textured MgO coating produced by ion beam assisted deposition. This was followed with a SrTiO3 buffer layer and a number of 0.4-0.6 um YBCO layers separated by $\sim$ 40 nm CeO2 layers, all laser-deposited. The results were striking: Films with Ic values in excess of 600 A/cm-width (75.4 K, self field) were routinely produced, with many exceeding 1000 A/cm-width. The highest Ic to-date is 1400 A/cm-width obtained in a coating with six YBCO layers and five CeO2 interlayers having a total thickness of 3.5 um and a Jc of 4.0 MA/cm2. This achievement demonstrates that thick YBCO films can be produced with the high Jc levels previously only available in thin films, enabling the fabrication of 1000 A/cm tapes with much less YBCO than the 5-10 mm thickness that would otherwise be required. The multilayer design itself is scalable to continuous processing of long tape lengths, and there are already several reports of lengths being coated by multiple passes of tape through the deposition zone: the addition of a very thin interlayer between YBCO passes is well within the reach of existing technology.

2:00 PM C7.2
Flux Pinning and Properties of $(Y,RE)_{1+x}\ Ba_{2-x}Cu_3O_{7-z}$ Thin Film Superconductors; RE = Eu,Er. Timothy J. Haugan, Timothy A. Campbell, Iman Maartense, Chakrapani V. Varanasi and Paul N. Barnes; PRPG, AFRL, Wright-Patterson Air Force Base, Ohio.

$REBa_2Cu_3O_{7-z}$ superconductors are being considered for applications of thin film coated conductors because of their high T_c (> 92 K), and high J_c at 77 K in useful magnetic fields. This paper considers the partial substitution of similar ionic radii Eu and Er for Y in $Y_{1-x}Ba_{2+x}Cu_3O_{7-z}$to vary and control physical properties such as lattice constants, T_cs, J_cs and flux pinning. Eu and Er were chosen because of theoretical studies that suggest partial substitution of these RE ions can enhance J_c(H) properties. Targets of $(Y,RE)_{1-x}Ba_{2+x}Cu_3O_{7-z}$ were prepared by solid-state reaction, and thin films of these compositions were deposited by pulsed laser deposition. Properties of the films were characterized by transport J_c(H,T,?), XRD, VSM, SEM and ac susceptibility.

2:15 PM C7.3
Controlled Supersaturation during High Rate YBCO on Tape and Crystal: Monitored by FTIR and XRD Hot Stage. Jeong-uk Huh, Gertjan Koster, Hong-Ying Zhai, Arturas Vailionis, Robert H. Hammond and Malcolm R. Beasley; Geballe Laboratory for Advanced Materials, Stanford University, Stanford, California.

High temperature superconductor $YBa_2Cu_3O_{7-x}$(YBCO) is deposited using electron beam co-evaporation at a rate of 10nm/s and higher.[i] FTIR measurements were done in-situ to analyze the real time temperature of the YBCO during growth and the optical properties of the various stages of deposition on tape and crystal. For each stage of YBCO growth there are distinct reflectivity spectra that correspond to its optical nature. Controlled oxidation monitored by FTIR allows us to study the relationship between phase stability, growth morphology and transport properties. These samples are characterized by XRD and transport measurement. Further details of the phase stability and growth morphology (supersaturation) are accessed using an ambient controlled X-Ray hot stage. [i] T. Ohnishi, J.U. Huh, R.H. Hammond and W. Jo, 2004 J. Mater. Res. 19, 977 Funded by AFOSR and tape provided by DoE-LANL

2:30 PM C7.4
Ultra-fine Multilayer Structures of YBa2Cu3Oy / EuBa2Cu3Oy for Coated Conductors. Terry G. Holesinger, Quanxi Jia, Paul Dowden, Boris Maiorov and Leonardo Civale; Los Alamos National Laboratory, Los Alamos, New Mexico.

The use of multilayer structures has been suggested as an approach to further improve the performance of the HTS layer of a coated conductor. A method is described here for the production of ultra-fine multilayer structures by pulsed laser deposition for stationary and moving substrates. Multilayer structures with periodicities of less than 10 nm have been grown on individual single-crystal and IBAD MgO templates. Continuous processing of ultra-fine multilayers on lengths of IBAD MgO has produced Ic values in excess of 200 A/cm-width.

3:15 PM *C7.5
Growth of Thick High Critical Current $YBa_2Cu_3O_7$ Films by HLPE. Jan Evetts, Ahmed Kursumovic and Judith MacManus-Driscoll; Materials Science, University of Cambridge, Cambridge, United Kingdom.

A range of hybrid liquid phase epitaxy (HLPE) processes will be described that enable high rate 'liquid assisted' growth of epitaxial $YBa_2Cu_3O_7$ as well as certain other oxide films without the many disadvantages of classical LPE [1]. Since growth occurs by diffusive transport of Y through a liquid flux layer of thickness 50-1000 nm the problem of an aggressive flux is minimized, also there is no requirement to maintain a precise undercooling and nucleation on mismatched substrates is not a problem, so a seed layer is not essential. The flux layer may be pre-deposited onto the substrate by various means including vacuum and non-vacuum techniques. Many different process configurations are possible and the working window for high J_c films appears to be wide. A range of oxygen partial pressures have been used and deposition has been carried out at both low pressures and atmospheric pressure. The composition of the liquid layer is maintained during film growth by feeding $YBa_2Cu_3O_7$, or the separate components, either from the vapour or by a powder route. Nucleation and growth of HLPE films can be described quantitatively in terms of the supersaturation of the flux and kinetic processes in the flux and at the growing interface. The solute supersaturation mediates a dynamic equilibrium growth rate for any particular deposition rate. Any fluctuation from dynamic equilibrium is compensated by a change in supersaturation that recovers the equilibrium state. The time constant for equilibration of transients in the deposition conditions is 1 ms for a 500 nm thick flux layer. Growth rates are determined by the surface kinetic coefficient and rates up to 35 nm s^{-1} have been demonstrated. When the deposition rate is high, J_c values of 2−4 MA cm^{-2} have been demonstrated consistently. Deposition of c-axis oriented epitaxial $YBa_2Cu_3O_7$ is reported on both seeded and non-seeded substrates. Films 1-3 micron thick with $T_c\sim$90 K and a transport critical current density J_c >2 MA cm^{-2} have been grown on a range of single crystal substrates as well as on buffered textured metallic tapes. In this work we have achieved transport critical currents as high as 400 A per centimetre width in $YBa_2Cu_3O_7$ films on RABiTS Ni-alloy tape with $NiO/SrTiO_3$ buffers. XRD and HRTEM studies indicate that the films are highly textured and contain a distribution of nanoscale epitaxial Y_2O_3 pinning particles. Low vacuum deposition, high growth rates and easy composition control with great flexibility in the feeding method are very attractive process characteristics. In addition the process has a high efficiency of material utilization, and thick films can be produced with excellent crystallinity and high critical current densities. These features suggest that HLPE has the potential to be a robust high-rate low-cost process for coated conductor processing. [1] 'Hybrid liquid phase epitaxy processes for $YBa_2Cu_3O_7$ film growth', A. Kursumovic et al, Supercond. Sci. Technol. **17** (2004) 1215-1223

3:45 PM C7.6
The Growth of Thin Crystalline YBCO Films through Intermediate Dense Glassy Precursors. Gertjan Koster[1], Jeong-Huck Lee[2], Sean Brennan[4], Ann Marshall[1], Bruce Clemens[3] and Theodore H. Geballe[1]; [1]GLAM, Stanford University, Stanford, California; [2]Department of Physics, Seoul National University, Seoul, South Korea; [3]MSE, Stanford University, Stanford, California; [4]SSRL, SLAC, Menlo Park, California.

Crystal growth via liquid or glass precursors has potential for growing many oxide films where the phase diagram does not permit equilibrium between the vapor and the crystal phases. We demonstrate using an intermediate glass phase in the growth of YBa2Cu4O8 (248) films where thermodynamic constraints prevent film growth directly from the vapor. The glass is formed by PLD at elevated temperatures to ensure high density, and possibly short-range cation order, from monolayer blocks using targets of BaCuO, YCuO, (Y,Ca)Ba2Cu3O7 and CuO in the sequence dictated by the 248 unit cell. Ex situ rate calibration has been adequate to keep the composition close to stoichiometric. The films are subsequently grown at high pressure and temperature. We present real-time crystallization studies of YBa2Cu4O8 (Y-248) from dense amorphous precursor thin films using x-ray scattering. The samples, deposited on SrTiO3 and LSAT (Lanthanum-Strontium-Aluminate-Tantalate) single crystal substrates, were annealed on a hot stage installed on the BL 7-2 4-circle diffractometer and the development of the Y-248 (0 0 16) and (1 0 8) peaks were monitored as a function of time and temperature, while flowing oxygen gas. Modeling of the observed transformation kinetics is in progress. Finally, Ca doped films have be successfully grown using this method, raising Tc, without any concession to the overall crystalline and transport properties.

4:00 PM C7.7
Oxyfluoride Decomposition during Conversion Step of ex situ Process. Masateru Yoshizumi, Daniel E. Wesolowski and Michael J. Cima; Massachusetts Institute of Technology, Cambridge, Massachusetts.

HF gas behavior in front of the growing YBCO during conversion of oxyfluoride precursor films is known to govern YBCO growth and, therefore, it is quite important to know the mechanism by which the decomposition of oxyfluorides occurs for accurate process design and control. The partial pressure of HF gas (P(HF)) in equilibrium with oxyfluoride precursor films and YBCO is influenced by the reaction path and, therefore, the F/Ba ratio trajectory of the film. The measurement of P(HF) and F/Ba ratio trajectory are unique and effective macroscopic methods to analyze the mechanism of oxyfluoride decomposition during the conversion process, and they can be compared with the results of microanalysis. In this study, the measurement of P(HF) and F/Ba ratio trajectory are performed during ex situ processing to obtain information about the mechanism of oxyfluoride decomposition. Both MOD derived precursor films and e-beam derived films are analyzed to show the differences caused by the precursor films' preparation method. The F/Ba ratio of green MOD derived oxyfluoride precursor films is close to 3 and drops with temperature to ~1.5 below 700oC. On the other hand, green films of e-beam derived precursor show a F/Ba ratio of about 2. The F/Ba ratio decreases with temperature; however, the temperature dependence of F/Ba ratio is quite small and the F/Ba ratio is still ~1.8 at 700oC. The results of P(HF) measurements indicate oxyfluorides deposited by e-beam decompose much slower than MOD derived oxyfluorides. P(HF) values of e-beam derived films are several times smaller than that of MOD derived films under the same conditions. A thermodynamic analysis of the data indicated that experimental free energy of formation values for YBCO matched literature values for the expected formation reaction for YBCO. However, the experimental results are not in agreement with literature values for predicted reactions to form intermediate compounds.

4:15 PM C7.8
Development of High-I_c ex situ YBCO Coated Conductors: Trends in Thickness Dependence, Grain Boundary Networks, and Vortex Pinning. Ron Feenstra[1], A. A. Gapud[1], E. D. Specht[1], C. Cantoni[1], A. Ijaduola[1,2], J. R. Thompson[1,2], D. K. Christen[1], T. G. Holesinger[3], D. M. Feldmann[4], D. C. Larbalestier[4], A. Palau[5], T. Puig[5] and X. Obradors[5]; [1]Oak Ridge National Laboratory, Oak Ridge, Tennessee; [2]University of Tennessee, Knoxville, Tennessee; [3]Los Alamos National Laboratory, Los Alamos, New Mexico; [4]Applied Superconductivity Center, University of Wisconsin, Madison, Wisconsin; [5]Institut de Ciencia de Materials de Barcelona, CSIC, Bellaterra, Spain.

Ex situ processes based on the post-deposition conversion of precursor layers containing BaF_2 are attracting attention worldwide for their possible deployment in YBCO coated conductor production processes. Interesting from a materials science perspective is the fact that, while there exist multiple ways to produce the precursor layer, basic thermodynamic and kinetic features of the ex situ conversion process are invariant of the precursor choice. The YBCO growth mechanism appears to be controlled by transient liquid phase formation, producing highly aspected, laminar grain structures with variable densities of pores and secondary phases. This paper presents recent progress in R&D to increase the critical current I_c to values > 400 A/cm-width (77 K). Precursors are produced by e-beam evaporation, ranging in thickness from 30 nm to 3 μm. YBCO films with high values of the critical current density J_c were obtained over the entire thickness range on a RABiTS template. We describe a thickness dependent trend in the ability of YBCO to overgrow substrate grain boundaries and form three-dimensionally meandering boundary surfaces. The role of process dependent variations in the grain boundary network is examined based on observed trends in J_c for the whole conductor and the intra-grain J_c. Microstructures affecting vortex pinning, modified by precursor compositional changes, are discussed. Research sponsored by the U.S. Department of Energy under contract DE-AC05-00OR22725 with the Oak Ridge National Laboratory, managed by UT-Battelle, LLC.

4:30 PM C7.9
XPS Study on E-Beam Co-Evaporation YBCO Precursors and their Post-Deposition Conversion. Yifei Zhang[1,2], Ron Feenstra[2] and David K. Christen[2]; [1]Department of Materials Science & Engineering, The University of Tennessee, Knoxville, Tennessee; [2]Condensed Matter Sciences Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Electron beam co-evaporation is one of the ex situ techniques being developed for the cost-effective fabrication of YBa2Cu3O7-? (YBCO) coated conductors. To achieve high critical current (Ic) and fast conversion, the microstructural as well as the chemical characteristics of the precursors and their evolution process towards the epitaxial c-axis oriented YBCO film during the post-deposition conversion annealing need to be further understood. In this study X-ray photoelectron spectroscopy (XPS) was used to investigate the compositional and chemical profiles of the precursors in their as-deposited states. Samples quenched at different moments from their processing were also inspected for identifying the transient elemental chemical states prior to the YBCO phase formation. XPS detailed spectra of both the cations and fluorine were recorded for the surfaces and through various depths after appropriate ion sputtering. Initial results indicated that the XPS core level peak position shifts as the chemical signatures can be used for revealing the conversion reaction.

4:45 PM C7.10
Solution Based Approaches to Enhance Flux-Pinning in YBCO for Low-Cost Coated Conductor Fabrication. Srivatsan Sathyamurthy[1,2], Keith J. Leonard[1] and Mariappan Paranthaman[1]; [1]Oak Ridge National Laboratory, Oak Ridge, TN, Tennessee; [2]University of Tennessee, Knoxville, Tennessee.

Great strides have been made in YBCO coated conductor fabrication using the RABiTS approach in the past few years and critical current densities (Jc) of over 3 MA/cm2 on 10 meter long tapes with an end-to-end critical current (Ic) of 270 A/cm-width have been achieved. Recently, maintaining high current densities at high magnetic fields using enhanced magnetic flux pinning has merited a lot of attention from the community. The most successful amongst the many approaches being studied is the addition of nanoparticles to the YBCO film. Significant enhancements in flux pinning have been reported for in situ YBCO films deposited using pulsed laser deposition using this approach. Solution deposition for processing buffer layers and YBCO has the potential to reduce the process complexity and make the conductor fabrication more cost-effective. At this juncture, when coated conductors are much closer to commercialization, an important goal for better performance and lower fabrication costs is to achieve enhanced flux pinning in a practical, cost-effective way in solution processed coated conductors. We have developed an innovative method to synthesize nanoparticles using a solution based approach. This route is compatible with MOD-YBCO synthesis and hence can be used to incorporate pinning centers in MOD-YBCO. Using this approach, we have successfully processed nanoparticles of various rare earth oxides, barium cerium oxide, and barium zirconate. Preliminary XRD and TEM analysis shows that the particle size is typically around 4 nm for the rare earth oxides and barium cerium oxide, and about 10 nm for barium zirconate. Pinning enhancements obtained by using these particles in MOD-YBCO are currently being studied, and the results from these studies will be reported.
Research supported by the Department of Energy, Office of Electric Transmission and Distribution. This research was performed at the Oak Ridge National Laboratory, managed by UT-Battelle, LLC for the USDOE under contract DE-AC05-00OR22725.

SESSION C8: Poster Session:
Chairs: Teruo Izumi and Judith L. MacManus-Driscoll
Thursday Evening, March 31, 2005
8:00 PM
Salons 8-15 (Marriott)

C8.1
In Situ Studies of Phase Evolution in $Ba_2YCu_3O_{6+x}$ Films During the BaF_2 Process. Igor Levin[1], Winnie Wong-Ng[1], Mark Vaudin[1], Lawrence Cook[1], Ron Feenstra[2] and Amit Goyal[2]; [1]NIST, Gaithersburg, Maryland; [2]Solid State Division, ONRL, Oak Ridge, Tennessee.

The "BaF2 ex situ process" has demonstrated the potential for producing high quality long Ba2YCu3Ox (Y-213) superconductors. This processs involves post-annealing in the water vapor of either e-beam co-evaporated or open-air solution processed BaF2-Y-Cu precursor films on rolling-assisted biaxially textured metal substrates (RABiTS). Despite the commercial potential of the "BaF2 ex situ process", the phase evolution upon formation of the Y-213 phase in the multi-component Ba-Y-Cu-F-OH system is not completely understood. In this work, we used high-temperature X-ray diffraction (HTXRD) to follow the phase formation during the BaF2-precursor process in situ. The studies were conducted using the amorphous precursor BaF2-Y-Cu films as well as the films representing the subsystems. The films were prepared using either the three-source e-beam evaporation or the TFA solution process. The HTXRD experiments were complemented by transmission electron microscopy studies of the samples quenched from the different stages of the process to further analyze the nature of the intermediate phases. The current understanding of the phase evolution process upon formation of the Y-213 phase from amorphous precursor films will be discussed.

C8.2

Structural Properties of YBa2Cu3O7 50 nm Films on SrTiO3 Single Crystal and Bi-crystal Substrates.
Maria Angeles Navacerrada[1,2], Mehta Apurva[3], Hizam Sahibudeen[2] and Juana A. Vivo Acrivos[2]; [1]Applied Physics, Complutense University, Madrid, Madrid, Spain; [2]Chemistry, San Jose State University, San Jose, California; [3]Stanford Synchrotron Radiation Laboratory, Stanford University, Stanford, California.

Since discovery of superconductivity in the oxide system YBa2Cu3O7 (YBCO) there has been a surge of interest in the growth of thin films of this material on different kind of substrates. We present a comparative study in terms of structural properties deduced from X - ray diffraction diagrams between YBCO thin films fabricated on SrTiO3 (STO) single crystal substrates and bicrystallines substrates with a symmetrical tilt angle of 24 degrees. YBCO thin films were epitaxially grown in a high pressure pure oxygen dc sputtering system. Critical temperatures (TC) are in the range of 89.5 - 91 K. The experiments have been carried out at room temperature at the station 7.2 of Stanford Synchrotron Radiation Laboratory (SSRL). Periodic Lattice Distortions (PLD) have been found around several Bragg peaks in YBCO thin films deposited on STO bicrystals while only diffraction peaks appear in the diagrams corresponding to the YBCO thin films deposited on STO single crystal substrates. The PLD have been observed in a region far away from the GB. Scans along different (HKL) show a distortion qPLD = (0.042, -0.042, 0) in reciprocal space with a transverse amplitude uPLD $\sim$ (0.08, 0.08, 0) in real space. There is no component along the L direction in accordance with YBCO thin films deposited on both kinds of substrates with similar TC value. The PLD may be associated with the 2 % lattice mismatch between the YBCO and the STO substrate, but since the PLD are not observed in the YBCO thin films deposited on the STO single crystal substrate they could be associated with the distortion induced by the GB of the YBCO thin film deposited on the bicrystal. Transmission electron microscopy measurements show that interatomic distances and relative positions of atoms, are changed by strain in the vicinity of the GB. This results in a change of the bond lengths, valence atoms and the number of charge carrier present in the grain boundary. Oxygen atoms have especially large displacements and a nonsuperconducting region enveloping the crystallographic GB is generated. The maximal displacements are in the atomic plane next to the geometric plane of the GB and it is not clear how this changes away from this plane. A small amount of twinning could be necessary to reduce the elastic energy associated to the GB. In this sense, qPLD would be associated to a long-range modulation induced in the YBCO thin film by the GB. Typical twinning directions in this material are in the (110) and (1-10) directions to accommodate the strain energy (of tetragonal, probably present in the GB region of YBCO thin film to orthorhombic phase). The small value of qPLD suggests it may not be detectable in TEM experiments. Thus XAS and XRD measurements in films showing this qPLD versus distance from the grain boundary is necessary for better understanding the PLD and their effect on transport applications.

C8.3

Transport Properties of $CaZrO_3$-Doped $YBa_2Cu_3O_7$ Films.
Noel Rutter, John Durrell, Mark Blamire and Judith MacManus-Driscoll; Dept. of Materials Science, University of Cambridge, Cambridge, United Kingdom.

We have doped YBCO films with $CaZrO_3$ in order to study the effects on the inter-granular and intra-granular critical current densities. Films deposited by PLD from a doped target have a significantly reduced critical temperature. In an attempt to improve the properties, we have varied the oxygen partial pressure during initial oxygenation in order to lower the oxygen content. Additionally, we have post-annealed the films in a low oxygen atmosphere. We report the transport properties of these films as a function of temperature, magnetic field and field angle. We compare the results with those obtained when the $CaZrO_3$ is diffused in from an overlayer rather than being dispersed throughout the bulk.

C8.4

Characterizing Superconducting Thin Films in Terms of the Microwave Surface Resistance.
Peiheng Wu, University of Nanjing, Research Institute of Superconductor Electronics, Nanjing, China.

High temperature superconducting thin films are excellent materials based on which many passive microwave devices (such as filters, resonators, etc) of outstanding performances can be made. For such applications it is crucial for the thin films to have surface resistance as low as possible. Experimentally many schemes have been devised to measure the surface resistance, while theoretically we can calculate the resistance at the surface of the thin film, the resistance at the interface between the thin film and the substrate, and the resistance of a bulk superconductor sample. Taking YBaCuO high temperature superconductor as an example, in this paper we carry out critical studies on the relationship between the measured surface resistance and other resistances mentioned above. For various values of the thin film thickness, the operating frequencies and the substrate parameters, we show that the relationship changes remarkably. These effects should be taken into consideration in characterizing superconducting thin films as well as in designing passive microwave devices based on them.

C8.5

Thickness Dependence of Critical Current, Ic, in PLD-YBCO Coated Conductor on PLD-CeO2/IBAD-GZO Buffered Substrate.
Akira Ibi[1], Kazuhiro Takahashi[1], Masaya Konishi[1], Takemi Muroga[1], Seiki Miyata[1], Tomonori Watanabe[1], Yutaka Yamada[1] and Yuh Shiohara[2]; [1]ISTEC-SRL Nagoya Coated Conductor Center, Nagoya; [2]ISTEC-SRL Division of Superconducting Tapes & Wires, Tokyo.

Critical current, Ic, of YBa2Cu3O7-δ(YBCO) coated conductor by ion-beam assisted deposition (IBAD) substrates and pulsed laser deposition (PLD) method has been improved in several institutes. Nevertheless, further high Ic is required for the industrialization. To obtain high Ic, it is necessary to increase the YBCO thickness. However, Ic saturates at a certain YBCO thickness, which is called critical thickness. It is important to investigate the cause of critical thickness for the fabrication of YBCO coated conductor with high Ic. Moreover, we found a new epitaxy phenomenon of PLD-CeO2, called gSelf-Epitaxyh which is effective to obtain a good in-plane texturing. The detailed microstructural characteristic and superconducting properties of YBCO coated conductor on the self-epitaxial PLD-CeO2 / IBAD-GZO buffered substrates is not yet investigated in detail. Therefore, we have investigated the delta phi, Ra value, the amount of existed a-axis oriented crystals, and Ic value of YBCO with increasing YBCO thickness on this buffered substrate by PLD method. For the sample with the in-plane alignment of 18°of delta phi of CeO2 cap layer, the Ic is 67.1 A/cm-width at about 2.0μm and the critical thickness is about 1.5μm. On the other hand, for the sample with the in-plane alignment of 4°of delta phi of CeO2 cap layer, the Ic is 177.2 A/cm-width at about 2.0μm and the critical thickness is about 2.0μm. Namely, a high degree of in-plane texturing enhanced a critical thickness and thus a good in-plane texturing of substrate is required to obtain thick YBCO coated conductor with high Ic. However, Ic saturated over the critical thickness of YBCO. Ra value of YBCO increased with increasing YBCO thickness, and the ratio of a-axis oriented crystals was increased drastically over the critical thickness. From these results, as the YBCO thickness increased, the surface morphology became much rougher. This was considered to be attributed to the surface temperature decrease of the YBCO with increasing the thickness and then the amount of the a-axis oriented crystals in the YBCO was increased. To solve this problem, we fabricated YBCO by multi-layer deposition, which was carried out at different setting temperatures to keep YBCO surface temperature constant with the increase in YBCO thickness. The YBCO 0.1μm in thickness was deposited in each deposition using Reel to Reel system. The first to third YBCO layer was deposited at a same setting temperature (810°C), then setting temperature was increased to a higher temperature of 840°C for 4 and 5th deposition. This process increased Ic from 27.2 to 44.6 A/cm-width. Thus, for the fabrication of thick YBCO coated conductor with high Ic, it was proved that multi-layer deposition was effective. This work was supported by the New Energy and Industrial Technology Development Organization (NEDO) as the Collaborative Research and Development of Fundamental Technologies for Superconductivity Applications.

C8.6

Electronic Mechanism of Critical Temperature Variation in $REBa_2Cu_3O_{7-\delta}$ High-T_c Superconductors.
Haibin Su[1] and Xiaojia Chen[2]; [1]Caltech, Pasadena, California; [2]Carnegie Institution of Washington, Washington, DC, District of Columbia.

An increasing number of applications of the 123-type high-T_c superconductors use materials other than Y-123. For example, in many bulk forms and multilayer applications, Y is replaced by Nd, Sm, or other rare-earth elements (RE). Although a nice trend of T_c in RE-123 superconductors has been revealed by Lin et al in 1995, the detailed studies at microscopic scale is missing due to complexity in both geometry and electronic structures. In addition, the variation of T_c in RE-123 is fairly small (between 87K and 95K). This motivates us to perform systematic studies on the trend of the critical temperature T_c due to both Madelung site potential difference between in-plane oxygen and copper sites ΔV_M and interlayer coupling in the optimally doped 123 superconductors. ΔV_M is found to decrease with the increase of the trivalent rare-earth ionic radius. This change enhances the next-nearest-neighbor hopping integral t', which results in the experimentally observed increase of T_c with the

rare-earth ionic radius. The coherent interlayer single particle tunneling parameter $t_\perp$ has more profound effect than t' on the nearly linear trend of T_c as a function of the rare-earth ionic radius. These results reveal the importance of electronic origin of the rare-earth ionic size effect on T_c in this family of bilayer cuprates.

C8.7

Discrete Fluxoid Dynamics Model. Masato Hiratani and Vasily V. Bulatov; CMS/MSTD, Lawrence Livermore National Laboratory, Livermore, California.

The study of stability of the fluxoid system is essential to predict and control the critical current of type II superconductors. In this work, a discrete computational model is developed to investigate 2D and 3D fluxoid dynamics. While physical properties of individual fluxoids are relatively clear, collective behaviors of fulxoids are so complex due to random thermal noise, interactions with local quenched disorders and other fluxoids, the AC/DC applied forces, and dissipations. Fluxoids are discretized and represented as nodes and interconnected links. Interactive forces between links are evaluated in paired manner (N-square terms) assuming the superposition of interactive forces. Drag coefficient is given as a function of density of quasi-electrons. Preliminary results indicate that there is a cross-over of fluxoid behavior from avalanche type jerky motion to smooth viscous motion as the applied force increases. Simulation results of a single and many fluxoid systems in low-Tc superconductors at different temperatures, magnetic fields, and pinning strengths will be presented. This work was performed under the auspices of the U.S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under Contract No. W-7405-Eng-48.

C8.8

Critical Current Anisotropy in Nano-Structured Superconductors. John Hay Durrell[1], Noel A. Rutter[1], Boris Maiorov[2], Haiyan Wang[2], Steve Foltyn[2], Leonardo Civale[2], Jan E. Evetts[1], Mark G. Blamire[1] and Judith Driscoll[1]; [1]Materials Science and Metallurgy, University of Cambridge, Cambridge, United Kingdom; [2]Superconductivity Technology Centre, Los Alamos National Laboratory, Los Alamos, New Mexico.

In order to properly characterise the magnetic field dependence of the critical current in a superconductor measurements of the critical current need to be carried out over the whole angular range of field. Such an approach, which requires a two-axis goniometer, allows effects which are otherwise obscured by the symmetry of the measurement system to be observed. Examples of this include intrinsic flux channelling in $YBa_2Cu_3O_{7-\delta}$ grown on vicinal substrates, vortex dragging in c-axis oriented superconductors and the grain boundary to in-grain critical current transition at grain boundaries in $YBa_2Cu_3O_{7-\delta}$. We present measurements on examples of the new generation of enhanced pinning superconducting materials which derive enhanced pinning from designed in nano-structure. These defects, which are carefully designed to match the optimum pinning length scale, can exhibit different effects on critical current anisotropy. Where an orientation independent enhancement in critical current is observed this normally stems from randomly distributed strong pinning centres. In contrast, directional pinning occurs when the nano-structuring has led to the formation of extended defects such as anti-phase boundaries and dislocations. A systematic understanding of the effect of nanostructures on pinning over the whole angular range is essential for the future design of coated conductors for specific applications. This critical current anisotropy stems simply from the interaction between the flux line lattice and the pinning centres. In coated conductors and thin films the pinning is firmly in the strong pinning limit. In this case the collective pinning volume is that of a single flux line and it becomes reasonable to describe the overall pinning behaviour in terms of interactions between individual flux lines and defects. For this reason it is possible to distinguish between critical current enhancement arising from an increased number of pinning centres which will tend to enhance the high field properties and that arising from more effective pinning centres which will enhance the critical current at lower fields.

C8.9

Matching Field Effect in the Critical Current of $YBa_2Cu_3O_7$ Films due to Periodic Y_2BaCuO_5 Inclusions. Boris A. Maiorov[1], Timothy Haugan[2], Terry G. Holesinger[1], Paul N. Barnes[2] and Leonardo Civale[1]; [1]Superconductivity Technology Center, Los Alamos National Laboratory, Los Alamos, New Mexico; [2]Air Force Research Laboratory, Wright-Patterson Air Force Base, Ohio.

The introduction of artificially engineered extended defects is one of the most promising ways of increasing the critical current density (J_c) in $YBa_2Cu_3O_7$ (YBCO) films. We present critical current measurements as a function of magnetic field (**H**) strength and orientation for YBCO films grown on single crystal $LaAlO_3$ with periodic Y_2BaCuO_5 (211) inclusions, that have been introduced into the YBCO in a layered fashion. The 211 inclusions induce a systematic increase of J_c for almost the whole angular and magnetic field range. In particular, for $\mathbf{H}\|$ c, this is reflected in a decrease of the *in − field* power-law-decay exponent α, with values as low as α=0.30 as compared to $\alpha \sim 0.55$ for YBCO films without 211 particles. For **H** orientations near the ab-planes, the 211 inclusions have a non-monotonic effect on J_c. For low particle densities the ab-peak decreases, but further increase in the 211 density results in a continuous enhancement of the ab-peak. The periodic distribution of the 211 inclusions give an additional increase in J_c for $\mathbf{H} \parallel$ ab when H is equal to the matching field (B^*). This situation occurs when the separation between vortex rows coincide with the distance (δ) between the equidistant planes that contain the 211 inclusions. Measurements performed in samples with different δ showed the correct dependence for $B^*(\delta)$. Also, the values found for $B^*(\delta)$ are temperature independent. These two finding are fingerprints of a geometric matching. This creates the possibility to increase J_c at a desired particular field by tunning a particular B^* through controlling the 211 density.

C8.10

Magnetic Field Dependence of Critical Current Density of PLD RE-Ba-Cu-O(RE=Er,Dy,Gd,Y) Film on CeO_2 Capped IBAD-GZO Layers. Kazuhiro Takahashi[1], Masaya Konishi[1], Tomonori Watanabe[1], Akira Ibi[1], Takemi Muroga[1], Seiki Miyata[1], Yutaka Yamada[1] and Yuh Shiohara[2]; [1]Nagoya Coated Conductor Center, ISTEC-Superconductivity Research Laboratory, Nagoya, Japan; [2]Divison Of Superconducting Tape and Wire, ISTEC-Superconductivity Research Laboratory, Tokyo, Japan.

Magnetic field dependence of critical current density is very important for both practical applications and understandings of the current limitation mechanism of high-T_c oxide superconducting materials. In order to investigate the magnetic field dependence of critical current density, we prepared samples of RE-Ba-Cu-O(RE= Er,Dy,Gd,Y) films with various thickness by a pulsed laser deposition(PLD) method on CeO_2/Ion-Beam Assisted Deposition(IBAD)-Gd-Zr-oxide(GZO) layer deposited on Hastelloy substrates. The RE-Ba-Cu-O(RE=Er,Dy,Gd) films were deposited for fixed substrates. Thickness of the films was estimated from the laser repetition rate and the deposition time. Y-Ba-Cu-O films were grown using multi-plume continuous PLD. The thickness was changed by the number of the deposition time. We measured the magnetic field B dependences of the critical current I_c measured by the conventional four-probe method in the magnetic fields up to 8T and compared those characteristics. In the Gd-Ba-Cu-O films, J_c less decreased with increasing the magnetic fields than Y-Ba-Cu-O films. This tendency was particularly clear over 5T magnetic field perpendicular to the film surface. For example, the J_c value of Gd-Ba-Cu-O film was 28900A/cm^2 at 77K in 6T magnetic field. This value of Gd-Ba-Cu-O film showed about 10 times as large as the J_c value of Y-Ba-Cu-O film. This result indicates that Gd-Ba-Cu-O film on a CeO_2/IBAD-GZO layer buffered Hastelloy substrate has an applicability for the use in high magnetic fields. This work is supported by New Energy and Industrial Technology Development Organization (NEDO) as Collaborative Research and Development of Fundamental Technologies for Superconductivity Applications.

C8.11

Growth and Characterization of Si/YSZ/CeO_2/YBCO for Broad-Band Photon Detection. Bruno Minetti[1,2,3], Angelica Chiodoni[1,2,3], Carlo Camerlingo[4], Fabio Fabbri[6], Laura Gozzelino[1,2,3], Francesco Laviano[1,2,3], Candido F. Pirri[1,2], Giuseppe Rombola'[1,2], Grazia Tallarida[5], Elena Tresso[1,2] and Enrica Mezzetti[1,2,3]; [1]Dept. of Physics, Politecnico di Torino, Torino, Italy; [2]I.N.F.M. UdR Torino Politecnico, Torino, Italy; [3]I.N.F.N. Sez. Torino, Torino, Italy; [4]C.N.R. Istituto di Cibernetica, Pozzuoli (NA), Italy; [5]I.N.F.M.-Laboratorio MDM, Agrate Brianza (MI), Italy; [6]ENEA, Frascati (Roma), Italy.

The possibility to take advantage of different materials features to implement hybrid devices for different applications was up to now an important goal. The integration between superconducting films and silicon is challenging because in such hybrid devices the unique properties of superconducting electronics would be exploited at best. In particular, for what concerns broad-band photon detection, $YBa_2Cu_3O_{7-x}$ (YBCO) is very appealing due to the wide superconducting gap. Furthermore, due to the characteristic features of the R vs. T curves, the quasi-particles created at low temperature by the photon excitation can move all along in a superconducting condensate, with a consequent lowering of the dissipative effects [1]. These properties seem provide optimal solutions. We report on the growth of Si/YSZ/CeO_2/YBCO multilayers by means of magnetron sputtering [2]. We characterized the multilayer by means of structural and dc the transport measurements, in particular R vs. T curves at different bias currents, and E vs. J characteristics at different temperatures. We investigated also the behaviour of pinning energy as

a function of current density at different temperatures. The structural characteristics (not optimised yet) explain the quite wide R vs. T transitions. However, it turns out that in the low temperature regime, the E-J characteristics exhibits transitions from under-critical state to over-critical state sharp enough to be considered in the framework of applications centred on photon detection. Further optimisations are in progress. The issue of the read-out of the voltage signals is also addressed and some new solutions are proposed.
Acknowledgments **This work was supported by MIUR under FIRB-RBAU01PYB3 and PRIN-2002038897 projects.** [1] A. Jukna and R. Sobolewski, "Time-resolved photoresponse in the resistive flux-flow state in Y-B-C-O superconducting microbridges", Supercond. Sci. Technol., vol. 16 (2003) pp. 911-915 [2] A. Chiodoni, V. Ballarini, C. Camerlingo, L. Gozzelino, E. Mezzetti, B. Minetti, C.F. Pirri, G.Rombola, E. Tresso, "R.F. sputtering deposition of buffer layers for Si/YBCO integrated microelectronics" submitted to Philosophical Magazine (2004)

C8.12

Transport Properties of $YBa_2Cu_3O_7$ Coated Conductors: Grain Boundary and Grain Vortices Behaviour. Joffre Gutierrez Royo[1], Anna Palau[1], Teresa Puig[1], Xavier Obradors[1], Laura Fernandez[2], Bernard Holzapfel[2], Alexander Usoskin[3] and Herbert Freyhardt[3]; [1]Materiales Magneticos y Superconductores, ICMAB-CSIC, Barcelona, Barcelona, Spain; [2]IFW, Dresden, Germany; [3]Zentrum fuer Funktion Wekstoffe, Goettingen, Germany.

Nowadays $YBa_2Cu_3O_7$ coated conductors are the most promising superconducting materials for power applications (cables, fault current limiters, motor etc.) and their performances are reaching their expected limits. However, Magneto-optic flux imaging and critical transport measurements have demonstrated the percolative nature of the supercurrent flow through their low angle grain boundaries (LAGBs). The effects derived from the granular character of these materials have become crucial issues for the understanding of the transport mechanisms. In this work we present an study of the transport properties of RABIT and IBAD $YBa_2Cu_3O_7$ coated conductors compared with results obtained on $YBa_2Cu_3O_7$ single crystals grown by different techniques. Results on J_c magnetic field dependence at low fields (<1T) and high fields (9T), J_c angular dependence and irreversibility line will be presented. The differences found between the systems are interpreted in terms of the different vortex pinning behavior and their interaction with the LAGBs. The magnetic hysteresis found at low magnetic fields in transport measurements is compared with those previously observed by dc-magnetization measurements[1]. The analysis is envisaged to sort out granularity effects from vortex pinning effects on coated conductors. [1]: A.Palau et al, Appl. Phys. Lett. 230, 84, (2004)

C8.13

AC Losses in High-TC Superconductors with Finite Thickness. Maamar Benkraouda and M. Mustafa; Physics, UAE University, Al-Ain, United Arab Emirates.

The structure and dynamics of magnetic vortices in high-Tc superconductors are studied. The model we use is applicable to highly anisotropic high-Tc superconductors, such as Bi and Th compounds, where the Josephson coupling is between the superconducting layers. The motion of the vortex lattice under the effect of an applied current causes dissipation. In this paper, we studied the AC losses occurring in a finite number of superconducting layers due to an applied AC current. It is found that the AC losses increase with the frequency and the amplitude of the applied current. To see the effect of pinning on the ac losses, we introduce randomly pinning centers in the layers. The effect of pinning on the reduction of ac losses is clear from the calculations.

C8.14

Progress on Control of Y_2O_3 Nano-Islands Density in Order to Induce Artificial Pinning Centers Formation in YBCO Thin Films. Paolo Mele[1,7,8], Kaname Matsumoto[1,8], Tomoya Horide[1,8], Osuke Miura[2,8], Ataru Ichinose[3,8], Masashi Mukaida[4,8], Yutaka Yoshida[5,8] and Shigeru Horii[6,8]; [1]Material Science and Engineering, Kyoto University, Kyoto, Japan; [2]Electrical Engineering, Tokyo Metropolitan University, Tokyo, Japan; [3]CRIEPI, Nagasaka, Japan; [4]Yamagata University, Yamagata, Japan; [5]Nagoya University, Nagoya, Japan; [6]University of Tokyo, Tokyo, Japan; [7]DCCI, University of Genova and INFM, Genova, Italy; [8]CREST-JST, Saitama, Japan.

For wide applications of $YBa_2Cu_3O_{7-d}$ (YBCO) high-temperature superconductors to electric devices it is necessary to obtain high critical current density J_c at the liquid nitrogen temperature and under magnetic fields. With this purpose, we introduced high-density columnar defects as artificial pinning centers (APCs) of the quantized vortices into YBCO films, during the film deposition procedure. APCs were introduced perpendicular to the film surface by using the distributed nano-sized Y_2O_3 islands prepared on $SrTiO_3(100)$ substrates. Varying the deposition and annealing conditions it is possible to control the density of the Y_2O_3 islands. The highest Y_2O_3 islands density (228 μm^{-2}) was obtained with fifteen laser pulses heating the $SrTiO_3$ substrate at 800 °C, then annealing in flowing oxygen at the same temperature. With a lower number of pulses the formation of nano-islands was not observed, while after a larger number the nano-islands trend to coalesce and their density decreases (45 μm^{-2} with thirty pulses). Keeping fifteen laser pulses and lowering the deposition temperatures the density of nano-islands becomes lower (13 μm^{-2} at 500 °C, 28 μm^{-2} at 700 °C, both annealed at 800 °C). If the annealing temperature of samples prepared with fifteen pulses at 800 °C changes, the islands density becomes ever lower with temperatures both lower (50 μm^{-2} with 700 °C) and higher (50 μm^{-2} with 900 °C) than 800 °C. After the island formation, PLD YBCO films are grown on the $Y_2O_3/SrTiO_3$ substrates. In order to clarify the correlation between the densities of islands and of the APCs, the as-grown YBCO films were etched by wet-chemical technique. The etch pits demonstrate the presence of screw dislocations inside the YBCO grains. A first comparison reveals that the density of dislocations is only 1/3 of the density of islands. It seems reasonable that controlling the island size it will be possible to increase the fraction of islands with an effective size to induce APCs.

C8.15

Ca Doped Y_2BaCuO_5 Thin Films. Srinivas Sathiraju[1,2], Andrew D. Chaney[2] and Paul N. Barnes[2]; [1]National Research Council, PRPG, Air Force Research Laboratory, Wright-Patterson Air Force Base, Ohio; [2]Propulsion Research and Power Generation, Air Force Research Laboratory, Wright Patterson Air Force Base, Ohio; [3]Propulsion Research and Power Generation, Air Force Research Laboratory, Wright Patterson Air Force Base, Ohio.

Recently our group has reported a new process for achieving a controlled dispersion of nanoparticles of Y_2BaCuO_5 (211) in $YBa_2Cu_3O_{7-x}$ (YBCO) thin films with the necessary particulate nanosize and high density [1]. In this paper we report the studies on Ca-doped 211 nanoparticles. $Y_{2-x}Ca_xBaCuO_y$ (where x =0, 0.1 and 0.2) targets were prepared using standard solid state route. Magnetization studies have shown that x = 0 has relatively better pinning properties than Ca doped 211 particulates when prepared using same deposition conditions, although studies on bi-crystals for improvement of intergranular current densities was inconclusive. To better understand the nature Ca doped 211 nanoparticles, we have deposited Ca doped 211 thin films on $LAlO_3$ and $SrTiO_3$ single crystal substrates and noticed that when x = 0.2, the films are superconducting below 77K. X-ray pattern show 211 peaks as well as peaks similar to c-axis orientated YBCO indicating the potential of minor phase separation in the processed material. The structural and microstructural properties of $Y_{1.8}Ca_{0.2}BaCuO_5$films will be presented and discussed. [1] T. Haugan, P.N. Barnes, R. Wheeler, F. Meisenkothen, and M. Sumption, Nature 430,p867 (2004).

C8.16

Enhancement of Flux Pinning in YBCO Coated Conductors via Processing-Induced Nanostructures. Albert A. Gapud[1], Roeland Feenstra[1], Amit Goyal[1], Claudia Cantoni[1], Tolga Aytug[1], Mariappan Parans Paranthaman[1], Sukill Kang[1], Keith J. Leonard[1], Terry G. Holesinger[3], Maria Varela del Arco[1], David K. Christen[1], Dhananjay Kumar[2] and James R. Thompson[4,1]; [1]Oak Ridge National Laboratory, Oak Ridge, Tennessee; [2]North Carolina A & T State University, Greensboro, North Carolina; [3]Los Alamos National Laboratory, Los Alamos, New Mexico; [4]University of Tennessee, Knoxville, Tennessee.

In developing high-temperature-superconductor(HTS)-coated conductors for motor applications, there is great interest in improving the critical current density J_c at temperatures ~ 30 K, in fields B ~ 2 T, and at different orientations θ of field relative to the c axis. Several groups have pursued this by modifying the HTS-film processing to introduce nanostructures into the superconducting bulk with the purpose of improving flux pinning (via the nanostructures themselves or strains and/or defects that they may induce). In this work we examine the structures that promote flux pinning in various films on $RABiTS^{TM}$: (1) *exsitu*-processed films with Y_2O_3 nano-precipitates which show an improvement in the uniformity of the angular dependence of J_c; (2) films processed by pulsed-laser deposition (PLD) with self-organized nano-inclusions of $BaZrO_3$ which show a strong J_c peak along the c direction; and (3) *insitu* film grown on substrates 'frosted' with nano-islands of various compositions. For each case we report significant improvement of J_c at target conditions, in terms of (1) in-field enhancement, (2) improvement in self-field, and (3) more uniformity with respect to θ. We also show, via mass-anisotropy scaling analysis, that the pinning is highly correlated. There is also an interesting scaling relation that is common to these films between J_c(2 T, 30 K) and self-field J_c at 77 K, which may prove useful as a benchmark for suitability in motor applications, as will be discussed.

C8.17

Novel Method of Introducing Particulate Pinning Centers in $YBa_2Cu_3O_{7-x}$ Films during Pulsed Laser Deposition.

Chakrapani Varanasi[1,2], Barnes N. Paul[2], Timothy J. Haugan[2] and Srinivas Sathiraju[3,2]; [1]Metals and Ceramics, Univeristy of Dayton Research Institute, Dayton, Ohio; [2]PRPG, AFRL, Wright-Patterson AFB, Ohio; [3]National Research Council, AFRL, Wright-Patterson, AFB, Ohio.

Introduction of flux pinning centers into bulk $YBa_2Cu_3O_{7-x}$ (YBCO) is widely known to improve the critical current density (J_c) significantly. Approaches to obtain similar enhancements in YBCO films that are used in coated conductor applications are presently looked at by several research groups by incorporating particulates that act as flux pinning centers. Significant improvements were demonstrated in pulsed laser deposited YBCO films with insulating particulate pseudo-layers by our group. The films, processed in this manner with pining centers arranged in a lamellar fashion, allow structured pinning centers with directional dependence of critical current density, controlled by the separation of the particulate pseudo-layers. However, a random distribution of pinning centers in the films which are not deposited in a layered fashion may be desired to avoid any preference for a given magnetic field orientation. This is especially relevant since in superconducting coil applications, the magnetic field will be present at a variety of angles to the coils. To determine the difference between the controlled layered-inclusion of particulates and controlled random inclusion of particulates, a special pulsed laser ablation YBCO target with an Y_2BaCuO_5 (Y211) sector was made and used to form YBCO films with Y211 particulates. By selecting a proper laser scanning sequence, desired amount of Y 211 particles were introduced randomly in the growing YBCO films. This technique allows separation of the respective constituents for a more controlled introduction of random non-layered particulates. Initial results show that YBCO films on lanthanum aluminate substrates can be grown with critical current density $> 3MA/cm^2$at 77K in self-field using this kind of target. Other results such as microstructure, magnetization J_c, etc. will be presented and comparison to the layered structure will be given.

SESSION C9: Multiscale Characterization of YBCO Films

Chairs: Leonardo Civale and Kaname Matsumoto
Friday Morning, April 1, 2005
Room 2000 (Moscone West)

8:30 AM *C9.1

AC Loss Characteristics of YBCO Coated Conductors.

Naoyuki Amemiya, Department of Electrical and Computer Engineering, Yokohama National University, Yokohama, Japan.

YBCO coated conductors are being considered the next generation high Tc superconductors. Since many electrical devices are operated with alternate current, AC loss reduction and its estimation are important issues for achieving practical electrical devices using high Tc superconductors. They are particularly crucial for YBCO coated conductors, because a large AC loss is generated in wide YBCO coated conductors subject to a perpendicular magnetic field. The author has been studying the AC loss characteristics of YBCO coated conductors experimentally and numerically: the AC loss of YBCO coated conductors has been measured using an AC loss measurement system, and the temporal evolution of electromagnetic field in YBCO coated conductors has been calculated numerically to evaluate the AC loss using several in-house codes based on the finite element method. In this presentation, the AC loss characteristics of YBCO coated conductors are reviewed. First, the author presents the AC loss characteristics of single YBCO coated conductors with conventional monolayer of YBCO on metal substrate. The presented data include the measured and calculated total AC loss in YBCO coated conductors carrying AC transport current in an AC external magnetic field. The calculated values by several models are compared with the measured values to validate the numerical modelings. Conductor width, critical current, critical current density profile across the width of conductors, etc. are varied to study their influences on AC loss characteristics. A challenge to reduce the AC loss in a perpendicular magnetic field is the application of multifilamentary structure to YBCO layer. Actually, a substantial AC loss reduction was demonstrated using non-twisted multifilamentary YBCO coated conductor samples with finite-length L. They simulated the twisted multifilamentary YBCO coated conductors with pitch 2L. These samples were prepared by striating Ag and YBCO layers using a laser ablation technique. At the next stage, a demonstration of AC loss reduction in twisted multifilamentary YBCO coated conductors is expected. A numerical model to simulate the electromagnetic phenomena in a multifilamentary YBCO coated conductor has been developed. Using this model, we found that coupling time constants of very thin multifilamentary YBCO coated conductors are rather small. Calculated AC losses in various multifilamentary YBCO coated conductors are presented to scale the AC loss with various conductor parameters. The whole AC loss of a winding or a cable composed of YBCO coated conductors can be estimated by integrating the AC loss of single conductors. With this manner, a method to evaluate the whole AC loss of a winding or a cable is presented finally. This presentation reviews in part the work supported by METI & NEDO and in part the work supported by AFOSR.

9:00 AM C9.2

Measurements and Theory of the Nonlinear Meissner Effect in High-Quality YBCO Films.

Daniel Agassi[1] and Daniel E. Oates[2]; [1]Naval Surface Warfare Center, Bethesda, Maryland; [2]MIT Lincoln Laboratory, Lexigton, Massachusetts.

The nonlinear Meissner effect (NLME) describes the dependence of the penetration depth on magnetic field. At microwave frequencies, the NLME is a source of nonlinearities such as intermodulation distortion (IMD), which can be detrimental in microwave devices such as bandpass filters. Although the d-wave symmetry of the order parameter in the cuprates leads to a distinctive power and temperature dependence of the effect, it has not been observed previously. We report new calculations based on a many-body approach that begins with the expansion of the constitutive relation relating the current density and vector potential. The linear term in this constitutive relation is the London theory and the second order vanishes by symmetry. The calculations predict: 1) The nonlinear penetration depth depends on the space-averaged current density (or equivalently, the total current) and must be treated by nonlocal electrodynamics, 2) the nonlinear penetration depth for a d-wave superconductor diverges at low temperatures, and 3) a nonmonotonic slope of the dependence of intermodulation power on the circulating power. We compare the calculations with our recently reported measurements of the temperature and power dependence of the NLME in high-quality YBCO films. We use measurements of the IMD power to extract the nonlinear penetration depth. These predictions, which involve only measurable parameters such as the London (linear) penetration length and lattice constant, agree very well with existing data. This agreement lends credence to the assertion that the observed nonlinearity in high-quality YBCO films is of intrinsic origin and this theory identifies the controlling parameters. The theory has important implications for practical HTS passive microwave devices. Those implications will be discussed along with strategies for minimizing IMD. This work was supported by the Air Force Office of Scientific Research

9:15 AM C9.3

A New Technique for the Measurement of AC Loss in Second-Generation HTS Wires.

Michael Osofsky[1], Robert J. Soulen[1], Jeff Sanders[2] and Mark Patten[3]; [1]Code 6361, Naval Research Laboratory, Washington, District of Columbia; [2]University of South Florida, Tampa, Florida; [3]Geocenters, Lanham, Maryland.

The successful application of superconductivity to motors and power system components depends on several factors. One of these involves characterization and minimization of the ac loss in the superconductor used for fabrication of the component. The sensitivity of previous measurements of ac loss has been limited by unwanted inductive voltages that were minimized by the addition of a complicated, compensation circuit. We have developed a much simpler circuit that drastically reduces this problem. Consequently, we have been able to measure ac loss with much improved sensitivity. We report on measurements of ac loss of several YBaCuO tape-shaped coated conductor HTS wires immersed in liquid nitrogen.

9:30 AM C9.4

Electrical Transport Properties of a Current Stabilized $YBa_2Cu_3O_7$ Coated Conductor.

Yates Coulter, Paul C. Dowden, Jeffrey O. Willis and Leonardo Civale; Superconductivity Technology Center, Los Alamos National Laboratory, Los Alamos, New Mexico.

The successful application of a high temperature superconductor is dependent on both its ability to carry large critical current, Ic, and to remain undamaged if the critical current is exceeded, e.g. under fault conditions. Coated conductors fabricated in Los Alamos consist of a polycrystalline nickel alloy substrate 1 cm wide, a template layer of MgO produced by ion beam assisted deposition (IBAD), one or more buffer layers, a Yttrium Barium Copper Oxide layer produced by pulsed laser deposition, and a silver overcoat. To protect the coated conductor in the event of currents in excess of Ic being carried we have electroplated copper with a common industrial process for use as a current stabilizing layer on the silver overcoat. Ics of the coated conductor samples were characterized as a function of position and magnetic field before and after the electroplating process. Results show a slight (few percent) decrease in Ic after the electroplating process. The self-field Ic values of the samples using a 1 microvolt criterion were greater than 200 amperes and the samples had critical current densities greater than 1 MA/cm2 at 75 K. In an experiment during which the current in a stabilized conductor was ramped past Ic to the point of sample destruction, good power law behavior was observed for low voltage levels (V<100 microvolts), with fitted power law exponents; n values near 30. At higher voltages, the n value decreased to a near linear voltage response as an increasingly larger fraction of current was being carried by the copper stabilizer layer. Eventually the current was increased to the point where heating became large enough for the conductor temperature to exceed the cooling ability of the liquid nitrogen bath and the sample was destroyed at a current of 550 amperes and ~2.5 times Ic. We present these results and discuss stabilized coated conductor performance and applications as a function of current stabilizer thickness, one or two sided coatings, and as a function of magnetic field.

10:15 AM *C9.5
Phase Separation and Lattice Disorder in YBCO Films on Coated Conductor Substrates. Victor A. Maroni[1], Beihai Ma[1], Quanxi Jia[2] and Jodi Reeves[3]; [1]Argonne National Laboratory, Argonne, Illinois; [2]Los Alamos National Laboratory, Los Alamos, New Mexico; [3]SuperPower, Inc., Schenectady, New York.

The occurrence of phase separation and lattice atom reordering in YBa2Cu3O7-x (YBCO) materials (thin films, thick films, textured bulk structures, and polycrystalline solids) has been known for well over a decade. At least four crystalline morphologies, Ortho-I (O-I), Ortho-II (O-II), tetragonal (T), and tetragonal-prime (T'), have been identified and have been found to coexist in a variety of embodiments. Lattice atom ordering effects occur in numerous ways, including vacancies, site exchanges, or intrusion by impurity atoms. Raman spectroscopy measurements have provided the most direct evidence of these phenomena, but some enlightening findings have come from x-ray diffraction studies and electron microscopy examinations. There is ample evidence in recent work on YBCO thin films to make a case that phase separation and cation disorder are two of the factors limiting the performance of the YBCO coated conductor. In this presentation we will illustrate the manifestations of phase separation and lattice atom disorder in spectroscopic and diffraction data and will show how these deviate structures correlate with the transport of current in the YBCO film. [*Work sponsored in part by the U. S. Department of Energy, Office of Electric Transmission and Distribution, as part of a DOE program to develop electric power technology, under Contract W-31-109-ENG-38.]

10:45 AM *C9.6
Imaging and Characterization of Nonuniform Current Transport in YBCO Coated Tapes. Takanobu Kiss[1,2], Masayoshi Inoue[1], Hideaki Tokutomi[1], Toshihiro Shouyama[1], Satoshi Koyanagi[1], Kazutaka Imamura[1], Akira Ibi[3], Junko Matsuda[4], Teruo Izumi[4], Yutaka Yamada[3] and Yuh Shiohara[4,3]; [1]Electrical and Electronic Systems Engineering, Kyushu University, Fukuoka, Japan; [2]Research Institute of Superconductor Science and Systems, Kyushu University, Fukuoka, Japan; [3]Nagoya Coated Conductor Center, Superconductivity Research Laboratory, Nagoya, Japan; [4]Division of Superconducting Tape and Wire, Superconductivity Research Laboratory, Tokyo, Japan.

Local current transport properties in YBCO coated tapes have been investigated by the combination of spatially resolved electric- and magnetic-imaging techniques. Moreover, relationship to the microcrystal structure has been studied by site-specified measurements of SEM and TEM. Local electric dissipation in YBCO coated tapes has been visualized in micro-meter length scale by use of low temperature scanning laser microscopy (LTSLM) at various conditions of bias current, temperature and magnetic field. As a complementary measurement, magnetic imaging has also been carried out for the same sample by using scanning SQUID microscopy (SSM). SSM allows us to analyze trapped vortex structure and current flow in the YBCO tapes. Correlation between the LTSLM image and the SSM image has been studied in detail. Furthermore, based on the insight of LTSLM and SSM, local crystallographic structure has been investigated at the site-specified position by SEM and TEM. Based on the combination of those measurements, we succeeded to clarify inhomogeneous current flow and the influence of current limiting obstacles in the tapes. This work was supported by the New Energy and Industrial Technology Development Organization (NEDO) as Collaborative Research and Development of Fundamental Technologies for Superconductivity Applications.

11:15 AM C9.7
Current Flow Characteristics in Striated Coated Conductors. Chuhee Kwon[1], L. B. Wang[1], P. Shelby[1], C. Khanal[1], J. L. Young[1], G. You[1], K. R. Barraca[1], George A. Levin[2], Timothy J. Haugan[2] and Paul N. Barnes[2]; [1]Physics and Astronomy, California State University Long Beach, Long Beach, California; [2]Air Force Research Laboratory, WPAFB, Ohio.

YBCO coated conductors with various striation patterns are investigated by scanning laser microscopy (SLM). The samples with long filamentary strips created by striation have shown to reduce the ac loss. Since the filamentary geometry without current sharing is susceptible to a single defect disabling a filament, various striation patterns are proposed to create the current sharing between filaments. In the superconducting transition region, we have studied the current distribution and Tc distribution using variable temperature scanning laser microscopy (VTSLM). In T < Tc, we have measured the local dissipation in order to locate the lower Jc* area in low temperature scanning laser microscopy (LTSLM). Striations are clearly visible in VTSLM images. The inside of striations has weaker signal (δV), and the filaments along the striations have stronger signal. We believe that the striations perform like artificial barriers to block the current and to compel the current to flow around them. Current sharing and redistribution are clearly observed where the filaments are connected via the openings in striations. In the samples with zipper-patterned striations, the zipper area acts as a place to share and to redistribute the current among filaments as intended. However, disabled filaments cause current crowding at the zipper area and lower Jc* (dissipation in superconducting state) is observed at the zipper. On the other hand in the brickwall-patterned samples, we find the lower Jc* near the opening of striations. This can be caused by the damage of YBCO while creating the striations or due to the current transport pattern determined by the striation geometry. We will present computer simulation results of VTSLM images on the role of striations, the effects of striation patterns, and the designing parameters of pattern geometry. In general, we find that the lower Jc* areas have lower Tc* and high δVm, which we consider as a sign of the current crowding. We find the major dissipation mechanism in the sample in the superconducting state to be the current crowding at bottleneck areas.

11:30 AM C9.8
Effects of Space Charge, Dopants, and Strain Fields on Surfaces and Grain Boundaries in YBCO Compounds. Haibin Su[1] and David O. Welch[2]; [1]Caltech, Pasadena, California; [2]Brookhaven National Laboratory, Upton, New York.

Statistical thermodynamical and kinetically-limited models are applied to study the origin and evolution of space charges and band-bending effects at low angle [001] tilt grain boundaries in $YBa_2Cu_3O_{7-\delta}$ and the effects of Ca doping upon them. Atomistic simulations, using shell models of interatomic forces, are used to calculate the energetics of various relevant point defects. The intrinsic space charge profiles at ideal surfaces are calculated for two limits of oxygen contents, i.e. $YBa_2Cu_3O_6$ and $YBa_2Cu_3O_7$. At one limit, O_6, the system is an insulator, while at O_7, a metal. This is analogous to the intrinsic and doping cases of semiconductors. The site selections for doping calcium and creating holes are also investigated by calculating the heat of solution. In a continuum treatment, the volume of formation of doping calcium at Y-sites is computed. It is then applied to study the segregation of calcium ions to grain boundaries in the Y-123 compound. The influences of the segregation of calcium ions on space charge profiles are finally studied to provide one guide for understanding the improvement of transport properties by doping calcium at grain boundaries in Y-123 compound.

11:45 AM C9.9
Impedance Spectroscopy Studies of La2CuO4+y Superconductors. Shu-Hau Hsu, Yunn-Shin Shiue, Ku-Pin Lee and Maw-Kuen Wu; Institute of Physics, Academia Sinica, Taipei, Taiwan.

It has been known that the excess oxygen remains mobile in La2CuO4+y (y<0.06) superconductors at low temperatures down to 290K where the phase separation takes place. In this study, the impedance measurements have been conducted on the La2CuO4+y polycrystalline samples at room temperature and 77K in various atmospheres, and a cyclic behavior was observed. This phenomenon is different from the cyclic effect found on the battery related materials caused by the charge-discharge cycles. Our results showed that the shifting of the impedance data is significant at high frequencies while the data in the low frequency region remains the same. The significance of such a cyclic behavior depends on the temperature, atmospheres, and seems to correlate to the superconductivity. The motion of the excess oxygen is thought to be responsible for the phenomenon observed.

SESSION C10: Structure and Chemistry Relationships with Flux Pinning in RE-123 Films
Chairs: Takanobu Kiss and Victor Maroni
Friday Afternoon, April 1, 2005
Room 2000 (Moscone West)

1:30 PM *C10.1
Understanding and Improving Vortex Pinning in $REBa_2Cu_3O_7$ Thin Films and Coated Conductors.
Leonardo Civale[1], Boris A. Maiorov[1], Judith L. MacManus-Driscoll[1,2], Haiyan Wang[1], Stephen R. Foltyn[1], Paul N. Arendt[1], Adriana C. Serquis[1,3], Terry G. Holesinger[1], Quanxi Jia[1], Brady J. Gibbons[1] and Vladimir Matias[1]; [1]Superconductivity Technology Center, Los Alamos National Laboratory, Los Alamos, New Mexico; [2]Dept. of Materials Science and Metallurgy, University of Cambridge, Cambridge, United Kingdom; [3]Caracterizacion de Materiales, Instituto Balseiro - Centro Atomico Bariloche, Bariloche, Argentina.

Recent progress in the development of coated conductors (CC) has been remarkable both in terms of eliminating the current carrying limitations due to large-angle grain boundaries, and in producing long lengths of tapes with good superconducting properties. As a result, a large fraction of the effort has now shifted towards the development of methods to enhance vortex pinning (and consequently the critical current density J_c), particularly at high fields. Of special interest are those methods suitable to be applied in continuous, industrial scale production. A prerequisite for J_c optimization is the identification of the pinning mechanisms that determine it, and a clear understanding of the correlations among processing, microstructure, and superconducting properties. With this goal, we performed transport measurements of J_c as a function of temperature (T), and magnetic field strength (H) and orientation (Θ), in a large variety of $REBa_2Cu_3O_7$ (RE-123) films (where RE is a rare earth), grown by different methods on either single crystal or metallic substrates. These studies allow us to identify several pinning sources and mechanisms, and ultimately to develop a H-Θ-T map of the pinning regimes. We observe systematic differences in J_c(H,Θ,T) for different fabrication methods, and in most cases clear correlations with the architecture and structure can be established. Particularly useful in this regard are several scaling laws that permit to characterize the pinning by a few parameters. This knowledge can be used as a guide to explore practical methods for process optimization and nano-engineering of pinning defects. We will show several examples of successful approaches to pinning enhancement, including introduction of nanoparticles, rare earth combinations, and modifications of the interface between the buffer layer and the RE-123 film. One of the most surprising conclusions of these studies is that several different approaches, applied to CC produced by various methods, are indeed very successful at increasing J_c. This indicates that there are still many possibilities that remained to be explored, particularly if combinations of pinning enhancement methods are considered, and suggests that pinning in CC can be "tuned" depending on the application.

2:00 PM C10.2
Modulation of the Vortex and Meissner States in $YBa_2Cu_3O_{7-x}$ Films by Heavy Ion Irradiation.
Enrica Mezzetti[1,2,3], Danilo Botta[1,2,3], Angelica Chiodoni[1,2,3], Roberto Gerbaldo[1,2,3], Gianluca Ghigo[1,2,3], Laura Gozzelino[1,2,3], Francesco Laviano[1,2,3], Bruno Minetti[1,2,3], Alberto Rovelli[4] and Antonino Amato[4]; [1]Dept. of Physics, Politecnico di Torino, Torino, Italy; [2]I.N.F.N. Sez. Torino, Torino, Italy; [3]I.N.F.M. UdR. Torino-Politecnico, Torino, Italy; [4]I.N.F.N. - L.N.S., Catania, Italy.

The paper reports on two strongly correlated issues. We firstly created local pinning modulations in $YBa_2Cu_3O_{7-x}$ films by means of confined high energy heavy ion irradiation. The high energy of the ions allows us to introduce nanometric size defects with a well defined anisotropy [1]. The dose was chosen in such a way to reduce the local critical current of the irradiated area. We used a quantitative magneto-optical analysis [2] to measure the magnetic field vector and the supercurrent for each point of the whole sample surface. The basic geometry of a rectangular region inside strip-shaped samples was considered in order to investigate in detail the effect of the orientation of planar boundaries with respect to the supercurrent flow direction [3]. Here we present the two complementary orientations of the modulated region, i.e., perpendicular and parallel to the main supercurrent flow. The comparison of the magnetic field and supercurrent distributions shows deep differences between the two configurations. In particular, the enhanced vortex diffusion, observed for the perpendicular case, was not found in the parallel configuration. In a such case, unexpected vortex bundle jumps and a Meissner volume compression are clearly observed after the vortices enter the irradiated region. Secondly we employed a dedicated irradiation facility to create, by means of an X-Y target movement, patterns of any shape. In this case, we both addressed the fundamental issues hinted in the previous part of the paper and we explored the geometry dependent capabilities of the patterned films for some pointed application. Acknowledgments **This work was supported by INFN under NASTRI project.** [1] F. Laviano, D. Botta, A. Chiodoni, R. Gerbaldo, G. Ghigo, L. Gozzelino, and E. Mezzetti, Phys. Rev. B 68, 014507 (2003). [2] F. Laviano, D. Botta, A. Chiodoni, R. Gerbaldo, G. Ghigo, L. Gozzelino, S. Zannella, and E. Mezzetti, Supercond. Sci. Technol. 16, 71 (2003). [3] E. Mezzetti, F. Laviano, D. Botta, A. Chiodoni, R. Gerbaldo, G. Ghigo, L. Gozzelino, in "Magneto-Optical Imaging", edited by T.H. Johansen and D.V. Shantsev, Kluwer Academic Publishers (2004), 167.

2:15 PM C10.3
Scaling of J_c(H,T) and Pinning Force Plots of $YBa_2Cu_3O_{7-x}$ Coated Conductors.
Sang Il Kim[1], Darren T. Verebelyi[2] and David C. Larbalestier[1]; [1]Applied Superconductivity Center, University of Wisconsin - Madison, Madison, Wisconsin; [2]American Superconductor Corporation, Westborough, Massachusetts.

Performance improvement of coated conductors (CC) is rapid, and there is a strong need for better evaluation of conductor performance. We recently measured Jc(H,T) over the wide range for three conductors with different textures, including a single crystal film, possessing Jc(0T, 77K) values of 0.9 - 5 MA/cm^2. Here, we present these data which show how scaling of Jc(H,T) and flux pinning plots can illuminate the domain in which grain boundaries (GB) and intragrain flux pinning limit the Jc properties. Scaling of Jc(H,T) over a wide range of the single crystal sample based on simple second order polynomial fits of Jc(T) allows us to estimate Jc(H$\leq$12T) at any temperature. We found that Jc(0T) and the irreversibility field change by $\sim$ 6 % (0.3 MA/cm^2) and by 0.8 - 0.9 T per Kelvin near 77 K, respectively, making performance of CC near 77 K very sensitive to small differences in superconducting transition temperature (Tc). Such variations mean that evaluation of low temperature CC performance by the Jc(0T,77K) value is uncertain. The Kramer plot and pinning force plot can be a basis for determining flux pinning properties of conductors, except where GB properties determine Jc . We deduced the domain of GB limitation by comparing the plots of various textured samples to that of single crystal sample. We found that the maximum of the pinning peak moves towards high fields due to the GB limitation in CC at low fields. Intragrain pinning dominates at large fields; in the regime where GBs are no longer an obstacle (H>H^{cr}). We conclude that the low-field regime where GB's limit the Jc (usually up to a few Tesla) does not determine the pinning properties at high fields where the intragrain pinning is limiting Jc. Because of this complexity, there is as yet no simple metric that can be universally applied to rank CC performance. Our paper is intended to stimulate discussion as to what such metrics should be.

2:30 PM C10.4
First Experimental Test of the Incorrect Assumption that Continuous Columnar Pinning Centers Produce the Highest Jc in Superconductors.
Alberto Gandini[1,2], Roy Weinstein[1,2], Ravi Sawh[1,2], Drew Parks[1,2] and Billy Mayes[2]; [1]TcSAM, Texas Center for Superconductivity and Advanced Materials, University of Houston, Houston, Texas; [2]Physics Department, University of Houston, Houston, Texas.

In the past decade, it has been stated in probably hundreds of papers that the optimum pinning centers are provided by continuous tracks created by ionic damage (known as columnar defects). The conventional wisdom, that the best pinning comes from continuous tracks, has never been questioned, nor experimentally tested. Although irradiation of HTS materials has been broadly studied, and researchers repeatedly have observed that above certain columnar defect density thresholds irradiated samples deteriorate rather than improve; the causes of such deterioration have not been investigated in depth. Columnar defects provide the maximum pinning potential. However, because of their large size they also severely reduce the percolating area, reducing Jc and the maximum pinnable field in the HTS material. Following this analysis, we proposed what we believed to be a new and more effective type of pinning center. We proposed to create discontinuous ionic damage with a lower damaged cross section. Both characteristics reduce the loss in the percolating area, hence we argued increase Jc, despite resulting in a lower pinning potential. To settle the question of which effect would be larger - the increase of Jc due to the improved percolation, or the decrease in pinning potential - we experimentally compared pinning morphologies, varying from continuous columnar defects to broken columns to aligned string-of-beads. The different pinning morphologies were formed by varying, in a controlled manner, the energy of the projectile ions. The experiment was conducted at the GSI (Germany) heavy ion accelerator using a 70 GeV U ion beam. This experiment allows us to directly compare which pinning center type results in the highest Jc, and represents a unique experiment with no equal in the literature. For the first time in a controlled experiment the energy loss per unit length, dE/dx, was a controlled variable, and tuned so as to produce pinning centers of various sizes and geometries. dE/dx varying between 14 KeV/nm to 40 KeV/nm were investigated. As shown in our latest paper (Physics Letter A, Vol. 331/3-4 pp 276-280, 2004), the data clearly show that discontinuous defects, formed at values of dE/dx = 21 KeV/nm, improve Jc more than columnar defects, which are formed at values of dE/dx > 35 KeV/nm, by factors of three to

sixty. This experimental finding is in clear contrast with the conventional, but experimentally untested, belief. This work stands as the first experimental test of the postulate that continuous columnar pinning centers produce the highest Jc, and shows that the postulate is incorrect.

3:15 PM *C10.5
Effects of Artificial Pinning Centers on Vortex Pinning in High-Temperature Superconducting Films.
Kaname Matsumoto[1,6], T. Horide[1,6], P. Mele[1,6], Y. Yoshida[2,6], M. Mukaida[3,6], A. Ichinose[4,6] and S. Horii[5,6]; [1]Department of Materials Science and Engineering, Kyoto University, Kyoto, Japan; [2]Nagoya University, Nagoya, Japan; [3]Yamagata University, Yamagata, Japan; [4]CRIEPI, Yokosuka, Japan; [5]University of Tokyo, Tokyo, Japan; [6]CREST-JST, Saitama, Japan.

For drastic improvement of J_c, we are investigating a novel technology by means of a nano structure engineering to introduce artificial pinning centers (APCs) into HTS, such as RBCO films (R=Y, Sm, Gd, etc.). It is necessary for the APC technology that the optimum spatial arrangement and distribution of APCs are designed theoretically and they are introduced into HTS films by the thin film technology with low cost. We have successfully introduced high-density extended crystalline defects, which resulted in one-dimensional APCs of the quantized vortices, into c-axis oriented $YBa_2Cu_3O_{7-x}$ (YBCO) films. The crystalline defects, created perpendicular to the film surface, were derived during the film deposition process by the distributed nano-sized Y_2O_3 islands prepared on $SrTiO_3$ (100) substrates. The Y_2O_3 nano-islands were approximately 3 nm in height and 25 nm in diameter and the density was controlled from 100 μm^{-2} to 300 μm^{-2} by choosing the Y_2O_3 deposition condition. In-field J_c of the films was remarkably enhanced by this method and reached to 0.12 MA/cm^2 (77K, $B//c$, 5T), which was 2-2.5 times higher than that of a pure YBCO film. The present films had a large J_c peak when the field was applied close to the c-axis. The results indicate that the strong APCs were introduced into the YBCO films. The vortex pinning by the present APCs is discussed based on the accommodation angle of the vortices.

3:45 PM *C10.6
Columnar Defects Comprised of Self-Aligned Nanodots and Nanorods in YBaCuO on RABiTS.
Sukill Kang[1,2], Amit Goyal[1], Keith J. Leonard[1], Albert A. Gapud[1], Maria Varela del Arco[1], Mariappan Parans Paranthaman[1], Patrick M. Martin[1], Anota O. Ijaduola[3] and James R. Thompson[3,1]; [1]Oak Ridge National Laboratory, Oak Ridge, Tennessee; [2]Oak Ridge Institute of Science & Technology, Oak Ridge, Tennessee; [3]Department of Physics & Astronomy, University of Tennessee, Knoxville, Tennessee.

For over a decade, scientists world-wide have sought means to produce columnar defects in superconductors similar to those produced by ion irradiation without the expense and complexity of ionizing radiation. We have succeeded in producing long, nearly continuous vortex pins along the c-axis in YBCO, in the form of self-assembled stacks of $BaZrO_3$ nanodots and nanorods using simple and practically scalable techniques. The nanodots and nanorods have a diameter of ~2-3 nm and an areal density ("matching field") of 8-10 tesla for 2vol% incorporation of $BaZrO_3$. In addition, four misfit dislocations around each nanodot or nanorod are aligned and act as extended columnar defects. YBCO deposited by laser ablation on standard "RABiTS" substrates for potential coated conductor applications exhibits enhanced pinning and a weak falloff in large magnetic fields H. In particular, the current density varies as $J_c \sim H^{-\alpha}$, with $\alpha \sim 0.3$ rather than the usual values 0.5 - 0.65. Similar results were also obtained for $BaZrO_3$ and YSZ as well as other materials. Details of the defect structure and transport and magnetic characterization of the samples as a function of volume percent of incorporated nanodots and nanorods will be presented. Research was sponsored by the U.S. Department of Energy under contract DE-AC05-00OR22725 with the Oak Ridge National Laboratory, managed by UT-Battelle, LLC. S. Kang would like to acknowledge the support of ORISE

4:15 PM C10.7
Chemical Routes to Nano-Scale Pinning in Coated Conductors.
Judith MacManus-Driscoll[1,2], Steve Foltyn[1], Quanxi Jia[1], Haiyan Wang[1], Adriana Serquis[3], Leonardo Civale[1], Boris Maiorov[1] and Dean Peterson[1]; [1]Los Alamos National Lab, Los Alamos, New Mexico; [2]Department of Materials Science, University of Cambridge, Cambridge, United Kingdom; [3]Centro Atomico Bariloche, San Carlos de Bariloche, Rio Negro, Argentina.

We have previously reported on systematic studies to increase pinning in $REBa_2Cu_3O_7$ coated conductors grown by pulsed-laser deposition. Different chemical modifications (including $BaZrO_3$ nano-particle additions, changing RE ion size variance (for constant RE ion size), and RE ion size (for constant RE ion size variance) have led to these improvements. In this work, we report on our efforts to combine these different pinning routes.

4:30 PM C10.8
Enhancement of the Superconductivity in High Fields of Y-Ba-Cu-O Materials.
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It is known that the critical current density (Jc) of superconductors can be enhanced by incorporating of extended defects to act as pinning centers. Pinning is optimized when the size of the defects approaches the superconducting coherence length (ex. 2-4nm for YBCO at 77 K). On the other hand, field induced pinning centers (ex. compositional fluctuation) were proven to enhance Jc in high field regions. In this study, nano-scale non-superconducting-particles, includes RE2BaCuO5 (RE211) and RE2O3 (RE: rare earth elements, includes Sm, Nd, and Gd), which were expected to act as artificial pinning centers, have been introduced into large, single-grain Y-Ba-Cu-O superconductors. The results indicate that the Jc-H curves varying with the type of addition. Two types of action of the additions were observed: one act as non-superconducting particle and nuclei site, and the other produce regions with oxygen deficiency and variation of Tc. By controlling the type and amount of additions, a pronounced peak extend till high fields was obtained. The method provides a possibility for the fabrication of Y-Ba-Cu-O superconductors, includes films, with enhanced flux pinning in high field regions.

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Studies on Nanolayered Flux Pinning Structures in YBa2Cu3O7-x Films.
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Fundamental studies directed toward higher critical current densities by improved magnetic flux pinning in YBa2Cu3O7-x (YBCO) is critical to coated conductor applications. Pinning is optimized as the size of the defects approaches the superconducting coherence length, ~2-4 nm for YBCO ? 77 K, and when the number of defects per unit area is sufficiently large, ~ (H/2)x10î1 #/cm2̂ where H is in Tesla. A new process has been recently developed for achieving a controlled dispersion of nanoparticles in YBCO thin films with the necessary particulate nanosize and high density [1]. The deposition process incorporates insulating nanoparticles into the YBCO films by multiple alternating, consecutive depositions of YBCO and the insulating material, such as Y2O3 and Y211. Particulate formation is caused by lattice mismatching with the YBCO, with a greater mismatch producing finer sized nanoparticles for similar layer coverage. However, based on initial magnetization results, lattice matched insulating material such as CeO2 provides alternate effects although the composite films are prepared in a similar manner. Flux pinning was found to be in some cases either slightly improved at either low fields < 0.5 T or in other cases at high fields > 8 T although degraded, sometimes severely, at interim magnetic fields. Most unexpectedly, the pinning performance of the various samples rapidly converges as the temperature is reduced from 77 K to 65 K, causing all films to have similar Jc(H) behavior at 65 K even though dramatically different at 77 K. Differences resulting from the above approach and a technique to remove the layered structure as well as the addition of Ca and Ag doping will be discussed. [1] T. Haugan, P.N. Barnes, R. Wheeler, F. Meisenkothen, and M. Sumption, Nature, vol. 430, 867 (2004).