SYMPOSIUM EE

EE: Frontiers in Superconducting Materials-New Materials and Applications

December 1 - 4, 2003

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* Invited paper

SESSION EE1: Coated Conductors-Fabrication
Chairs: Ron Feenstra and Vladimir Matias
Monday Morning, December 1, 2003
Constitution B (Sheraton)

8:30 AM *EE1.1
Development of IBAD/PLD Process for 100-m Length Y-123 Coated Conductors. Yasuhiro Iijima, Kazuomi Kakimoto, Yasunori Sutoh, Shoji Ajimura and Takashi Saitoh; Fujikura Ltd., Tokyo, Japan.

In recent years remarkable progress has been made on processing technology for Y-123 coated conductors. Ion-Beam-Assisted Deposition (IBAD) and Pulsed-Beam-Deposition (PLD) have developed to be viable methods with the aid of recent improvement for vacuum technologies like large area ion source, and industrial excimer laser, etc. We have performed 100-m length formation of Y-123 tapes by using independent reel-to-reel vacuum systems of IBAD and PLD. Biaxially textured $Gd_2Zr_2O_7$ buffer layers were routinely fabricated with $\Delta\phi$ of 10 degrees by IBAD with production speed of 0.5m/h. In order to search for missing growth parameters during long time reel-to-reel operation, an ion beam divergence measurement system was constructed which have Faraday cups scanning behind arrayed apertures. The dependence of biaxially textured growth on assisting beam divergence was investigated, considering the dependence on ion energy, and ion current density. In-plane texture improvement was discussed using ion/atom flux ratio and beam divergence. For further improvement of in-plane texture, secondary buffer layers were deposited by PLD on IBAD $Gd_2Zr_2O_7$ films of $\Delta\phi$ of 10 degrees. 1.5-2.0 μm thick CeO_2 and $Gd_2Zr_2O_7$ films were deposited with both $\Delta\phi$ of 5 degrees. Those secondary buffer layers had very large grain sizes over 1 μm, far bigger than the ones for IBAD films. Dense stress contrast was observed by TEM cross-sectional images near the interfaces between PLD and IBAD buffer layers. Y-123 films were formed on them by PLD with $\Delta\phi$ of 3-4 degrees. Y-123 films with $\Delta\phi$ of 7 degrees were formed by PLD on 100-m length IBAD tapes with $\Delta\phi$ of 10 degrees. The tape moving speed was 4.0 m/h and cyclically deposited for several times in order to homogenate longitudinal Ic/Jc distributions. Ic of 40A and Jc of 0.8MA/cm^2 (77K, self-field) was obtained in end-to-end of 100m length. Ic of 74A and Jc of 0.6MA/cm^2 (77K, self-field) was obtained in end-to-end of 46m length. The end-to-end Ic/Jc values degraded to be about half as much as the ones of 10cm length samples. The reason for Jc degradation of those long length samples were considered to be: a) substrate temperature control mistake during cyclically PLD process, and b) handling mistake of samples before Ag cap layer coating. A single layer Y-123 film was also formed by PLD on a 80-m length IBAD/PLD-CeO_2 tape with $\Delta\phi$ of 7 degrees. Jc of 1.8MA/cm^2 (77K, self-field) was obtained in approximately whole length. 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.

9:00 AM *EE1.2
YBCO Coated Conductors with Extra-High Engineering Current Densities and Their Implementation in Power Engineering. Alexander Usoskin[1], Herbert C. Freyhardt[1,2], Alexander Issaev[1] and Jurgen Knoke[1]; [1]Zentrum fuer Funktionswerkstoffe gGmbH, Goettingen, Germany; [2]Institut fuer Materialphysik, Universitaet Goettingen, Goettingen, Germany.

Newest state of the art in developing coated conductors with extra-high engineering current densities, up to almost 400A/mm^2, is reported. Features of cost-efficient technological route based on employment stainless steel substrate tapes, IBAD and high-rate pulsed-laser-deposition are discussed and compared with alternative routes. It is clearly shown that an optimisation of CeO_2 layer in IBAD-YSZ / CeO_2 double-layered buffers can lead to a significant enhancement of the in-plane texture of YBCO films accompanied by a considerable increase of their critical current densities. Employing a modified IBAD technique the IBAD-YSZ-buffered stainless steel tapes up to 23m long, 4mm wide, have been fabricated. Typical FWHM values of 11-12.5° of the in-plane texture were achieved for 1.1-1.6μm-thick buffer layers. CeO_2 buffer layers were deposited using either an e-beam evaporation or a high-rate pulsed-laser-deposition (HR-PLD) methods. Exploiting the HR-PLD for the subsequent processing of thin (0.02-0.1μm) CeO_2 layer and YBCO film, coated tapes with a length up to 10m have been manufactured. At YBCO in-plane texture with FWHM=6-7.5° critical currents of 85-105A (in end-to-end measurements at 77K & SF) are achieved in (3.5-4)mm wide long length coated conductors. With thickening the CeO_2 layer up to 2.2μm, the FWHM value of 6° of the in-plane alignment have been achieved. This resulted in an enhancement of the in-plane alignment of thick (~3μm) YBCO films, which can exhibit an FWHM of only 3.5°. With high quality buffer layer systems, an effect of self-improvement of YBCO in-plane texture with increasing YBCO film thickness is observed and discussed. In long coated conductors of (6-10)m x 4mm, very high Ic's of 85-125A were observed. These Ic-values correspond to critical currents per cm-width of 215-272A/cm. In shorter conductors with a length of 0.2-1m, the critical currents of 317-391A per cm-width of the tape could be measured. With a 0.1mm-thick substrate-tape employed, the engineering current density of the coated conductors exceeds presently 250A/mm^2 for the tapes in 10m-lengths and 350A/mm^2 for the tapes in 1m-lengths. We consider a realistic possibility for further improvement of the current density to >500 A/mm^2. These extra-high engineering current densities reveal new functionalities of the coated conductors in the power engineering, especially, in the power transmission and conversion. Various application fields are considered with this respect. This work was supported in part by the EU within the "Growth" Project No. GRD1-2000-25267, and the German BMBF within the Project No.13N7876.

9:30 AM EE1.3
Continuous Preparation of Pulsed Laser Deposited Oxide Buffer Layers and YBCO for Coated Conductor Applications. Brady J Gibbons, Sascha Kreiskott, Chris Sheehan and Vlad 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 x 0.1 mm), continuous ion-beam assisted deposition (IBAD) of an 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 100 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 70 A in short pieces. In our system the LMO can be produced at a rate of up to 21 m/hr. Conversely, the YBCO layer is produced currently at ~1 m/hr. We will present results of studies to increase the throughput of the YBCO layer. The effects of high rate deposition on the structural and electrical properties will be discussed. This work is funded by the Department of Energy Office of Power Technologies.

9:45 AM EE1.4
Development of HoBCO Coated Conductor by Pulsed Lase Deposition. Koso Fujino, Shuji Hahakura, Konishi Masaya and Kazuya Ohmatsu; Energy and Environmental Technology Research Laboratories, Sumitomo Electric Industries, Ltd., Osaka, Japan.

Rare earth (RE)-Ba-Cu-O superconducting materials have been expected as a next generation superconducting wire with the high Jc and Ic under the high magnetic field. We have investigated $HoBa_2Cu_3O_{7-\delta}$ (HoBCO) material and have also tried to fabricate a coated conductor and a thin film on a single crystal substrate. Through these accumulations, we confirmed that the HoBCO had the excellent superconducting properties as well as the YBCO had. HoBCO coated conductors have been developed by using a physical vapor deposition such as a pulsed laser deposition (PLD). HoBCO layers have been deposited on flexible metal substrates with bi-axially textured buffer layers. We have already produced the 55m long HoBCO coated conductor experimentally and have kept to improve the electrical properties and the long length deposition technique. The latest results about our trial production will be reported.

10:30 AM *EE1.5
Continuous Coated Conductor Fabrication By Evaporation. Werner Prusseit, Ralf Nemetschek, Christian Hoffmann, Robert Semerad, Georg Sigl and Helmut Kinder; THEVA GmbH, Ismaning, Germany.

Coated conductors will play a crucial role for the generation and distribution of electrical energy in the future. To realize kilometers of flexible steel tape coated with the complex high temperature superconductor oxides THEVA is exploring and treading entirely new paths. In search of a scalable and economic production technique we have focussed on proprietary technologies which combine buffer layer alignment by inclined substrate deposition (ISD) and the fabrication of coated conductor tape based on vacuum evaporation. In the course of this year several crucial breakthroughs have been achieved which render this route a viable industrial production process offering the advantages of high volume deposition rates, uniformity and little maintenance. Since all fabrication steps are a reel to reel processes they allow straightforward upscaling from the pilot plant handling hundred meters to the production line designed for kilometers of tape. The basic corner stones of the technology - deposition of several micron thick films, high speed growth and continuous long lengths coating - have been successfully demonstrated. A consistant pilot production process comprising all steps from electropolishing the steel tape, oriented buffer layer deposition to the superconductor growth

has been set up. The latest results of this development will be presented and discussed in detail.

11:00 AM EE1.6
Investigation on Microstructures and Growth Mechanism of Y123 Films Deposited by Modified TFA-MOD Method.
Junko S Matsuda[1], Yoshitaka Tokunaga[1], Ryo Teranishi[1], Hiroshi Fuji[1], Atsushi Kaneko[1], Shigenobu Asada[1], Tetsuji Honjo[1], Yasuhiro Iijima[2], Takashi Saitoh[2], Teruo Izumi[1] and Yuh Shiohara[1]; [1]Superconductivity Research Laboratory, ISTEC, Tokyo, Japan; [2]Materials Technology Laboratory, Fujikura Ltd., Tokyo, Japan.

We have fabricated YBa$_2$Cu$_3$O$_7-y$(Y123) films on CeO$_2$/Gd$_2$Zr$_2$O$_7$/Hastelloy tapes by the modified metal organic deposition(MOD) method with different heat-treatment conditions in the crystallization process as well as calcination process. Microstructures and distributions of chemical composition of these films were evaluated by transmission electron microscopy(TEM) and energy dispersive X-ray spectroscopy(EDS). We have already reported that the Y123 films with high I$_C$ values exceeding 200A were formed by ordinary MOD method using Y,Ba and Cu-trifluoroacetates including the multi-coating process. Recently, the starting solution materials were modified in order to shorten the calcination time. In the present work, we have investigated effects of the heat-treatment conditions on microstructures and superconducting properties of the films in the process using the modified starting materials. Partial pressure of water has an influence on the microstructures of the films. The sizes of the pores became finer and the I$_C$ values increased with the increment of the water partial pressure. The growth mechanism, which may affect the microstructures, will be discussed using the results of TEM observation about the cross-sections of the quenched films during the heat-treatment. This work was supported by the New Energy and Industrial Technology Development Organization(NEDO).

11:15 AM EE1.7
All-solution coated conductor fabrication.
Srivatsan Sathyamurthy[1], Mariappan Paranthaman[1], Hong-Ying Zhai[1], Sukill Kang[1], Amit Goyal[1], Shafiq M Bhuiyan[2,1] and Kamel Salama[2]; [1]Oak Ridge National Laboratory, Oak Ridge, Tennessee; [2]University of Houston, Houston, Texas.

The most successful coated conductors based on the RABiTS approach currently use the architecture YBCO/CeO2/YSZ/Y2O3/Ni/NiW where each of the intermediate layers is processed using a variety of vacuum based techniques and the YBCO is processed using an MOD technique. Solution deposition of intermediate layers has the potential to reduce the number of intermediate layers required and reduce process complexity. In our work, using solution processed lanthanum zirconate (LZO) films as seed layers instead of the e-beam deposited Y2O3 layer, comparable critical current density of 1.9 MA/cm2 has already been demonstrated. It has also been demonstrated that the LZO film can also serve as a barrier layer in place of the sputtered YSZ film. Thus, using a 60-80nm thick solution processed LZO film as a single buffer layer, critical current density of 1.9 MA/cm2 has been demonstrated using PLD-YBCO. Recently, we have developed a solution based processing route for deposition of CeO2 thin films on LZO barrier layers. In this paper, the processing and properties of all-solution coated conductors with a simplified buffer architecture (YBCO/CeO2/LZO/NiW) will be discussed. The U.S. DOE, Division of Materials Sciences, Office of Science and Office of Distributed Energy and Electric Reliability-Superconductivity Program, and Office of Energy Efficiency and Renewable Energy sponsored this research. This research was performed at the Oak Ridge National Laboratory, managed by UT-Battelle, LLC for the USDOE under contract DE-AC05-00OR22725. Sincere acknowledgements also extended to Oak Ridge Associated Universities for making this work possible.

11:30 AM EE1.8
Pulsed Electron Deposition for Coated Conductor Applications.
Hong-Ying Zhai[1], Hans M Christen[1], Ron Feenstra[1], Frederick A List III[2], Amit Goyal[2], Keith J Leonard[2], Yongli Xu[2], Kartik Venkataraman[3], Victor A Maroni[3] and Divid K Christen[2]; [1]Condensed Matter Science Dividion, Oak Ridge National Laboratory, Oak Ridge, Tennessee; [2]Metal and Ceramics Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee; [3]Materials Science Division, Argonne National Laboratory, Argonne, Illinois.

Pulsed electron deposition (PED) offers great flexibility in the deposition of different materials. It is conceptually similar to pulsed laser deposition (PLD) except that a short pulse of photons is replaced by energetic electrons to ablate material from a ceramic target. Motivated by the scalability of the approach and its potential as a cost-effective method for coated-conductor fabrication, we have applied PED to the growth of high-temperature superconductors on RABiTS and on single-crystal substrates. As a straightforward "mimicking" of the PLD process, however, PED results in thin films with reduced critical currents and containing undesired crystalline phases. Therefore, various alternatives have been investigated, ranging from precursor deposition for ex-situ YBCO formation to various modifications of in-situ growth. The latter include the use of non-stoichiometric targets, varying the background gas composition, and methods of electron shielding. Results of transport measurements, scanning electron microscopy, transmission electron microscopy, x-ray diffraction, and Raman spectroscopy are combined to understand the differences between PED and PLD growth, and to provide information about the steps required to obtain high-quality superconductors. Research sponsored by the United States Department of Energy, Office of Energy Efficiency and Renewable Energy, Office of Distributed Energy and Electric Reliability- Superconductivity program. This research was performed at the Oak Ridge National Laboratory, managed by UT-Battelle, LLC for the United States Department of Energy under contract No. DE-AC05-00OR22725.

11:45 AM EE1.9
Film Growth and Thermodynamics of YBCO by High-Rate *In − situ* Electron Beam Deposition.
Jeong-uk Huh, William Jo, M R Beasley and R H Hammond; Geballe Laboratory for Advanced Materials, Stanford University, Stanford, California.

High-rate *in − situ* $YBa_2Cu_3O_7$ (YBCO) film growth was demonstrated by means of molecular beam epitaxy with electron beam co-evaporation and added oxygen. Eventhough our oxygen pressure is low, $\sim$ 5 x 10^{-5} Torr, we can synthesize as-grown superconducting YBCO films at a deposition rate of around 10nm/s, with average critical current density (J_c) more than 2.0 MA/cm^2. The growth morphology (TEM) shows that a liquid assists in the growth, with a portion having perfect layer-by-layer c-axis growth, while the rest is island-type growth. The island growth morphology portion is close to 50% of the film with a local J_c of 5 - 7 MA/cm^2. The system oxygen pressure of $5x10^{-5}$ Torr should not be sufficient to grow the YBCO at the temperature range studied, which indicates that we have higher oxygen activity present in the growth. Relatively high temperatures of around 900 °C have been necessary in this process so far. At this temperature at a given oxygen activity, Ba-Cu-O liquid forms along with the YBCO epitaxy. This liquid seems essential for high J_c-YBCO film growth at very high growth rate, and may be essential for all high-rate processes. Consideration of the YBCO phase stability in the liquid Ba-Cu-O leads to a possibility of lower temperature growth down to 800 °C, and lower still by the addition of oxyfluorides to the liquid, suitable for coated conductor tape synthesis. Work supported by the AFOSR

SESSION EE2: Coated Conductors-Properties
Chairs: Brady Gibbons and Werner Prusseit
Monday Afternoon, December 1, 2003
Constitution B (Sheraton)

1:30 PM *EE2.1
Intrinsic and materials related effects on the thickness dependence of J_c in YBCO coated conductors*.
Ron Feenstra[1], T. G. Holesinger[2], D. M. Feldmann[3], A. A. Gapud[1], D. K. Christen[1], E. D. Specht[1], L. Heatherly[1], A. Goyal[1], P. N. Arendt[2], S. I. Kim[3] and D. C. Larbalestier[3]; [1]Oak Ridge National Laboratory, Oak Ridge, Tennessee; [2]Los Alamos National Laboratory, Los Alamos, New Mexico; [3]Applied Superconductivity Center, University of Wisconsin, Madison, Wisconsin.

The role of thickness dependent trends in the microstructure in controlling the critical current density J_c is examined for YBCO epitaxial films produced by a BaF_2 ex situ process. A fundamental question, which has remained unanswered to date, relates to the nature of defects enabling strong flux pinning in these films and the observed large J_c. Theoretical models taking into account the size, distribution, and geometry of the flux pinning defects lead to distinct predictions for the thickness dependence of J_c, depending on which defect type dominates. Identification of the relevant intrinsic behavior, thus, is essential for understanding thickness dependent trends in J_c and formulating pathways to increase I_c, the total critical current. In this presentation, data of J_c as a function of YBCO layer thickness d for films of variable thickness (0.3-3 μm) are examined, alongside through-thickness data obtained by successive thinning of thick-film specimens. Substrates include RABiTS, IBAD, and single crystals. The microstructure was studied by XRD, SEM, and TEM at various magnifications, both in plan-view and cross-sectional imaging. Early indications are that besides obvious current-blocking defects (e.g. non c-axis YBCO grains), the relation between microstructure on a 0.1-1 μm length scale and J_c is complex and probably indirect. *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.

2:00 PM *EE2.2
Identification of pinning mechanisms in $YBa_2Cu_3O_7$ coated conductors. L. Civale[1], J. Y. Coulter[1], J. O. Willis[1], A. Serquis[1], B. Maiorov[1], Q. X. Jia[1], H. Wang[1], S. R. Foltyn[1], J. L. MacManus-Driscoll[1,2], P. N. Arendt[1] and M. P. Maley[2]; [1]STC-MST, Los Alamos National Laboratory, Los Alamos, New Mexico; [2]Dept. of Materials Science and Metallurgy, University of Cambridge, Cambridge, United Kingdom.

The objective of this work is to explore the mechanisms that limit the supercurrent in YBCO coated conductors (CC) on IBAD MgO with improved texture, which exhibit a Jc at 75K and self field as good as that of films on single-crystal substrates. To that end we characterized the transport Jc of the CCs as a function of temperature and magnetic field intensity and orientation, and we investigated their microstructural properties using X-ray diffraction, transmission electron microscopy, scanning tunneling microscopy, and scanning electron microscopy, looking for correlations with the transport results. We then compare these results with those of YBCO films on single-crystal substrates. We have used the angular dependence of J_c for identification of several pinning sources that are dominant at different field orientations. In particular, we have investigated in detail the peaks in J_c, which arise from different types of correlated disorder for applied magnetic field parallel to the c axis and the ab planes. We found that the relevant sources of pinning are similar in CC and films on single crystal substrates, although the relative importance of each mechanism is different, resulting in slightly different angular and field dependences of J_c. An important conclusion of this study is that over large field and orientation ranges, the Jc in the CC is higher than in films on single-crystal substrates. This demonstrates that the Jc in films on single crystals does not constitute an upper boundary for the performance of CCs, and that pinning in the latter materials can be further improved by appropriate engineering of the microstructure.

2:30 PM EE2.3
Through-thickness superconducting and normal state transport properties revealed by thinning of thick film ex-situ YBa2Cu3O7-x coated conductors. Matthew Feldmann[1], Sang Il Kim[1], David Larbalestier[1], Ron Feenstra[2], A. Gapud[2], Terry Holesinger[3] and P. Arendt[3]; [1]University of Wisconsin, Madison, Wisconsin; [2]ORNL, Oak Ridge; [3]LANL, Los Alamos, New Mexico.

It is generally observed that the critical current density of YBCO films decreases rapidly as their thickness increases. While such behavior is predicted from 2D collective pinning models, empirical observations of the thickness dependence of Jc are believed to be largely processing dependent at present. To investigate this behavior in ex situ YBCO coated conductors, samples with YBCO layer thickness of 0.82 - 2.9 um on buffered metal tapes were repeatedly thinned by ion milling and measured for rho(T) and Jc(H). Films of YBCO thickness 2.0 and 2.9 um were deposited on IBAD-YSZ substrates, and had Jc values of 0.73 and 0.97 MA/cm2 respectively. These films exhibited very linear Ic(t) dependencies as they were thinned, with little or no evidence of dead layers in the YBCO, suggesting that further increases in Ic can be obtained by growing thicker YBCO films. As they were thinned to small thickness (< 0.5 um), the 2.0 and 2.9 um films had lower Jc values than those found for films reacted from thin (< 0.5 um) precursors on nominally identical substrates. This result may be explained by a variable microstructure through thickness as revealed by cross sectional SEM and TEM.

2:45 PM EE2.4
Electrical and magnetic property characterizations of Cu-RABiTS with conductive buffer layers. Tolga Aytug[1,3], M. Paranthaman[1], J. R. Thompson[3,1], A. Goyal[1], A. A. Gapud[1], H. Y. Zhai[1], N. Rutter[1], A. O. Ijaduola[3], H. M. Christen[1], D. K. Christen[1] and R. E. Ericson[2]; [1]Oak Ridge National Laboratory, Oak Ridge, Tennessee; [2]3M Company, St. Paul, Minnesota; [3]University of Tennessee, Knoxville, Tennessee.

For the development of $YBa_2Cu_3O_{7-\delta}$ (YBCO)-based coated conductors for electric power applications, it is highly desirable to electrically and thermally stabilize the high temperature superconducting (HTS) coating. In addition, non-magnetic tape substrates are an important factor in order to reduce the ferromagnetic (FM) hysteresis energy loss in ac applications. Here, we demonstrate electrically connected high-J_c ($> 2x10^6$ A/cm^2 at 77 K) YBCO coatings on biaxially textured non-magnetic Cu tapes having a conductive bi-layer architecture of $La_{0.7}Sr_{0.3}MnO_3$/Ni. The current-voltage (I-V) and power handling characteristics of a model, ideally coupled conductor architecture (HTS + conductive buffer + Cu-substrate) were analyzed and compared with the experimental results. In addition, hysteretic FM loss due to 1.5 μm thick Ni seed layer was also investigated and compared to the projected loss for an achievable coated conductor tape. Fundamental issues and measures that are imperative for electrical stability of a coated conductor are also addressed.

3:30 PM *EE2.5
Chemical Routes to Increasing Low Field and High Field Pinning in Epitaxial REBa2Cu3O7 films.
Judith Louise MacManus-Driscoll[2,1], Stephen Foltyn[2], Qanxi Jia[2], Haiyan Wang[2], Adriana Serquis[2], Leonardo Civale[2], Boris Maiorov[2] and Dean Peterson[2]; [1]Materials Science and Metallurgy, Univ. of Cambridge, Cambridge, United Kingdom; [2]MST-STC, Los Alamos National Lab, Los Alamos, New Mexico.

Over the past 15 years, many studies have focused on understanding the naturally strong pinning in REBa2Cu3O7 films. It is clear that line defects associated with the mode of epitaxial growth from the vapor phase play a strong role. Despite the wealth of information about the pinning mechanisms, so far there has been no success in increasing pinning in already-high-quality-films by a simple, practical route. It is important to do this in order to decrease the cost of coated conductors as measured by the $/KA.m figure. In this talk, we report our systematic studies of increasing pinning in REBa2Cu3O7 films deposited by pulsed-laser deposition. By using different chemical modifications, we show that it is possible to separately enhance Jc in both the low field and high field pinning regimes.

4:00 PM EE2.6
Microstructural Development of Ex-Situ YBa2Cu3O7 Films on RABiTS and IBAD MgO Templates.
Terry George Holesinger[1], Paul Arendt[1], Vladimir Matias[1], Brady Gibbons[1], Roland Feenstra[2], Amit Gapud[2], Elliot Specht[2], Matthew Feldmann[3], Si Kim[3], David Larbalestier[3], Darren Verebelyi[4], Wei Zhang[4], Xi Li[4] and Martin Rupich[4]; [1]Los Alamos National Laboratory, Los Alamos, New Mexico; [2]Oak Ridge National Laboratory, Oak Ridge, Tennessee; [3]University of Wisconsin, Madison, Wisconsin; [4]American Superconductor Corporation, Westborough, Massachusetts.

Ex-situ conversion of F-containing YBa2Cu3Oy precursors is an economically attractive process for adding the superconducting layer to a coated conductor substrate. Understanding the phase conversion process and final microstructural assemblage is crucial to maximizing the superconducting properties. Each process used to build a YBa2Cu3Oy (Y-123) coated conductor creates an interface along which defects or interfacial reactions may result. These defects can be additive and propagate through the entire film structure to affect the growth and properties of the superconducting film. The effects of substrate features, buffer layers, and conversion processes of the ex-situ Y-123 films on the resulting microstructures are discussed. Interfacial reactions between the substrate, buffer layers, and Y-123 films are examined. Y-123 films produced from BaF2-based precursors deposited by e-beam evaporation or metal organic deposition (MOD) of trifluroacetates are compared in terms of their final microstructures, phase assemblage, and superconducting properties. The initial stages of processing during which phase segregation can occur, Y-123 and secondary phase development, and the degree of conversion completion in fully processed coated conductors are also examined. Implications for thick film (t > 1 micron) development and structural refinements are discussed.

4:15 PM EE2.7
Reel-to-Reel Raman Microscopy of Long-Length Coated Conductor. Victor A. Maroni[1], Kartik Venkataraman[1], Dominic F. Lee[2], Jodi Reeves[3], Martin W. Rupich[4], Wei Zhang[4] and X. Li[4]; [1]Argonne National Laboratory, Argonne, Illinois; [2]Oak Ridge National Laboratory, Oak Ridge, Tennessee; [3]SuperPower, Inc., Schenectady, New York; [4]American Superconductor, Westborough, Massachusetts.

Reel-to-reel (R2R) Raman microscopy investigations have been performed on YBCO coated conductor tapes ranging in length from one to twelve meters. Tapes formed using a variety of YBCO precursor approaches (i.e., trifluoroacetate, MOCVD, and ex situ BaF2) were examined. Several of the investigated tapes were processed using a quenched tape methodology wherein the tape is slowly rolled into a preheated furnace and then rapidly reeled back out of the furnace to create a graded Y-Ba-Cu-O phase assemblage along the length of the tape. The Raman results for these quenched tapes track YBCO phase evolution from the amorphous precursor stage, through early YBCO phase formation, through optimum YBCO development, and on into the over-heat-treated state. R2R Raman measurements on fully-processed/electrically-characterized tapes provided informative insights about the correlation between local phase composition/texture and relative critical current. The ability of Raman microscopy to (1) track YBCO c-axis texture, (2) detect intermediate and impurity phases (such as, CuO, BaF2, Ba-Cu-O compounds, and BaCeO3), (3) provide information about their location and morphology, and (4) function effectively on moving tapes suggests that Raman-based methods may be useful for in-line coated conductor process monitoring. [*Work at Argonne National

Laboratory and Oak Ridge National Laboratory was sponsored by the U.S. Department of Energy (DOE), Energy Efficiency and Renewable Energy, as part of a DOE program to develop electric power technology.]

4:30 PM EE2.8
Microstructure-Property Relationships in Thick MOCVD and PLD YBCO Coated Conductors. Michael Hatzistergos[1], Harry Efstathiadis[1], Jodi Reeves[2], V. Selvamanickam[2], Eric Lifshin[1] and Pradeep Haldar[1]; [1]School of NanoSciences and NanoEngineering, University at Albany - SUNY, Albany, New York; [2]SuperPower Inc., Schenectady, New York.

$YBa_2Cu_3O_{7-x}$(YBCO) high temperature superconducting films were grown 0.4 μm to 4.2 μm thick on buffered metal substrates by pulsed laser deposition (PLD) and metallorganic chemical vapor deposition (MOCVD). The microstructural and electrical characterization of the films was performed by focused ion beam microscopy, scanning electron microscopy, x-ray diffraction and current-voltage measurements at 77 K in self-field. As commonly reported in the literature, a decrease in the critical current density (Jc) in some MOCVD and PLD YBCO films was observed with increasing film thickness. For MOCVD films increasing in thickness from 0.5 μm to 4.2 μm, the J_c dropped from 2.9 MA/cm^2 to 0.1 MA/cm^2. Similarly, as PLD films increased from 0.4 μm to 2.0 μm, the Jc dropped from 2.5 MA/cm^2 to 0.6 MA/cm^2. The J_c decrease in the thick films was found to be related to compositional and microstructural defects that were directly observed using cross-sectional focused ion beam imaging, which revealed defects such as pores, misaligned grains and second phase particles that were confirmed by x-ray diffraction and scanning electron microscopy. However, contrary to the above observations, and in contrast to many reports in the literature, one set of PLD YBCO films did not suffer a substantial decrease in J_c with increasing thickness. In these films, the J_c of 1.0 μm, 2.0 μm, 3.0 μm, and 4.0 μm thick PLD YBCO films was 1.2 MA/cm^2, 1.1 MA/cm^2, 1.1 MA/cm^2, and 0.8 MA/cm^2 respectively. In this work we will compare and contrast the microstructural variations that caused the very different Jc dependence within and among these PLD and MOCVD YBCO films.

4:45 PM EE2.9
Coated Conductors: Phase Relations in the Ba-Y-Cu-F-O-H System. Winnie Kwai-Wah Wong-Ng[1], Lawrence P. Cook[1], I. Levin[1], M. Vaudin[1], Julia Suh[1] and Ron Feenstra[2]; [1]Ceramics, NIST, Gaithersburg, Maryland; [2]Solid State Chemistry Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

E-beam co-evaporated BaF_2-Y-Cu-precursor films on RABiTS, treated by post-annealing in the presence of water vapor, have demonstrated the potential of producing high quality, long length $Ba_2YCu_3O_{6+x}$ (Y-213) superconductors. The details of phase equilibria and the phase evolution of the Y-213 phase in the multi-component Ba-Y-Cu-F-O-H system have been an important subject of investigation in recent years. It is crucial to determine the role of liquid, specifically, whether an intermediate fluorine-containing low-temperature liquid forms, and, whether its formation plays a role in governing the formation of the Y-213 phase. We have accomplished the design and setup of the laboratory apparatus (atmospheric controlled furnaces, DTA, preparation of BaO), and sample handling procedure necessary for completing experiments in this air-sensitive system. Since the interplay of phase equilibria and kinetics is important in this system, we have investigated the melting equilibria involving Y-213 under reducing processing atmospheres, and have also employed *insitu* high temperature x-ray diffraction (HTXRD) to follow the phase formation of the Y-213 phase, starting from amorphous films supplied by ORNL. Results from study of the melting equilibria of the Ba,Y,Cu//O,F reciprocal system and subsystems, the possible role of hydroxide in low-temperature melt, and the phase formation of Y-213 films and films of the Ba,Y,Cu//O,F subsystems, as investigated using HTXRD, will be summarized.

SESSION EE3: Coated Conductors-Scale Up
Chairs: Judith Driscoll and Alexander Usoskin
Tuesday Morning, December 2, 2003
Constitution B (Sheraton)

8:30 AM *EE3.1
Progress in Coated Conductor Technology Scale Up at SuperPower. Venkat Selvamanickam, Hee-Gyoun Lee, Yijie Li, Xuming Xiong, Yunfei Qiao, Yi-Yuan Xie, Jodi Reeves, Allan Knoll, Tom Salagaj and Ken Lenseth; SuperPower, Schenectady, New York.

Coated conductor technology is being scaled up to manufacturing in the pilot-scale facilities at SuperPower. SuperPower is developing High Temperature Superconductor (HTS) deposition technologies that have been used to achieve high deposition rates. These deposition techniques are Metal Organic Chemical Vapor Deposition (MOCVD) and Pulsed Laser Deposition (PLD). An additional advantage of large deposition zone area provides MOCVD the potential of highest throughput possible among HTS deposition processes for coated conductors. Ion Beam Assisted Deposition (IBAD) is used for buffer deposition. IBAD provides the advantages of room temperature deposition and ability to use high strength, non magnetic, low loss substrates. High-strength nickel alloy substrates have been polished in lengths of 10 to 100 m with uniform surface roughness of 1 to 2 nm. IBAD buffer layers with uniform in-plane texture of 10 to 11 degrees have been fabricated in lengths of 10 m. Coated conductors with critical current performance in excess of 100 A have been demonstrated in 10 m lengths. Coated conductors produced at SuperPower show significantly better performance at high magnetic fields and at high levels of mechanical strain. These properties are important for practical use of coated conductors in several device applications. Progress has been made in developing new techniques of applying copper stabilizer and in producing narrower widths of conductor. Several unique process control and quality control tools were brought into operation for continuous process and performance evaluation of lengths of tapes at various stages of fabrication. This work was partially supported by the U.S. Department of Energy, and the U.S. Air Force through funds from DUST & AFOSR. This work was partially conducted under CRADAs with Los Alamos and Argonne National Laboratories and Air Force Research Laboratory at Wright Patterson Air Force Base.

9:00 AM *EE3.2
Commercial YBCO Coated Conductor Wire Development. Wei Zhang, Xiaoping Li, Thomas Kodenkandath, Darren Verebelyi, Urs Schoop, Cees Thieme, Marty Rupich, Ed Siegal, Nguyet Nguyen and Joe Lynch; American Superconductor Corp., Westborough, Massachusetts.

The development of the Second Generation (2G) high temperature superconducting wire has progressed past the initial stage of laboratory demonstrations and is now focused on developing and testing high critical current conductor designs required for commercial applications. YBCO wires are now being produced by AMSC in 10 meter lengths with critical currents of up to 184 A/cm-width (77K, self-field) and in short length with significantly higher critical currents. However, the operational demands of commercial HTS applications require that, in addition to a high critical current, the superconducting wire also meets stringent mechanical and electrical stability requirements which vary by application. These mechanical and electrical stability requirements can be achieved by laminating a copper foil to the YBCO tape. This architecture can provide mechanical and electrical stability properties meeting the commercial wire requirements. Results will be presented on (1) improvements in the performance of 10 meter lengths of continuously processed 2G wires (2) the fabrication and characterization of the laminated wire architecture and (3) the performance of prototype devices fabricated from the 2G wires.

9:30 AM *EE3.3
Development of Long YBCO Coated Conductor using Self-Epitaxial CeO2 Buffered IBAD in SRL Nagoya Coated Center. Yutaka Yamada[1], Takemi Muroga[1], Tomonori Watanabe[1], Hiroyuki Iwai[1], Seiki Miyata[1] and Yuh Shiohara[2]; [1]Nagoya Coated Conductor Center, ISTEC-SRL, Nagoya, Japan; [2]Devision of Superconducting Tapes and Wires, ISTEC-SRL, Tokyo, Japan.

SRL Nagoya Coated Conductor Center (NCCC) is now studying intensively long Y123 coated conductor with newly installed continuous Reel-to-Reel machines of IBAD and PLD. In this presentation, I will introduce our recent results using these machines and a new buffer layer deposition technique. i) New buffer method to a long conductor fabrication Recently we found a new phenomenon, Self-Epitaxy of PLD-CeO2 buffer, meaning that a CeO2 layer on an IBAD seed layer develops the degree of the bi-axial alignment without any help of assisting Ar ion. With this method, the deposition rate was more than 100 times faster than the conventional IBAD process. Thus, the whole wire production speed will be improved much. Up to now we obtained the highest degree around 2 degrees of CeO2 buffer on the IBAD tape substrate. This resulted in also high Jc of 4.4 MA/cm2 for PLD-YBCO coated conductors. ii) Long wire fabrication Using the above Reel-to Reel machines, we are now fabricating long IBAD tapes. Now the length reached 20m with the degree of the biaxial alignment of 10-20 degrees. In the following process using PLD, the effort for the long wire is also being carried out. PLD-CeO2 self-epitaxial layer exhibited the high production speed more than 10m/hr in this PLD Reel-to-Reel system. Our tentative results including high Jc of 2MA/cm2 and Ic of 100A for short samples indicate that the combination of (PLD +Self-Epitaxy+IBAD) methods is considered to be promising for the industrialization of YBCO coated conductor. For this purpose, we are now investigating also the possibility of the enhancement of the production rate of the

whole YBCO coated conductor. This work was supported by NEDO as collaborative Research and Development Fundamental Technologies for Superconductivity Applications.

10:30 AM EE3.4
Continuous Preparation of IBAD-MgO Templates for YBCO Coated Conductor Applications. Sascha Kreiskott, Brady J. Gibbons, Chris J. Sheehan and Vladimir Matias; Superconductivity Technology Center, LANL, Los Alamos, New Mexico.

A reel-to-reel deposition system at the Los Alamos Research Park has been used extensively for the ion-beam assisted deposition of MgO (IBAD-MgO). Subjects of our work have been both the production of longer length coated conductor templates (~10 meters) and combinatorial research on the IBAD-MgO process. The quality of the IBAD-MgO layers was analyzed by *insitu* RHEED analysis and *exsitu* x-ray diffraction. X-ray data was obtained for 100 - 200 nm epitaxial MgO layers on top of IBAD-MgO. Electropolished Hastelloy C276 tapes (1 cm width, 0.1 mm thickness) with RMS surface roughness values below 1 nm (measured by AFM on 5 x 5 μm^2) were used as substrate. Several factors have been found to have an important influence on the resulting in-plane MgO texture. Most importantly, the texture is determined by the flux-ratios of the incoming MgO vapor and the Ar ions. The higher the ion to MgO flux ratio the sharper is the achieved in-plane texture. Another very important influence comes from the amorphous Al_2O_3 and Y_2O_3 buffer and seed layers for the IBAD-MgO growth. A seed layer, such as Y_20_3, is required for the IBAD-MgO process. An additional buffer between the substrate and the seed layer increases the stability of the template during subsequent high temperature processes by preventing diffusion and reaction. In dependence of surface roughness, microstructure, and architecture of the amorphous layer stack, different growth behavior and resulting in-plane texture for fixed IBAD-MgO growth conditions could be found. With optimized deposition conditions IBAD-MgO/epi-MgO layers with in-plane texture FWHM values as low as 3° could be deposited in a continuous way on a single 6 nm thick Y_20_3 seed layer. Because a thin single seed layer provides only limited protection against cation diffusion from the substrate, a thicker amorphous Al_2O_3 buffer layer of approximately 80 nm thickness is added between substrate tape and Y_20_3 seed layer. On this stack IBAD-MgO/epi-MgO layers of several meters length with in-plane orientation FWHM values below 5° have been achieved. On the MgO templates $LaMnO_3$ buffers and YBCO were deposited using PLD. On both thin and thick buffer/seed layer architectures high J_C (>1.6 MA/cm^2, 75 K, self field) YBCO films of more than 1 μm thickness could be obtained. However, deposition conditions for YBCO were less restrictive for the use of the thicker buffer architecture. This work is funded by the Department of Energy Office of Power Technologies.

10:45 AM EE3.5
Ion-Beam-Assisted Pulsed-Laser Deposition of MgO Buffer Layers for Superconductor Coated Conductors.
Ronald P Reade and Paul Berdahl; Environmental Energy Technologies, Lawrence Berkeley National Lab, Berkeley, California.

The original Stanford process for ion-beam assisted deposition (IBAD) of biaxially-textured (001) MgO buffer layers for superconductor coated conductors has now been widely explored and further developed by Los Alamos National Laboratory and others. As this method approaches potential use in manufacturing, it is becoming very important to understand the way the process behaves in different environments. To date, most of the research on IBAD MgO has been done using electron-beam and, to a lesser extent, ion-sputtering vapor sources. We have been running experiments using pulsed-laser deposition (PLD) as the vapor generation method, and will present the results of these studies. In particular, we will point out the similarities and differences between the results by PLD and the other methods, and thereby further define the "process window" for successful (001) MgO growth.

11:00 AM EE3.6
Influence of Assisting and Sputtering Ion Beams on Films in IBAD Process. Seiki Miyata[1], Tomonori Watanabe[1], Takemi Muroga[1], Hiroyuki Iwai[1], Yutaka Yamada[1] and Yuh Shiohara[2]; [1]Nagoya Coated Conductor Center, ISTEC-SRL, Nagoya, Japan; [2]Division of Superconducting Tapes and Wires, ISTEC-SRL, Tokyo, Japan.

Since a long length and high degree of an in-plane alignment can be attained, ion beam assisted deposition (IBAD) is a promising method to fabricate a template film for YBCO coated conductors. We fabricated a 50-m long IBAD tape using reel-to-reel system and obtained 4.4 MA/cm^2 of J_c for a short YBCO sample. Despite of the excellent results, however, the mechanism of the biaxially alignment of IBAD is still unclear. The IBAD method employs dual ion beam system, where one is for sputtering a target material and the other is for assisting an alignment of a film. Off-normal incident angle of assisting beam provides an in-plane alignment in addition to an out-of-plane alignment of the film. To clarify roles of these ion beams in detail, we investigated influence of changes in the ion beam currents and voltages on film properties. Decreasing current of an assisting ion beam induced a tilting of out-of-plane axis of <100>, indicating underlying instability of crystal orientation. Without an assisting ion beam, <100> axis no longer appeared as an out-of-plane axis, but <111> axis did. Roles of ion beams for an in-plane alignment and crystallization energy of the material will be also discussed. 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.

11:15 AM EE3.7
Recent Advancements in the Chemical Solution Deposition of $YBa_2Cu_3O_{7-x}$ Coated Conductors. Jeff Dawley[1], Paul Clem[1], Michael Siegal[1], Donald Overmyer[1], James Voigt[1], Dominic Lee[2] and Fred List[2]; [1]Sandia National Laboratories, Albuquerque, New Mexico; [2]Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Chemical solution deposition (CSD) has the potential to be an economical approach for fabricating films of *c*-axis $YBa_2Cu_3O_{7-x}$ (YBCO) and buffer materials, such as ABO_3 perovskites, for coated conductor applications. However, in order for CSD to be a viable commercial process, the time required to deposit, pyrolyze, and crystallize the YBCO needs to be as short as possible, while still maintaining high quality. We previously demonstrated that a novel fluorinated solution synthesis approach, using diethanolamine (SanDEA) to control the organic decomposition, could dramatically reduce the pyrolysis time for CSD-YBCO films. In this presentation, results of integrating the SanDEA precursor onto buffered metal tapes will be discussed. Growth rate experiments show that the SanDEA precursor can be crystallized into *c*-axis YBCO at rates as high as 25 Å/sec. J_c (77K) values > 1 MA/cm^2 have been measured for ~0.25 micron thick films fabricated on Oak Ridge's $CeO_2/YSZ/Y_2O_3/Ni/Ni$-W(3%) substrates. Integration of the SanDEA precursor onto solution deposited $SrTiO_3$ buffered metal tapes, and results for 0.75+ micron thick, single coating YBCO films will also be discussed. Sandia is a multiprogram laboratory operated by Sandia Corp., a Lockheed Martin Company, for the US Dept. of Energy under contract DE-AC04-94A185000. Oak Ridge National Laboratory is managed by UT-Battelle, LLC for the United States Department of Energy under contract No. DE-AC05-00OR22725.

11:30 AM EE3.8
All-solution deposited coated conductors: defects and current limiting mechanisms. Paul Clem[1], Jeff Dawley[1], Michael P. Siegal[1], Donald L. Overmyer[1], Jacob Richardson[1], James A. Voigt[1] and Terry Holesinger[2]; [1]Sandia National Laboratories, Albuquerque, New Mexico; [2]Los Alamos National Laboratory, Los Alamos, New Mexico.

A recently-developed solution-deposition method has enabled all-solution deposition of YBCO//SrTiO3//Ni//Ni-W coated conductor composites with MA/cm2 critical current densities. This talk will summarize some of the critical features of this process, including a cataloging of defects within the YBCO and SrTiO3 buffer layer that can limit current density. In particular, we have applied high resolution transmission electron microscopy (HRTEM) and scanning electron microscopy (SEM) to samples and found grain misorientations, film porosity and high surface roughness of the SrTiO3 buffer layer to be deleterious to Jc values and YBCO microstructure. Additionally, defects within the YBCO film have been found to limit coated conductor Jc. This talk will discuss efforts to eliminate these YBCO and buffer defects in pursuit of higher critical current densities for all-solution deposited coated conductors. Sandia is a multiprogram laboratory operated by Sandia Corp., a Lockheed Martin Company, for the US Dept. of Energy under contract DE-AC04-94A185000.

11:45 AM EE3.9
Microstructures of YBa2Cu3O7-x Thick Films by Metal-Organic Chemical Vapor Deposition. Jianming Zeng[1], Penchu Chou[1], Alex Ignatiev[1], Jie Lian[2] and Luming Wang[2]; [1]University of Houston, houston, Texas; [2]University of Michigan, Ann Arbor, Michigan.

High quality superconducting YBa2Cu3O7-x (YBCO) thick films were grown on LaAlO3 (LAO) substrates by a photo-assisted metalorganic chemical vapor deposition (PhA-MOCVD) technique with a single liquid precursor delivery system. Employment of single liquid precursor delivery process is found to be much effective for PhA-MOCVD-YBCO thick film growth since the reproducibility of high quality YBCO thick films is drastically improved compared to the case of usually used separate solid precursor delivery. This strongly suggests that PhA-MOCVD with a single liquid precursor

delivery technique is promising process for the production of high quality YBCO thick films for various commercial applications. Microstructures of the prepared YBCO thick films have been investigated by scanning electron microscopy and high-resolution transmission electron microscopy. High quality of the prepared YBCO thick films were confirmed by the results of X-ray diffraction and Tc, Jc measurements.

SESSION EE4: Coated Conductors - Buffers, HTS Layers
Chairs: Terry Holesinger and Venkat Selvamanickam
Tuesday Afternoon, December 2, 2003
Constitution B (Sheraton)

1:30 PM EE4.1
Alternative Buffer Layer Architectures for YBCO Coated Conductors. Mariappan Paranthaman[1], S Sathyamurthy[1], T Aytug[1], M S Bhuiyan[1], L Heatherly[1], A Goyal[1], D K Christen[1], D M Kroeger[1], X Li[2], U Schoop[2], D T Verebelyi[2] and M W Rupich[2]; [1]Oak Ridge National Laboratory, Oak Ridge, Tennessee; [2]American Superconductor Corporation, Westborough, Massachusetts.

The main goal of our work is to research and develop faster, potentially lower cost, and simpler RABiTS buffer-layer architectures that are compatible with ex-situ BaF2 or TFA processes. Alternative to the standard RABiTS four-layer architecture of CeO2/YSZ/Y2O3/Ni/Ni-W, we have developed several architectures based on two effective potential Ni diffusion barrier layers, LaMnO3 (LMO) and La2Zr2O7 (LZO). These buffers were grown epitaxially on biaxially textured and strengthened Ni-W metal tapes by scalable vapor and/or solution techniques. We have also successfully eliminated the need for Ni over-layers using either LZO or MgO seed layers. Using the metal-organic decomposition (MOD) approach, we have developed a method to grow epitaxial CeO2 cap layers. Thick YBCO films with Ic's approaching 190 A/cm-width have been obtained on these alternative architectures and the results will be presented in detail. ---------- Research sponsored by the U.S. DOE, Division of Materials Sciences, Office of Science, Office of Energy Efficiency and Renewable Energy, Office of Distributed Energy and Electric Reliability- Superconductivity Program. Oak Ridge National Laboratory is managed by UT-Battelle, LLC for the U.S. Department of Energy under contract No. DE-AC05-00OR22725.

1:45 PM EE4.2
Microstructure of $SrTiO_3$ buffer layers and its effects on superconducting properties of $YBa_2Cu_3O_{7-\&\#948;}$ coated conductors. Haiyan Wang, Stephen R Foltyn, Paul N Arendt, Quanxi Jia, Judith L MacManus-Driscoll, Xinghang Zhang and Paul C Dowden; Superconductivity Technology Center, Los Alamos National Lab, Los Alamos, New Mexico.

A thin layer of $SrTiO_3$ has been successfully used as buffer layer to grow high quality superconducting $YBa_2Cu_3O_{7-\&\#948;}$(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° $\sim\sim$ 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. It is interesting to note 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. For example, the critical current density of YBCO films increases by a factor of two when the deposition temperature of $SrTiO_3$ buffer layer increases 100°C systematically. Detailed microstructure studies including transmission electron microscopy (TEM), scanning electron microscopy (SEM) and atomic force microscopy (AFM) were used to explore the microstructure and growth mechanisms of $SrTiO_3$ thin films deposited under different conditions and 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 and a clean and sharp interface with both MgO and YBCO, which further proves that $SrTiO_3$ can be a promising candidate as the buffer layer for high performance superconductor coatings.

2:00 PM EE4.3
Electrodeposition of textured buffer layer for YBCO Superconductor Oxide Films. Raghu Nath Bhattacharya[1], Priscila Spagnol[1], Jun Chen[1], Tolga Aytug[2], Claudia Cantoni[2], David Christen[2] and Dominic Lee[2]; [1]NREL, Golden, Colorado; [2]ORNL, Oak Ridge, Tennessee.

In this presentation we will discuss the electrodeposition of biaxially textured seed metal buffer layer for YBCO superconductor oxide films. It is well established now that to obtain superior critical current densities for YBCO superconductors we need biaxially textured crystalline substrates. One way to accomplish biaxial texturing in a superconducting material is to grow epitaxial YBCO onto biaxial textured substrates. Superconducting oxide layers cannot be deposited directly on textured metal substrates, for example Ni and Ni-W, and Cu, since superconductors interact adversely with the substrate in a manner that degrades the superconductor material, especially during the high temperatures at which the superconductor materials are deposited or processed. To overcome these adverse interactions, a buffer layer of material is deposited to form a chemical barrier between the metal substrate and the superconductor. At present we are developing biaxially textured seed metal buffer layer materials inexpensively by electrodeposition method. We are testing electroplated biaxially textured Au and Ni on textured metal tapes of NiW and Cu, and on epitaxial Cu layers on single crystal MgO and LAO. In this meeting we will discuss the epitaxial growth of electrodeposited Ni and Au on single crystal MgO/Cu and LAO/Cu and also the properties of the superconducting YBCO material prepared on these substrates.

2:15 PM EE4.4
Oxygen superstructure mediated epitaxial growth of oxide buffer layers on Ni(001). Junghoon Choi, J. E. Giencke, D. C. Larbalestier and C. B. Eom; Materials Science and Engineering, University of Wisconsin-Madison, Madison, Wisconsin.

We have investigated the surface structures of the epitaxial Ni(001) films on (001) SrTiO3 substrates as a function of gas ambient conditions (O2, forming gas, and H2O) and their effects on the epitaxial growth of oxide materials by reflection high energy electron diffraction (RHEED). Depending on the gas environment and the substrate temperature, the Ni films show three different surface structures; clean (001) Ni, c(2x2)-O superstructure, and textured NiO. The metastable oxygen c(2x2) superstructure on the Ni(001) was observed to be formed by water vapor dissociation in a forming gas environment which significantly suppresses oxidation rate at a growth temperature of 600 C. As a consequence of the c(2x2)-O superstructure, we have successfully achieved epitaxial growth of various oxide materials (SrTiO3, CaTiO3, CeO2, and Y2O3) by pulsed laser deposition (PLD). In contrast, growth on textured NiO surfaces or clean Ni surfaces produces multi-oriented films. This result is similar to the epitaxial oxide buffer layer growth on a sulfur c(2x2) reconstructed Ni surface by Cantoni et al. Details of nucleation mechanism of epitaxial oxide thin films on Ni and the thermodynamic and kinetic limitations of the c(2x2)-O surface for the epitaxial growth of various oxide buffer layers will be discussed.

2:30 PM EE4.5
MOD Approach to Grow Epitaxial CeO2 Buffer Layers on Biaxially Textured Ni-W Substrates for YBCO Coated Conductors. Md Shafiqur Bhuiyan[1,2], M Paranthaman[1], S Sathyamurthy[1], E A Payzant[1] and K Salama[2]; [1]ORNL, Oakridge, Tennessee; [2]University of Houston, Houston, Texas.

We have grown epitaxial CeO2 buffer layers on biaxially textured Ni-W substrats for YBCO coated conductors using a newly developed MOD approach. Precursor solution of 0.25M concentration was spin coated on short samples of Ni-3%W substrates and heat treated at 1100 deg. celsius in a gas mixture of Ar-4%H2 for 15 minutes. Detailed X-ray studies indicate that the CeO2 film has a good out-of-plane and in-plane texture with a full-width-half-maximum of 5.8 deg. and 7.5 deg. respectively. High temperature XRD studies show that the nucleation of CeO2 starts at 600 deg. celsius and reaches the complete crystallization at 1100 deg. celsius. Results on the properties of YBCO films grown on RABiTS architecture with CeO2 seed/cap layers will be presented.

2:45 PM EE4.6
Role of Initial Precursor State in Nucleation of Thick Ybco Films by Barium Fluoride Process. Vyacheslav Solovyov, Harold Wiesmann and Masaki Suenaga; Materials Science, Brookhaven National Laboratory, Upton, New York.

We present an experimental study of nucleation 1-5 microns thick YBCO layers on flexible metallic substrates. YBCO precursor was deposited by vacuum co-evaporation of BaF2, Y and Cu. Initial state of the precursor is proven to be important for stable c-axis growth of thick YBCO films. We believe that the way the precursor is oxidized after the vacuum deposition determines the film permeability for HF. High permeability is needed for thick films to allow for easy out-diffusion of HF, which has a significant effect on YBCO nucleation. Oxidation of yttrium metal in the precursor is important in this respect. High-temperature oxidation results in formation of dense yttrium oxide. Such a precursor has low permeability for HF and is unsuitable for the thick film growth due to extensive random grain nucleation. Low-temperature oxidation in water vapor converts yttrium metal to low-density oxy-hydroxides. This forms highly permeable precursor, which can be converted to c-axis oriented

YBCO. We report about results of controlled oxidation of the precursor and demonstrate correlation between the oxidation state and the YBCO nucleation. This work was performed under auspices of US Department of Energy under contract No DE-AC-02-98CH10886.

3:30 PM EE4.7
Properties of oblique $YBa_2Cu_3O_{7-\delta}$ artificial grain boundaries. John H. Durrell, M. J. Hogg, Z. H. Barber, B. A. Glowacki, M. G. Blamire and J. E. Evetts; Materials Science and Metallurgy, University of Cambridge, Cambridge, United Kingdom.

Low-angle grain boundaries are commonly considered as the limiting factor determining the critical current of coated conductors. Previously we have shown, that for grain boundaries in $YBa_2Cu_3O_{7-\delta}$ the critical current density, j_c, exhibits a magnetic field angle dependent cross-over from grain boundary (GB) to in-grain (IG) like behavior. This behavior has been modelled by treating the grain boundary as a weak pinning plane intersected by vortices that are strongly pinned at either end in the grain. Within a single vortex picture the current crossing the grain boundary exerts a Lorentz force on the vortex which is balanced by weak pinning in the GB and by vortex distortion due to attachment at its ends. When in-grain pinning is high j_c is determined by the force to cut a vortex line at the boundary. A cross-over occurs for low in-grain pinning or when insufficient vortices cross the grain boundary. As would be expected from such a single vortex model, the form of $j_c(\phi)$ is independent of B but dependent on T. From the model the force required to cut a vortex line has been determined as a function of T. Transport critical current measurements have been performed on $YBa_2Cu_3O_{7-\delta}$ single grain boundaries with various GB angles, and the magnetic field applied both in and away from the plane of the film. The variation of j_c has also been determined as a function of the angle between the magnetic field and the grain boundary for grain boundaries which are not perpendicular to the direction of current flow. As in the case of perpendicular grain boundaries j_c is found to be strongly suppressed only when the applied magnetic field is within an angle ϕ_k of the grain boundary. This angle is as small as 10° at 8 T and 75 K. The minima in the observed $j_c(\phi)$ behavior is always symmetrical. This means that in the grain boundaries studied the current flow is 'perpendicular' to the grain boundary in the angular range for which the GB properties dominate. This observation implies that the $j_c(\phi)$ behavior that would be observed for in-plane fields in coated conductors will differ depending on whether current flow is IG or GB limited.

3:45 PM EE4.8
Power Law Analysis of Critical Current Measurements of YBCO Coated Conductors. Yates Coulter, Superconductivity Technology Center, Los Alamos National Laboratory, Los Alamos, New Mexico.

Our coated conductor development effort utilizes research, development and characterization of small samples to provide directions for our 1cm wide by 1 meter plus long sample fabrication effort. Small coated conductor bridges (~1cm long by ~0.02cm wide) are fabricated, and their critical currents, Ics, are measured as a function of temperature, applied magnetic field B, and field angle,F. The V (I) curves are fitted by a power law to determine the exponent, N. Meter long coated conductor samples are routinely characterized for self-field Ic and then for Ic homogeneity as a function of position. On these long samples, we find that the N value is an increasing function of the critical current. While there is good correlation between N values derived from analysis of V (I) curves measured on small bridges and on the larger coated conductor tapes, Ic (B, F) measurements demonstrate that N values calculated from V (I) curves taken as a function of applied field angle,F, are not simply a unique function of the critical current. When N vs Ic(F, T=75K, B={0-7T}) is plotted, two distinct functions emerge, one for N (B ——ab), the other N B ——c-axis with data spanning the difference between the curves. These results suggests a transition between dissipation mechanisms occurring when B is parallel to the c-axis and B is parallel to the ab plane and is consistent with the existence of an angular dependent irreversibility line, which is highest for B——ab and lower for B——c-axis. We present results of Ic and N values for small bridges on metal and single crystal substrates and on large 1cm wide tape coated conductors. From the comparison of these results we obtain information on the relevant pinning mechanisms in these different types of samples.

4:00 PM EE4.9
Comparative Study of the Through-Thickness J_C in Two *ex – situ* MOD YBCO Coated Conductors, one with Exceptional Performance. Sang Il Kim[1], David M. Feldmann[1], David C. Larbalestier[1], Darren T. Verebelyi[2], Wei Zhang[2] and Terry G. Holesinger[3]; [1]Applied Superconductivity Center, University of Wisconsin - Madison, Madison, Wisconsin; [2]American Superconductor Corporation, Westborough, Massachusetts; [3]Los Alamos National Laboratory, Los Alamos, New Mexico.

Recently *exsitu* metal-organic deposition (MOD) processed YBCO films on RABiTS (NiW) have developed exceptional properties with critical currents per unit width reaching a value of 270 A/cm. We have used ion milling to compare the through-thickness performance of this conductor to an earlier 120 A/cm conductor. We find that both conductors show a rising J_c with decreasing thickness and that the higher I_c conductor attains a J_c value of 4 MA/cm^2 below 0.3 μm thickness. The J_c values of the lower I_c conductor are about half the higher I_c conductor, but the normal state resistivities are equal. The data will be discussed in terms of their through-thickness microstructure and properties. It is clear that this performance is extremely promising for commercial coated conductor performance.

4:15 PM EE4.10
Transport properties and J_c-simulation of high J_c coated-conductors. Bernhard Holzapfel, Jens Haenisch, Kerstin Demmler, Laura Fernandez, Aarti Singh, Vadlamani Sarma and Joerg Eickemeyer; Institute of Metallic Materials, IFW Dresden, Dresden, Germany.

RABiTS based coated conductor samples were used to investigate the influence of the low angle grain boundary network on the temperature and magnetic field dependence of the critical current density and IV-characteristics. YBCO layers with critical current densities >1 MA/cm^2, prepared on the same template via chemical solution based deposition and by standard pulsed laser deposition (PLD) were compared. The transport properties show clear crossover behaviour between inter- and intragranular Jc-limitation. The underlying grain boundary network of the samples was quantitatively characterized by Electron Backscattering Diffraction (EBSD) mappings. Jc-simulations using a fast and simple limiting-path algorithm were used to investigate the influence of the grain boundary misorientation statistics on Jc in these samples. Due to the limitation of the critical current density Jc by grain boundaries and the percolative current flow through a statistical network of grain boundaries, Jc depends strongly on width and length of the sample area under consideration. This effect is investigated using large EBSD maps and will be compared to existing pure statistical approaches.

4:30 PM EE4.11
Angular dependence of critical current in $DyBa_2Cu_3O_7$ films with naturally grown inclined correlated defects.
Boris Alfredo Maiorov, J. Y. Coulter, J. O. Willis, A. Serquis, Q. X. Jia and L. Civale; Superconductivity Technology Center, Los Alamos National Laboratory, Los Alamos, New Mexico.

We present measurements of the angular dependence of the critical current density (J_c) in $DyBa_2Cu_3O_7$ films as a function of magnetic field and temperature. We found evidence of the presence of two types of naturally grown correlated disorder, one parallel to the c axis and one inclined by a few degrees with respect to it. Each type of defect produces a peak in the angular dependence of J_c with its own characteristic field and temperature dependence. The c-axis peak is more prominent at lower temperatures and higher fields, while the inclined defects are stronger at higher temperatures. The maximum of the inclined peak shifts away from the c axis as the field is lowered due to a misalignment between the internal and applied magnetic fields. We studied films of different thicknesses and compared their properties with those of typical $YBa_2Cu_3O_7$ films

4:45 PM EE4.12
Magneto-Optical Imaging of Flux Pinning Characteristics in YBCO Thick Films Grown by PLD and BaF_2 ex-situ Processes. Qiang Li[1], Zuxin Ye[1], Masaki Suenaga[1], Yimei Zhu[1], Vyacheslav Solovyov[1], Weidong Si[1] and Stephen R Foltyn[2]; [1]Brookhaven National Lab, Upton, New York; [2]Los Alamos National Lab, Los Alamos, New Mexico.

Magneto-optical imaging (MOI) techniques were used to investigate the flux pinning characteristics in the YBCO thick films growth by either BaF_2 ex-situ post-reaction process on $SrTIO_3$ (STO) substrates or by pulsed laser deposition (PLD) on $LaALO_3$ (LAO) or STO substrates. A uniform pattern of flux penetration and trapping was observed in the PLD films on either LAO or STO substrates. A tree branch pattern of flux penetration and trapping was observed in BaF_2 ex-situ processed films. The branching scale is in the order of tens of micron. Despite this remarkable difference, the averaged value of critical current density for all these films obtained by both the MOI and bulk magnetization measurements is similar. The MOI results suggest that the additional disorder unique to BaF_2 films affects the local critical current distribution, but is likely much larger than the coherence length of YBCO, which does not change the intrinsic pinning of YBCO. *This work was supported by the U. S. Department of Energy, Division of Materials Sciences, Office of Basic Energy Sciences under contract No. DE-AC02-98CH10886.

SESSION EE5: Poster Session: Conductors and MgB2
Chairs: Victor Maroni and Marijn Oomen
Tuesday Evening, December 2, 2003
8:00 PM
Exhibition Hall D (Hynes)

EE5.1
Pulsed electron beam deposition of $YBa_2Cu_3O_{7-\delta}$ thin films. Ram Janay Choudhary[1], S. R. Shinde[1], S. B. Ogale[1], V. N. Kulkarni[1], T. Venkatesan[1], K. S. Harshavardhan[2] and Mikhail Strikovski[2]; [1]Center for Superconductivity Research, University of Maryland, College Park, Maryland; [2]NEOCERA, Inc., Beltsville, Maryland.

Thin films of $YBa_2Cu_3O_{7-\delta}$ (YBCO) are grown on (001) $LaAlO_3$ substrates by pulsed electron deposition (PED). This technique is based on channel-spark discharge system with magnetically self-focused electron beam. Parameters such as discharge voltage and background pressure have been optimized for the growth of high quality YBCO films. The films grown under optimized conditions are found to be highly c-axis oriented and exhibit good in-plane alignment as observed in the x-ray diffraction (XRD) ϕ-scan. The rocking curve full width at half maximum for the (005) peak is 0.4 degree compared to that of the substrate of 0.3 degree. The surface of the films is smooth, with the RMS roughness of $\sim$ 5 nm. For a 100 nm thick films, the measured critical current density (J_C) is about 14.8 and 0.9 MA/cm^2 at 4K and 77K respectively. Various issues such as the angular distribution of the composition profile, surface morphology of the film, variation in J_C with thickness of YBCO, variation in composition of the film with changes in the growth conditions will be discussed. The results are compared with those for films grown by pulsed laser deposition. Work Supported by Maryland Industrial Partnership (MIPS) program.

EE5.2
Using High Speed Imagery During The Pulsed Laser Deposition Of YBa2Cu3O7-x to Identify Key Process Control Parameters. Carl J Druffner and Glen P. Perram; Department of Engineering Physics, Air Force Institute of Technology, Wright-Patterson Air Force Base, Ohio.

Optical signatures from the pulsed laser deposition (PLD) of YBa2Cu3O7-x (YBCO) superconducting films may be used for the process control required to produce long lengths of coated conductors. An intensified, gated CCD camera has been used to observe the PLD plume propagation dynamics with high spatial (200 micron) and temporal (50 ns) resolution. Plume imagery, with 100s of video frames per plume movie, have been obtained with several band pass filters to restrict the emission to various components of the plume, including Ba, Cu, Y, O, and YO. The plumes are highly forward peaked, with a $\cos^n(\theta)$ angular distribution where n = 50 - 1000, depending on the propagation distance and time. The dependence of the forward peaking on laser fluence, oxygen pressure, plume expansion time, and emitting specie has been characterized. Most significantly, a strong correlation has been identified between the difference in copper and barium angular distributions and the critical currents of the deposited films. Plume images may also be analyzed to characterize the time-of-flight speed distributions. The width of the speed distributions exhibits a minimum as a function of oxygen pressure for conditions where the best films are typically achieved.

EE5.3
Partitioning of energy among translational, electronic, and vibrational states during the pulsed laser deposition of $YBa_2Cu_3O_{7-x}$. Patrick D Kee and Glen P Perram; Department of Engineering Physics, Air Force Institute of Technology, Wright-Patterson AFB, Ohio.

Excimer laser ablation of $YBa_2Cu_3O_{7-x}$ targets at 1-2 J/cm^2 yields highly excited atoms, with less than 1% of the laser beam energy required for vaporization. Emission time-of-flight spectra establish kinetic energies of 10-50 eV and emission spectra indicate electronic state distributions of 1,000-10,000 K. The plumes remain collisionally dynamic even at high background pressures and low laser beam energy. For example, the temperature of the spin-orbit split Ba I ($^3D_{1,2,3}$ states is 1100 $\pm$ 400 K), whereas the temperature derived from Y I ($^2D^\circ$, $^4F^\circ$) is much higher, 8000 $\pm$ 1000 K. The plume components retain high electronic temperatures and significant ionization, even at laser beam energies near threshold for plume emission. The time-of-flight spectra exhibit plume splitting at oxygen background pressure above 1 Torr, with the fast component increasingly intense at higher pressures. A systematic characterization of the time-of-flight and emission spectra has been conducted to aid process control in the manufacture of long lengths of superconducting YBCO wires

EE5.4
Measurement of HF Partial Pressure during the BaF_2 Process. Masateru Yoshizumi and Michael J Cima; Massachusetts Institute of Technology, Cambridge, Massachusetts.

The BaF_2 process is one of the commonly used processes for deposition and growth of highly oriented YBCO films since they are highly textured and achieve high values of Jc. Recently, it has been clarified that the removal of HF gas from the film surface controls YBCO growth. The partial pressure of HF gas (P_{HF}) is quite important either to improve the process or to understand the thermodynamics of the process. There is no experimental determination of this partial pressure and the thermodynamic stability of the solid phases is not sufficiently accurate for its estimate. A new method was developed for the P_{HF} measurement in equilibrium with MOD-derived YBCO films during processing. A Knudsen cell is used to measure the vapor pressure. The method can accommodate the small P_{HF} by quenching specimens and measuring fluorine content by a fluorine selective electrode. This approach offers far greater precision that the traditional mass measurement. YBCO precursor films on LAO single crystals were placed in a small ceramic cell covered with a plate. A precision hole has been fabricated in the plate. The cell assembly heated for a specified time in a furnace under appropriate atmosphere. Quenching the cell is followed by residual fluorine measurement. The P_{HF} in the cell can be obtained by difference between samples from different time points. Results of these studies have been used to determine the free energies of relevant reactions.

EE5.5
Substrate Planarization Studies On IBAD Substrates. Srinivas Sathiraju[1,5], John P Murphy[2,5], Angela L Campbell[3,5], Lyle B Brunke[4,5] and Paul N Barnes[5]; [1]National Research Council, Air Force Research Laboratory, Wright Patterson Air Force Base, Ohio; [2]University of Dayton Research Institute, Air Force Research Laboratories, WPAFB, Ohio; [3]MLPJE, Air Force Research Laboratories, WPAFB, Ohio; [4]UES, Inc., Air Force Research Laboratories, WPAFB, Ohio; [5]Propulsion Research and Power Generation Branch, Air Force Research Laboratory, Wright Patterson Air Force Base, Ohio.

To achieve high critical currents in second generation superconductors deposited on metallic substrates, substrate average roughness and texture of the buffer layer are key factors. Especially while depositing buffer layers using ion beam assisted deposition (IBAD), the substrate smoothness is key for obtaining good texture of the buffer layers. However, there are no systematic studies reported on the substrate planarization to the best of our knowledge except for a limited study by Los Alamos National Laboratory. In this paper, planarization of ion beam assisted deposition (IBAD) substrate and deformation textured substrated (RABiTS) is presented using an inductively coupled radio frequency (rf) discharge operating at 13.56MHz. The inductively coupled discharge system was constructed using a pancake coil antenna. Linearized substrates were created by exposure to an Ar discharge for varying time periods. Inconel, Hastealloy, and textured Ni substrates have been studied under varying RF plasma conditions, such as pressure, RF power and etch time to determine the effects on substrate roughness. Results will be presented on the planarization effects on the substrate and subsequent buffer/YBCO layers using an etch process. Plasma planarization conditions will be presented with respect to surface roughness also.

EE5.6
Textured copper metallic substrates for second generation high temperature superconductors. Nicholas A. Yust[1,2], Rama M. Nekkanti[3,1], Lyle B. Brunke[3,1], Paul N. Barnes[1] and Raghavan Srinivasan[2]; [1]PRPG, Air Force Research Laboratories, WPAFB, Ohio; [2]Mechanical and Materials Engineering, Wright State University, Fairborn, Ohio; [3]UES, Inc., Air Force Research Laboratories, Dayton, Ohio.

High current densities are now routinely obtained in coated YBCO conductors deposited on textured nickel and nickel alloy substrates. An alternate substrate that is non magnetic (for low AC losses) and highly conductive (for thermal and electrical quench protection) is preferable for many practical applications. Textured metallic substrates based on copper may provide such an alternative that meets these requirements. In our work, highly textured metallic copper substrate tapes were produced using the rolling-assisted biaxially textured substrate (RABiTS) process. This technique incorporates cold rolling and subsequent recrystallization resulting in excellent in-plane as well as out-of-plane alignment. Results will be presented on the texture development behavior of copper subjected to various deformation levels and recrystallization heat treatments. X-ray diffraction was performed to gauge the quality of in-plane and out-of-plane texture in copper and the Phi Scan FWHM indicated in-plane macro-texture orientations as low as 5°. Orientation Imaging Microscopy analysis will be included in addition to preliminary results

on depositing buffers layers and the subsequent YBCO film.

EE5.7
Fabrcation of YBCO Film onCeO_2 Capped IBAD Layer. Tomonori Watanabe[1], Hiroyuki Iwai[1], Takemi Muroga[1], Seiki Miyata[1], Yutaka Yamada[1] and Yuh Shiohara[2]; [1]Nagoya Coated Conductor Center, ISTEC-SRL, Nagoya, Japan; [2]Division of Superconducting Tapes and Wires, ISTEC-SRL, Tokyo, Japan.

$YBa_2Cu_3O_{7-\delta}$ (YBCO) deposition on CeO_2 capped Ion-Beam Assisted Deposition (IBAD) substrate has been studied for the fabrication of coated conductors. The CeO_2 cap layer, which was deposited on the IBAD Gd-Zr-oxide (GZO) layer using pulsed laser deposition (PLD), showed high grain alignment with $\Delta\phi$ (full width at half maximum from X-ray ϕ-scan) below 10 degrees. YBCO layer was deposited by PLD. In a short samples, we obtained the highest critical current density (Jc) of 4.4MA/cm^2 for 0.4μm thick YBCO film and high critical current (Ic) of 276A/cm for 1.2μm thick one. The continuous deposition system, which was mainly constructed by the high power laser equipment and reel-to-reel substrate transfer system, has been developed for the fabrication of long coated conductors. We obtained high Jc of 0.96MA/cm^2 at 77K in the continuously deposited YBCO films on the CeO_2 capped IBAD-GZO layers as well as those in short samples. In order to prepare longer and high Ic coated conductors, we have been investigating the influence of YBCO film deposition rate and thickness on Jc and Ic. These influences and our progress in several m-length coated conductor preparation 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.

EE5.8
Development of Y-Ba-Cu-O Coated Conductor Using Aerosol Assisted Chemical Vapor Deposition Approach. Daniel Fisher, Manisha Rane, Harry Efstathiadis and Pradeep Haldar; School of NanoSciences and NanoEngineering, University at Albany - SUNY, Albany, New York.

A non-vacuum method of producing high temperature superconducting $YBa_2Cu_3O_{7-x}$ films on $SrTiO_3$ (STO) substrates using an Aerosol Assisted Chemical Vapor Deposition (AACVD) process is being implemented. Efficient AACVD is desirable in YBCO superconductor development due to its high film growth rate and low cost. Two different aerosol generation processes have been investigated. Stoichiometric solutions of Y, Ba, and Cu nitrates were used as the aerosol source delivered by a controlled flow rate. Film depositions were performed at the substrate temperature range of 800 °C to 900 °C in atmospheric pressure for a variable duration of time depending on the desired film thickness. Microstructural, chemical, and electrical characterization of the films was performed by x-ray diffraction (XRD) spectroscopy, plan view scanning electron microscopy (SEM), energy dispersion spectroscopy (EDS), focused ion beam (FIB) microscopy, and current-voltage (I-V) measurements in self-field at 77 K. Film composition depth profiling was performed by Auger electron spectroscopy (AES). Film thickness and composition uniformity have been found to change with varied substrate temperature and inert gas delivery flow rate.

EE5.9
Growth of YBCO films on RABiTS in the partial pressure using the BaF_2 ex-situ process. Jaeun Yoo[1], Keith J Leonard[1], Dominic F Lee[1], Huey S Hsu[1], Lee Heatherly[1], Fred A List III[1], Noel A Rutter[2], Mariappan P Paranthaman[1] and Donald M Kroeger[1]; [1]Metals and Ceramics, Oak Ridge NAtioanl Laboratory, Oak Ridge, Tennessee; [2]Materials Science & Metallurgy, University of Cambridge, Cambridge, Pembroke, United Kingdom.

YBCO films are grown on NiW RABiTS in the range of total pressure 50-80 Torr using BaF_2 ex-situ process. We investigate effects of post annealing parameters on transport properties of YBCO films using 0.3 -1 μm precursor films. For 0.3 μm films, the highest J_C value of 2.6 MA/cm^2 was obtained under the conditions of P_{total}=55 Torr, T_S=740°C. For thicker precursor, mainly, water vapor pressure is modified in order to achieve high I_C value. For 0.8 μm films, J_C value of 1.4 MA/cm^2 was obtained.

EE5.10
Growth of high quality, epitaxial TiN seed layers on RABiTS. Jaeun Yoo[1], Amit Goyal[1], Sukil Kang[1] and Noel Rutter[2]; [1]Metals and Ceramics, Oak Ridge NAtioanl Laboratory, Oak Ridge, Tennessee; [2]Materials Science & Metallurgy, University of Cambridge, Cambridge, Pembroke St, United Kingdom.

We investigate the experimental parameters for growth of high quality, epitaxial TiN thin films directly on NiW, Ni/NiW, Cu-RABiTS using RF sputtering as a function of RF sputtering power, substrate temperature and the N_2/Ar ratio used. RF sputtering power P_{RF} was varied bewteen 25 and 200 W, the substrate temperature T_S was varied between 350 and 700 °C, and the N_2/Ar ratio of processing gas was varied between 0 and 1. The crossover from (111)-oriented grains to (002)-oriented grains of TiN thin films occurred as T_S increased for NiW substrate while for Cu substrate, crystalline orientation changed from (002) to (111) with increase in deposition temperature. For the in plane texture, 0°-and 45°-rotated grains are competing according to growth condition due to large lattice mismatch (lattice constant a0 for TiN 4.24 Å, for Ni 3.52 Å, Cu 3.61 Å). TiN thin films on NiW are grown biaxially textured for the conditions of higher P_{RF} (> 100 W) and higher T_S (> 600 °C) with certain ratios of N_2/Ar gas. We demonstrate YBCO films with high I_C values using the buffer structure of TiN/MgO/$LaMnO_3$.

EE5.11
YBa2Cu3O7-δ Thin Film Growth by Post-deposition Processing of Precursors at Very Low Oxygen and Water Pressures. Yifei Zhang[1,2], Ron Feenstra[1], James R Thompson[1,2], Albert A Gapud[1], Tolga Aytug[1] and David K Christen[1]; [1]Oak Ridge National Laboratory, Oak Ridge, Tennessee; [2]The University of Tennessee, Knoxville, Tennessee.

YBa2Cu3O7-δ (YBCO) epitaxial films of thickness 0.1-1.0μm were grown on single crystal substrates using ex-situ post-deposition processing in which e-beam co-evaporated BaF2 precursors and TFA precursors were annealed in a low-pressure gas mixture of oxygen and water vapor. The partial pressures of oxygen (PO2) and water vapor (PH2O) are as low as 10mTorr and 0.1mTorr, respectively. X-ray diffraction and SEM inspection were conducted for structure characterization of the films. The effects of water vapor pressure as well as other processing parameters on film microstructure and properties were investigated. High critical current densities (Jc) of ~3.6 MA/cm2 at 77K in self-field were achieved, yielding properties comparable to those of the best in-situ films and ex-situ films from similar precursors processed under normal atmospheric pressure condition. This research is sponsored by the U.S. Department of Energy under contract DE-AC05-00OR22725 with the Oak Ridge National Laboratory, managed by UT-Battelle, LLC.

EE5.12
Monofilamentary dysprosium doped Bi-2212 superconducting tapes produced by a melt-textured growth process under an external 1T magnetic induction from a gel-like precursor on nickel substrate. Marcel Ausloos[2], Sebastien Rahier[1], Nicole Fonder[1], Jean-Francois Fagnard[3], Philippe Vanderbemden[3] and Rudi G. Cloots[1]; [1]Chemistry Department, University of Liege, Sart-Tilman, Belgium; [2]Physics Department, University of Liege, Sart-Tilman, Belgium; [3]Electricity Department, University of Liege, Sart-Tilman, Belgium.

Dysprosium doped Bi-2212 superconducting tapes have been produced by a melt-textured growth process under an external 1T magnetic induction. Nickel substrates have been preferred due to the chemical compatibility between NiO and the Bi-2212 liquid phase at high temperature. 2201 secondary phases are produced during the melt-textured growth process following the peritectic decomposition of the Bi-2212 phase. Annealing under different atmospheres has been tested in order to favour the peritectic recombinaison of 2201 and the residual liquid phase. Superconducting properties have been measured to determine the best conditions for producing an optimized material. Mechanism for recombination through the peritectic temperature by annealing has been studied on bulk specimens. Microstructural data confirmed the complex chemistry of this material.

EE5.13
Abstract Withdrawn

EE5.14
Measuring the Hole State Anisotropy in MgB2 by Electron Energy-Loss Spectroscopy. Robert Friedrich Klie[1], Yimei Zhu[1], Guenter Schneider[3] and Johan Tafto[2]; [1]Materials Science, Brookhaven National Laboratory, Upton, New York; [2]Department of Physics, University of Oslo, Oslo, Norway; [3]Institute fuer Allgemeine Physics und Center for Computational Materials Science, Technische Universitaet Wien, Wien, Austria.

We have examined polycrystalline MgB2 by high-resolution electron energy loss spectroscopy (EELS), multiple-scattering and density of state calculations. In particular, we have studied two different crystal orientations, [110] and [001] with respect to the incident electron beam direction, and found significant changes in the near-edge fine-structure of the B K-edge. Density functional theory suggests that the pre-peak of the B K-edge core loss is composed of a mixture of pxy and pz hole states. The EELS results were obtained using the JEOL 3000F and the JEOL 2010F operated at 300kV and 200kV, respectively, and a VG HB501 operated at 100 kV, equipped with a

spherical aberration corrector. We will show that the individual contributions in the B K-edge pre-peak can be distinguished only in the VG HB501 with an experimental energy resolution better than 0.5 eV. For conventional TEM/STEM instruments with an energy resolution of ~1.0 eV the pre-peak still contains valuable information about the local charge carrier concentration that can be probed by core-loss EELS. By considering the scattering momentum transfer for different crystal orientations, it is possible to analytically separate pxy and pz components from of the experimental spectra. Direct measurements of the pxy-charge carrier concentration with a sub-nanometer accuracy will then be possible. Further, the effects of anion and cation doping on the charge carrier can be analyzed using the techniques described in this paper and possible pinning centers in this newly discovered superconductor can be identified directly. With careful experiments and analysis, EELS can be a unique tool measuring the superconducting properties of MgB2, doped with various elements for improved transport properties on a sub-nanometer scale. This work is supported by the U.S. Department of Energy, Division of Materials Sciences, Office of Basic Energy Science, under Contract No. DE-AC02-98CH10886.

EE5.15

Fabrication of MgB2 Conductors by Hot Rolling.

Harry New Jones, Chia R. Feng, Michael Osofsky and Khershed P. Cooper; Code 6325, Naval Research Laboratory, Washington, District of Columbia.

Steel sheathed MgB2 rods having a dense, well-connected, core have been fabricated using a hot rolling technique. The starting materials consist of powdered boron and magnesium granules which are packed inside a 19 mm diameter thick walled tube with a 6.3 mm diameter bore. The tube is sealed by pressing in a steel plug to compact the charge and then arc welding to produce an airtight seal that can survive plastic deformation. The steel tube is heated to 900 C and hot rolled with a diamond grooved rolling mill through several passes and reheats until a 90% reduction in area is achieved. The hot rolled rod is then allowed to cool slowly from 900 C inside a furnace. The resulting 2 mm dimater MgB2 core appears, on a metallographic basis, to be dense and well connected. Resistivity and transition temperature measurements on a sample of the MgB2 core extracted from the sheath indicate a low resistivity with a sharp transition. This experiment demonstrates that a useful MgB2 superconductor geometry can be produced using the combination of an in situ synthesis reaction coupled with simultaneous hot deformation.

EE5.16

Intergranular Nanostructure and Possible Spinodal Decomposition in Low Resistivity Bulk MgB2 with Varying Critical Fields. Xueyan Song, Valeria Braccini and David Larbalestier; Applied Superconductivity Center, University of Wisconsin-Madison, Madison, Wisconsin.

Three electromagnetically well-characterized bulk samples with resistivities at 40K varying from 1 to 18 $\mu\Omega$cm were investigated by conventional and high-resolution transmission electron microscopy. Clean, coherent or semi-coherent grain boundaries and dirty grain boundaries wetted by amorphous phases were found in all three samples, even though the starting sample A had the very low resistivity characteristic of clean-limit samples of 1 $\mu\Omega$cm at 40K. Taking account both of porosity and the wetted grain boundary density reduces ρ(40K) to ~0.5 $\mu\Omega$cm. Additional samples B and C generated by exposing sample A to Mg vapor had ρ(40K) of 14 and 18 $\mu\Omega$cm. Intragranular nanoprecipitates indexed from the electron diffraction rings as MgB7 with a size of 1-5 nm were observed in local areas of the 1 and 18 $\mu\Omega$cm samples. Because the starting samples was found to be Mg-deficient by 2 separate measurements, we propose that nano-precipitates form by a reaction such as Mg1-xB2 going to MgB2 +y MgB7. The possibility of this being a spinodal reaction is discussed.

EE5.17

Artificail Pinning Technology and Nano Structure Engineering for High Jc Superconducting Films.

Kaname Matsumoto[1,6], Masashi Mukaida[2,6], Yutaka Yoshida[3,6], Ataru Ichinose[4,6] and Shigeru Horii[5,6]; [1]Dept. of Materials Science and Engineering, Kyoto University, Kyoto, Japan; [2]Dept. of Electrical and Information Engineering, Yamagata University, Yonezawa, Japan; [3]Dept. of Energy Engineering and Science, Nagoya University, Nagoya, Japan; [4]Dept. of Electrical Physics, CRIEPI, Tokyo, Japan; [5]Dept. of Superconductivity, University of Tokyo, Tokyo, Japan; [6]CREST, JST, Tokyo, Japan.

Jc of the superconductors is determined by the vortex pinning and it does not exceed depairing current density Jd. Very high Jc values (4.2 K, 5 T), namely 5-10 % of Jd, have been reported so far in the optimized NbTi superconducting wires. HTS materials (Bi2223, YBCO, etc.) have large Jc such as 0.3-3 % of Jd in the 4.2 K vicinity and the magnetic fields. However, these are decreased to 0-0.3 % of Jd at 77 K and 5 T. The effect of crystalline anisotropy and the thermal fluctuation in HTS are indicated as the main reasons of Jc suppression. Simultaneously, it should be noted that the lack of the effective pinning centers of HTS in the 77 K vicinity is also the big cause. For drastic improvement of Jc, we are investigating a novel technology by means of a nano structure engineering to introduce artificial pinning center (APC) into HTS, such as RBCO films (R=Y, Sm, Nd, etc.). If crystal defects, which can be utilized as APC, are classified in the dimensionality, there are one-dimensional, two-dimensional, and three-dimensional APC's such as dislocations, grain boundaries, fine precipitates, etc. in HTS films. It is necessary for the APC technology that the optimum spatial arrangement and distribution of APC's are designed theoretically and they are introduced into HTS films with the thin film technology. We are trying to introduce APC's in HTS films by a nano fabrication, growth and composition controls of the films, etc. Recently Jc of 0.2 MA/cm2 (77 K, 5 T, B//c) has been achieved in HTS films by APC introduction. This is the value of several times higher than those of conventionally prepared HTS films, and it approaches Jc of 0.3 MA/cm2 (4.2 K,5 T) of practical NbTi superconductors.

EE5.18

Route Into Room-Tc Superconductivity on Base of Resonant Coupling Effect In 2D Crystals ff MgB2-Type Nanotubes.

V. Vladimir Pokropivny, tHEOR.MAT.SCI., Inst.Problems Materials Science of NAsu, Kiev, Ukraine.

Superconducting properties of nanotubes (NTs) are reviewed. Theoretical requirements for ideal room-Tc superconductor (RTSC) point out on two-dimensional (2D) crystals built from noncarbon NTs of superconducting bulk material as the ideal media. Combining Little's and Ginzburg's ideas with recent progress in NTs research, the 2D lattice of superconducting noncarbon NTs was shown to be as unique quantum macroscopic crystal and ideal RTSC [1,2]. Coherent low-attenuated circular-mode vibrations provide ideal conditions for Cooper pairing and Bose-Einstein condensation. However a fabrication of such crystals is a very difficult technological problem due to complex composition of YBaCuO, etc. Superconductivity in new simple MgB2 compound with Tc 39 K is analyzed. The puzzle of it is hidden in it two-gap two-phonon mechanism on base of E2g-mode. Novel joint model of a nanotubular multi-phonon multi-gap room-Tc superconductivity is suggested on base of whispering gallery of circular zero-points phonon modes (twistons, rotons), in particular E2g-mode, resulting to resonant electron-phonon coupling. It is in accordance with some recent experimental data confirming the effect of nanotubular superconductivity and indicating on possible RTSC with Tc=400 K in 2D bundles of C-NTs. Novel route is advanced to fabricate such RTSC on base of 2D crystals built from simple MgB2, NbSe2, Bi, Sn or other superconducting nanotubes. 1. V.V. Pokropivny. J.Superconductivity 13, 607 (2000). 2. V.V. Pokropivny. Physica C 351, 71 (2001).

EE5.19

Correlation of Local Magneto-optical Measurements of Critical Current Density to Microstructure in Polycrystalline Superconductors.

Szuya Liao[1,2], Eric E Hellstrom[1,2] and David C Larbalestier[1,2]; [1]Applied Superconductivity Center, University of Wisconsin-Madison, Madison, Wisconsin; [2]Department of Materials Science and Engineering, University of Wisconsin-Madison, Madison, Wisconsin.

Crucial to significant application of large-scale superconducting electric devices for power industry is the development of wires with high critical current densities (J_c) at temperature where cryogenic losses are tolerable. In a state-of-art overpressure processed Ag-sheathed $(Bi,Pb)_2Sr_2Ca_2Cu_3O_x$ monocore conductors with self-field bulk transport $J_c \sim 48$ kA/cm^2 at 77 K, large variations of local J_c were observed and the local J_c can be as high as 5 times the bulk transport J_c, indicating that current percolates through polycrystalline conductors and the local fraction of current-carrying cross-section is significantly less than unity. Therefore, fully exploiting the fundamental current-carrying capability of polycrystalline superconductors requires an understanding of the correlation of local J_c to microstructure. In our present work we obtain a 2D map of the critical current density J_c distribution over a polished cross section of a superconductor in slab geometry by quantitative magneto-optical imaging (MOI) of flux distribution together with a model-independent determination of the corresponding current distribution, and use backscattered-SEM imaging and EDS mapping to define the microstructure and phase balance. The spatial correlation between the images is established by using the registration marks cut by focused ion beam (FIB). In this work, we will evaluate the spatial resolution of each technique and justify the correlation precision between local magneto-optical measurements of J_c and microstructure in polycrystalline superconductors.

EE5.20
Interaction of MgB_2 with Atmospheric Contaminants, and its Effect on Properties. Lawrence P. Cook[1], Ralph Klein[1], Winnie Wong-Ng[1], Edgar S. Etz[1], Raquel A. Ribeiro[2] and Paul C. Canfield[2]; [1]NIST, Gaithersburg, Maryland; [2]Iowa State University, Ames, Iowa.

Vapor pressure and enthalpy of solution measurements have been completed on several different samples of MgB_2, from different sources. One explanation of the differences in results among the samples has to do with their preparation, handling and storage. We have compared materials handled only under glovebox conditions with others exposed to air. To investigate the effect of interaction of MgB_2 with water vapor, samples have been exposed to high humidity and characterized calorimetrically, thermogravimetrically, and by x-ray powder diffraction and Raman. Effects due to reaction with atmospheric CO_2 and O_2 are also being investigated. Results of mearuement before and after exposure will be presented and compared, and discussed with regard to equilibria in the system Mg-B-O-H-C.

EE5.21
Hysteresis in the Transport Critical Current of Coated Conductors: Analysis of Intra- and Inter-grain J_c. Albert A. Gapud[1], J. R. Thompson[2,1], H. J. Kim[1], R. Feenstra[1] and D. K. Christen[1]; [1]Oak Ridge National Laboratory, Oak Ridge, Tennessee; [2]Department of Physics, University of Tennessee, Knoxville, Knoxville, Tennessee.

The mechanism behind supercurrent flow through grain/grain-boundary networks in superconductors is a topic of great interest, especially for potential industrial applications of materials such as coated conductors (CC). It is well known that the critical current density $J_c(H)$ in such systems can be hysteretic relative to increasing or decreasing applied field H. Of particular interest is the observation of a "peak" in $J_c(H)$ at low fields as H is decreased from high fields, due in part to the cancellation of applied field by the return field within grain boundaries produced by trapped flux inside the grains. In the case of CC the presence of this phenomenon in the magnetization has been analyzed recently by Palau et al. However, because of the percolative nature of current flow in these materials, until now the hysteretic behavior of *transport* critical current has not been observed. Films grown on RABiTS and IBAD-YSZ-Hastelloy were patterned into an array of 100-micron wide parallel strips – eliminating in the case of RABiTS most percolative flow around grain boundaries – then transport measurements were made in a standard four-contact configuration. Hysteresis and the flux-trapping peaks in $J_c(H)$ are clearly seen for the first time for these materials. Control studies were conducted using YBCO films deposited on $SrTiO_3$ bicrystal substrates containing a single [001] grain boundary, with angles of 2 to 7 degrees. Using both linear-strip and ring-patterned samples, transport critical currents and magnetic moments were measured in applied magnetic fields, revealing hysteresis with a greatly pronounced flux-trapping peak in $J_c(H)$ for decreasing field. The results can be modeled to yield near-quantitative agreement with observed intragrain and grain-boundary J_c. These results present new opportunities for granularity studies, especially on the nature of percolative current flow in CC, as will be 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.

EE5.22
Effects of Oxygen on the Superconductivity Properties of MgB2 studied by EELS and DFT. Juan Carlos Idrobo[1], Nigel Browning[2,3] and Serdar Ogut[4]; [1]Physics, University of California Davis, Davis, California; [2]Chemical Engineering and Materials Science, University of California Davis, Davis, California; [3]National Center for Electron Microscopy, Berkeley National Laboratory, Berkeley, California; [4]Physics, University of Illinois at Chicago, Chicago, Illinois.

Since the discovery of MgB2 a range of different values for the critical temperature, critical current density, and resistivity have been reported, indicating that the transport properties in MgB2 depend strongly on sample preparation conditions. Two main causes have been considered for the property variations: Mg vacancies and O impurities. Superconductivity in MgB2 is driven by hole transport through the boron orbitals. The presence of oxygen as segregates into the grain boundaries and precipitates in the bulk of polycrystalline materials could have a large effect on the hole carrier concentration, therefore, changing the superconducting properties and explaining the variation measured in the transport properties of MgB2. In this work we will present the study of oxygen impurities in MgB2 by scanning transmission electron microscope (STEM) using atomic resolution Z-contrast imaging and electron energy loss spectroscopy (EELS). We have studied in detail the segregation of oxygen into the grain boundaries as well as precipitates into the bulk. We have found experimentally and using first principles calculations that some precipitates present changes in the electronic fine structure of the boron K-edge, i.e. sharpness in the pre-peak associated as a change in density of states close to the Fermi level. This pre-peak has been the focus of diverse studies, and an increase in its intensity is associated with a better performance of MgB2 as a superconductor with a higher critical temperature. Work is underway to evaluate the origin of the change in the pre-peak shape and its effect on superconducting properties.

EE5.23
High Jc MgB_2 Powder-in-Tube tapes using mechanically alloyed nanocrystalline precursor powder. Bernhard Holzapfel, Wolfgang Haessler, Claus Fischer, Olaf Perner, Juergen Eckert, Konstantin Nenkov, Guenther Fuchs and Ludwig Schultz; Institute of Metallic Materials, IFW Dresden, Dresden, Germany.

Since the discovery of superconductivity at 39 K in intermetallic magnesium diboride intensive research is conducted to develop a low-cost MgB_2 conductor that can be used for magnet applications at intermediate temperatures using the "powder-in tube" (PIT) technique. It was demonstrated that nanocrystalline MgB_2 samples obtained by mechanical alloying show improved superconducting properties. In this contribution we report on our recent results on Fe-cladded MgB_2 conductors that have been prepared by the PIT method using mechanically alloyed nanocrystalline Mg+2B powder mixtures as precursor consisting of the constituents Mg, B and MgB_2. Despite reduced Tc values of about 31 K, maximum critical current densities (Jc) of 22 kA/cm^2 and 7 kA/cm^2 in external magnetic fields of 7.5 T and 10 T, respectively, are achieved at 4.2 K. These values exceed those of all other so far reported undoped MgB2 tapes, what can be attributed to the very fine-grained microstructure of the superconducting phase. The irreversibility fields Hirr of these tapes are 9.5 T and 4.2 T at 10 K and 20 K, respectively.

EE5.24
Critical Current Modeling For Coated Conductor Applications. Noel Antony Rutter[1,2] and Amit Goyal[1]; [1]Metals & Ceramics Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee; [2]Department of Materials Science & Metallurgy, University of Cambridge, Cambridge, United Kingdom.

In multi-granular superconducting tapes, such as those fabricated by the RABiTS method, the overall critical current density will usually be limited by dissipation at grain boundaries. A Monte-Carlo grain growth simulation has been incorporated into existing percolation models in order to calculate critical currents of grain networks. Intra-granular dissipation is also included in the model in order to investigate the conditions for which grain boundaries cease to be the limiting factor. Using the model, the effects of the overall conductor dimensions and the average grain size have been investigated in detail. For standard conductor shapes, it is most favorable to have a small average grain size, a factor which will be most important for applications in which reduction of AC losses is important. The effect of the grain boundaries may also be reduced by having anisotropic grain shapes, such that they are aspected along the tape length direction. The grain shape will also determine the effect of magnetic fields on the boundary network, with implications for high-field applications.

EE5.25
The Reaction Sequence and Growth Kinetics of MgB_2 Layer During *exsitu* Annealing of Amorphous Boron Film. Hyun-Mi Kim[1], Sung-Soo Yim[1], Ki-Bum Kim[1], Dae-Hwan Kang[1], Seung-Hyun Moon[1], Young-Woon Kim[1] and Ho-Nyun Lee[2]; [1]School of Materials Science and Engineering, Seoul National University, Seoul, Seoul, South Korea; [2]LG Electronics Institute of Technology, Seoul, Seoul, South Korea.

The discovery of superconducting property with a relatively high transition temperature (T_c = 39K) in MgB_2 by Nagamatsu et al. motivated worldwide intensive research efforts on this material. Right after the introduction of the superconducting property in this material, many researchers have become interested in growing thin films of MgB_2 in order to fabricate Josephson junction devices. Among the various methods employed so far, the two-step method of α-B deposition and post annealing at a temperature above 800°C under Mg vapor pressure has produced the best quality films. Unfortunately, however, the films made by this process usually develop rough surfaces detrimental to the operation of thin film devices. It have been reported that the reaction sequence and microstructure evolution of an MgB_2 layer during the two-step process. The reaction sequence and microstructure evolution of crystalline MgB_2 layer is examined during post annealing of the evaporated amorphous boron (α-B) with the Mg vapor. Mg is found to diffuse rapidly into the α-B layer in the initial stage of reaction with a uniform concentration of about 12 at.%. Thin layer of crystalline MgO layer is observed at the interface

between α-B and Al_2O_3 substrate. It is identified that an MgB_2 layer starts to form at the surface by the nucleation and growth process in polycrystalline form. It appears that there exist two distinct growth fronts in MgB_2 layer; one lies at the surface and the other lies at the interface between the MgB_2 layer and the α-B. The microstructural evolution of this layer shows significant difference depending on the location of these two growth fronts, unlikely conventional gas-solid reaction in thin film process. Thus, the fully crystallized MgB_2 layer is composed of the two layers differently grown. However, the overall growth kinetics of MgB_2 layer obeys the conventional continuous layered growth model on the thin film binary diffusion couple. The growth kinetics of each layer also followed the model.

EE5.26

Superconducting MgB_2 thin film deposited by laser ablation through an *insitu* heating process. Seung Hwan Shim[1], Jong-Won Yoon[2], Kenji Kawaguchi[2], Naoto Koshizaki[2] and Kwang Bo Shim[1]; [1]Hanyang University, Seoul, South Korea; [2]AIST, Tsukuba, Japan.

The discovery of superconductivity at 39 K in binary compound MgB_2, including the particular properties such as relatively higher critical current density and negligible effect of grain boundary on the current density, compared to high Tc cuprates, has created excitement about the possibility of this material in electronic application (eg., microwave filter and SQUIDs). In this work, nano-structured MgB_2 thin films were deposited on various substrates(sapphire, MgO and Si) by in situ one-step process of laser ablation with substrate heating. The fully densified MgB_2 pellet prepared by a spark plasma sintering was used as a target. The deposition process was carried out under various Ar background gas pressures. Laser energies varied from 50 to 200 mJ/pulse at the repetition rate of 10 Hz. For the formation of stoichiometric MgB_2, the film was deposited with multiplayer structure, i.e., Mg-rich layer interposed between near stoichiometric MgB_2 layer. Because the Mg is easily evaporated during the high temperature annealing. From FE-SEM analysis, the surface morphology of the as-deposited thin films showed uniformity without debris. The Ar pressure dependence on film composition was investigated using XPS. At low pressure range below 50 Pa, boron deficiency was observed. Over 100 Pa atomic concentration of all constituent elements was almost constant, especially with the [Mg]/[B] ratio to be 1:2. From these results, we have succeeded in preparation of nanocrystalline MgB_2 thin film in certain pressure range and investigated the effect of its microstructural features on the superconductivity by measuring the dc magnetic susceptibility and magnetization hysteresis using a SQUID magnetometer.

EE5.27

Electrodeposition of Bi-2212 Superconductor Oxide Films. Priscila Delega Spagnol[1], Raghu N Bhattacharya[1], Jun Chen[1] and Allen M Hermann[2]; [1]NREL, Golden, Colorado; [2]Physics, University of Colorado, Boulder, Colorado.

Biaxially textured $Bi_2Sr_2CaCu_2O_X$ (Bi-2212) films with thickness around 1-2 μm have been prepared from electrodeposited precursors by a melt quench/melt growth process. Magnetization measurements for the electrodeposited, Bi-2212 superconductor films show critical current density values greater than 5 x 10^6A/cm^2 at 4 K in zero field. The electrodeposition technique is a potentially low cost non-vacuum technology. The precursors of BSCCO film were co-deposited at a constant potential of -4V from the respective nitrate salts dissolved in dimethyl sulfoxide solvent. In this meeting, we will discuss the influence of precursor compositions and processing conditions on critical current density of Bi-2212 films. We will also present the results Bi-2212 superconductor oxide films on textured metal substrates.

EE5.28

Reduced AC Transport Losses for Ag-Sheathed Bi2223 Tapes by Controlling Filament Arrangements. Ryoji Inada[1], Yuichi Nakamura[1], Akio Oota[1], Tetsuya Fukunaga[2] and Pingxiang Zhang[3]; [1]Toyohashi University of Technology, Toyohashi, Aichi, Japan; [2]Gifu National College of Techonology, Motosu-gun, Gifu, Japan; [3]Northwest Institute for Nonferrous Metal Research, Xian, Shaanxi, China.

We succeeded in reducing the AC transport self-field losses at 77 K for Ag-sheathed (Bi,Pb)-2223 tapes by controlling the filament arrangements in their cross section. The multifilamentary tapes with sectioned filament arrangements along a width direction were prepared by rectangular deformation process, composed of two-axial rolling and standard one-axial flat rolling. The transport self-field losses at 77 K in the frequency range between 40 and 200 Hz were measured by standard AC four-probe method using a dual phase lock-in amplifier. Although the losses were mainly dominated by the hysteresis loss of the superconductor filaments, the loss values for the tapes with optimized filament arrangements are reduced by 50-65% compared with that for the tapes by standard PIT process, even in the higher current range near the critical current Ic. Numerical calculations suggest that the loss reduction is mainly ascribed to the suppression of magnetic flux due to self-field passing through between the current-free region and the filaments positioned near the tape edge. The effect of longitudinal magnetic field externally applied parallel to the sample axis on the transport losses for the tapes with various filament arrangements were also studied. This work is supported in part by the 21st century COE program "Intelligent Human Sensing", from the ministry of Education, Culture, Sports, Science and Technology of Japan, and Research Foundation for the Electrotechnology of Chubu.

EE5.29

Development of a MOCVD Technology for Integrated Single Buffer Layer/YBCO Layer Fabrication for Coated Conductors. Alexander Molodyk[1], Xin Zhang[1], Jian-Ming Zeng[1], Jia-Shu Liu[1], Pen-Chu Chou[1], Alex Ignatiev[1], Louis Castellani[2], Les Fritzemeier[2] and Rene Kawalec[2]; [1]Texas Center for Superconductivity and Advanced Materials, University of Houston, Houston, Texas; [2]Metal Oxide Technologies, Inc, Houston, Texas.

A MOCVD technology to commercially fabricate YBCO coated conductors on biaxially aligned metal tapes at up to few kilometre lengths is under development. The conductor architecture is based on a single CeO_2(Sm_2O_3) buffer layer and a YBCO superconducting layer. Both the buffer and YBCO layers are deposited by the photo-assisted MOCVD technique that allows achieving high deposition rates on the large areas necessary for industrial scale applications. The prototype fabrication system implements a continuous reel-to-reel process with in-line structure where the buffer and YBCO layers are deposited successively without breaking vacuum. The substrate tape is inserted from air, and pre-treated prior to depositions. The finished multi-layer tape undergoes an oxygen anneal before the conductor is received in air at the take-up reel. Thus, the in situ process starts with a bare metal tape yielding finished product at the other end of the system. Excellent superconducting properties (over 1 MA/cm^2, 77 K, in self-field) have been achieved in the system on small, buffered metal samples. Continuous deposition of 15 metre long moderate-quality YBCO tape has been performed demonstrating good system stability. The deposition of 1 metre high quality YBCO tape is ongoing. The results of XRD, SEM studies, and electrical measurements of small samples and long tapes will be presented.

EE5.30

Processing for Coated Conductor by Modified TFA-MOD Method. Hiroshi Fuji[1], Tetsuji Honjo[1], Ryo Teranishi[1], Yoshitaka Tokunaga[1], Junko Shibata[1], Shigenobu Asada[1], Yutaka Yamada[1], Teruo Izumi[1], Yuh Shiohara[1], Yasuhiro Iijima[2] and Takashi Saitoh[2]; [1]ISTEC-SRL, Tokyo, Japan; [2]Fujikura Ltd., Tokyo, Japan.

Metalorganic deposition using Trifluoroacetates(TFA-MOD) processing has been expected as a strong candidate for the fabrication processes of coated conductors because of its low cost and high superconducting performance. However, in order to apply the tape for the realized applications, the development of higher Ic, the longer tape and the higher production rate etc. is required. In order to realize higher Ic, the following two approaches were considered. One is to make Jc increase and the other is to increase thickness of the superconducting layer with maintaining high Jc. For the former approach, a high textured CeO_2 buffer layer by PLD deposition on a GZO-IBAD buffered tape was used. Concerning the latter approach, the multi-coating process has been investigated. On the other hand, the new starting materials were developed in order to shorten the calcinations time for increasing overall production rate. Consequently, the high superconducting performance was obtained as to be 2.0 MA/cm^2 and 292A (77K in self-field) on a highly textured CeO_2/ GZO-IBAD buffer tape by the multi-coating method using newly developed starting materials. Furthermore, a large scale equipment for the continuous long tape process by Reel-to-Reel system was applied. As a result, the uniformity of the textured YBCO layer was confirmed by the XRD analysis and the superconducting characteristics will be reported. 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.

EE5.31

Study on Bi(2223)/Ag Tapes of Inscribed Rolling Process. GuanSen Yuan and Ribao Feng; Superconducting Materials Research Center, General Research Institute for Nonferrous Metals, Beijing, China.

An inscribed rolling (IR) technique was designed for deforming the high temperature superconducting Bi2223 tape in PIT method. The elasto-plastic finite element method (FEM) was applied for simulating the IR process. By the analyses of stress field, strain field and

pressure field etc., some advantageous characteristics in IR process are investigated for applying to manufacture the Bi2223 tape.Meanwhile the effects of IR process on improving the properties of tape were studied by the contrast experiments with traditional rolling (TR) and cold pressing (CP). Because of the homogenous stress distribution and obvious widening in the tape during the IR process, it is in favor of decreasing the cracks along the transverse direction. The experimental results show that the volume and texture of Bi2223 are improved and much more density of the superconducting filaments is taken by multiple IR process. The widening of the tape obtained by IR process is closed to the CP process and is larger than the TR process obviously. So that IR is a typical deformation of two-axial extendedness and will impinge on the distribution and type of crack generated in the tape. The critical current (Ic) measurements of the tapes made by different deformation process are also discussed in this paper. This work is supported by National Natural Science Foundation of China.

EE5.32
Optimization Studies on Thermal and Mechanical Manufacturing Processes for Multifilament Superconducting Tape and Wire. Burak Basaran and Mustafa Yavuz; MECHANICAL ENGR., TEXAS A&M, COLLEGE STATION, Texas.

There are many parameters profoundly effective on the electrical performance of ceramic core superconducting composite wire and tapes, which remain ambiguous and require more labor on their optimization. BSCCO 2212 has not been paid the attention and investment it deserved in this regard, all optimization efforts were made for BSCCO 2223. In our work, a practical and inexpensive manufacturing method thermally and mechanically optimized for Pb doped BiSrCaCuO 2212 superconducting multifilament (38 filaments) wires and tapes was successfully employed by utilizing standard and easy to obtain components available on the market.. Optimized parameters can be classified under material, mechanical (deformation) and heat treatment (thermal) subgroups: Parameters involved with materials included investigation of deformation behavior of two different sheath metals; pure silver and 0.02% magnesium dispersion reinforced silver alloy. Pb doped BiSrCaCuO 2212 ceramic superconductor powder, the other source of material related parameters, was synthesized following 'Thermal co-decomposition' method. Fabrication of mono and multifilament wires with Oxide Powder in Tube (OPIT) method followed next. Optimization of drawing deformation was practiced to achieve the best ceramic grain alignment and smoother ceramic powder core/metal sheath interface in order to avoid 'sausaging' in wires. Rolling of the wire products into tapes by following different deformation regimes was the other manufacturing stage of the project; variable and constant reduction-per-pass deformation paths were employed to reveal their effects on our composites with distinct sheath material and filament formation. In search of best (optimum) heat treatment schedule for our Bi2212 superconductor composites, a modified version of 'step solidification partial melting' was employed successfully. A solution through tried recipes for the bubbling problem that occurred with our tapes was also addressed. Electrical performance tests of fully reacted wires were carried out in our laboratory and very promising results were attained.

EE5.33
Transport properties of Ni-alloy sheathed MgB2 superconducting tapes. Giovanni Grasso, Andrea Malagoli, Andrea Tumino, Carlo Fanciulli, Davide Nardelli, Carlo Ferdeghini and Antonio Sergio Siri; LAMIA, INFM, Genova, Italy.

Nickel and Nickel-alloy sheathed MgB2 tapes were manufactured by the Powder-In-Tube method with mono- and multifilamentary configuration. Their transport properties were measured in liquid helium bath in an external magnetic field up to 20 Tesla, as well as a function of the temperature. A self field 4.2K critical current density up to 1 MA/cm2 has been reported over short sections of conductors fabricated in unit length up to 100 meters. The magnetic field dependence of the critical current resulted to be very sensitive to the thermo-mechanical treatment that the conductor experiences during the fabrication procedure. Improved field behavior is observed for conductors treated at lower temperatures, or that have experienced a higher degree of cold working.

EE5.34
Atomically Sharp MgO/MgB_2 Interface In Epitaxial MgO/MgB_2 /SiC Multilayer. Sheng-Yong Xu[1], Jin-Guo Wang[2], Guo-Da Lian[2], Alexej V Pogrebnyakov[1], Qi Li[1] and Xiao-Xing Xi[1]; [1]Physics, Penn State University, University Park, Pennsylvania; [2]MRI, Penn State University, University Park, Pennsylvania.

For superconductor-insulator-superconductor (SIS) Josephson junctions (JJs), the insulator between the two superconductors should have a thickness less than, or comparable to, the coherence lengths of the superconducting layers, thus technically it is always challenging to create a uniform and ultrathin insulating barrier layer for the synthesis of JJs made from superconductors with short coherence lengths. We synthesized in situ epitaxial $MgO/MgBB_2$ multilayers on (0001) SiC single crystal substrates with the technique of hybrid physical-chemical vapor deposition (HPCVD). We directly observed atomically sharp interfaces between MgO and MgB_2 by means of high-resolution transmission electron microscopy (HRTEM) and electron energy loss spectroscopy (EELS). It shows that (111) MgO can be epitaxially grown on (0001) MgB_2, and vice versa, with commensurate interfaces. Ultrathin crystalline MgO layers of 3-6 monolayers thick, embedded in the single-crystal-like body of the MgB_2 film, are observed. These ultrathin MgO layers show sharp interfaces on both top and bottom surfaces to the MgB_2 lattices, and are structurally stable at room temperature under irradiation of electron beams by showing sharp and stable electron diffraction patterns. The thickness of the ultrathin crystalline MgO layers observed, 1-2 nm, is less than the coherence length of MgB_2, which is around 3 nm along its c-axis. The results have direct impacts on the technical approaches for applications of MgB_2 materials in SIS JJs and JJ-based electronics.

EE5.35
Strain-Induced Changes of the Superconducting and Normal-State Properties of Epitaxial MgB_2 Films Grown by HPCVD. Alexej V. Pogrebnyakov[1,2], Srinivasan Raghavan[2,3], Joan M. Redwing[2,3], James E. Jones[1], Xiaoxing Xi[1,3], Sheng-Yong Xu[1], Qi Li[1,3], Venu Vaithyanathan[2,3] and Darrell G. Schlom[2,3]; [1]Department of Physics, The Pennsylvania State University, University Park, Pennsylvania; [2]Department of Materials Science and Engineering, The Pennsylvania State University, University Park, Pennsylvania; [3]Materials Research Institute, The Pennsylvania State University, University Park, Pennsylvania.

An increase of the transition temperature, T_c, and a decrease of the residual resistivity, ρ_0, with increasing film thickness was observed for epitaxial MgB_2 thin films grown by hybrid physical-chemical vapor deposition (HPCVD) on 4H-SiC and sapphire substrates. In this process, the MgB_2 film deposition rate depends linearly on the concentration of B_2H_6 in the inlet gas mixture. The superconducting and normal-state properties of the MgB_2 films were found to be relatively independent of the deposition rate over the range investigated in this study. The thickness dependencies for the films on 4H-SiC and sapphire substrates were similar, exhibiting an initial increase (decrease) of T_c (ρ_0) with thickness accompanied by a leveling off at high thickness values (above about 300 nm for films on 4H-SiC and 150 nm for films on sapphire). Thick films on 4H-SiC substrates have T_c values of around $41.7 - 41.8$ K, while T_c values of the films on sapphire substrates level off at around 40 K. This difference is attributed to residual stress in the MgB_2 films due to a dissimilarity of the thermal expansion coefficients of SiC and sapphire. The thickness dependence of T_c is believed to be related to strain in the films – an increase in tensile strain was measured with increasing layer thickness. The best parameters obtained were: a T_c of 41.8 K, a ρ_0 of 0.28 $\mu\Omega$cm, and a residual resistance ratio, RRR, of 32 for the films on 4H-SiC substrates and a T_c of 40.5 K, a ρ_0 of 0.26 $\mu\Omega$cm, and RRR of 35.6 for the films on sapphire substrates.

SESSION EE6: HTS Wires and Applications
Chairs: Bernhard Holzapfel and Yutaka Yamada
Wednesday Morning, December 3, 2003
Constitution B (Sheraton)

8:30 AM *EE6.1
Evaluation of Current Limiting Mechanisms in Practical Superconductors. David C Larbalestier, [1]Applied Superconductivity Center, University of Wisconsin-Madison, Madison, Wisconsin; [2]Department of Materials Science and Engineering, University of Wisconsin-Madison, Madison, Wisconsin; [3]Department of Physics, University of Wisconsin-Madison, Madison, Wisconsin.

An apparently simple goal of much superconductor development is to raise the critical current density and thus the critical current of the whole conductor. In practice no conductor fabrication process is perfect, leading to the general situation that I_c and J_c are limited not just by flux pinning but by other defects that control the active cross-section through which current flows. It is thus conceptually important to be able to separate that component of I_c that is controlled by flux pinning from that component controlled by defects. The characterization tools available to us for such a task are now quite extensive, for example magneto optical imaging and low temperature scanning laser microscopy to reveal local J and E and all sorts of microstructural characterization tools to which we may correlate such measurements. I will survey some of the issues involved in understanding such current limiting mechanisms from our recent

studies of Nb_3Sn, Bi-2223 and YBCO coated conductors. *In collaboration with many colleagues at UW-ASC and in the broader community

9:00 AM *EE6.2
Characterisation And Analysis Of Transport In HTS In Terms Of Two Seperate Vortex Systems. Bennie ten Haken, Danko van der Laan, Marc Dhalle and Herman ten Kate; Unv of Twente, Enschede, Netherlands.

The transport properties of Bi based tapes are analysed in the frame of the phenomenological parallel path model. At high fields the current is only carried by a percolating "strong-linked" backbone, while in low fields the surrounding "weak-linked" matrix also contributes to the overall current-carrying capacity. We illustrate this by showing how 1) the anisotropy of the critical current with respect to the direction of an applied magnetic field can only be fully understood when both paths are considered seperately; 2) anomalous features in the slope and curvature of the current-voltage relation are easily explained within this framework and 3) the dependence of the critical current on axial strain gives indications as to the nature of the "weak links" in low magnetic fields. Even if the dissipation mechanisms limiting the critical current in both paths are different, their temperature dependence shows that they are not independent. Based on results obtained on tapes whose oxygen content was cycled, we explain this coupling in terms of two interacting vortex systems. Furthermore, the parallel path analysis suggests that a similar picture might also hold for YBCO coated conductors.

9:30 AM EE6.3
Enhanced Residual Secondary Phase Dissolution by Atmosphere Control in Bi-2212 Superconductors.
David Sager[1], Mirabai Koch[1], Lorenz Meier[1], Bengt Hallstedt[1], Ludwig J Gauckler[1], Makan Chen[2], Markus Hoidis[2] and Willi Paul[2]; [1]ETH Materials, Zurich, Switzerland; [2]ABB Corporate Research, Baden-Daetwil, Switzerland.

For power applications, where primarily high current carrying capabilities are required and therefore thick film and bulk material is processed, the Bi2Sr2Ca1Cu2O8 (Bi-2212) compound has evolved as one of the most promising. The recrystallization from the partial melt state is incomplete, due to the stability of the 014x24 phase and sterically hindered diffusion from recrystallized Bi-2212 platelets [1]. Therefore considerable amounts of residual 014x24 and 4413, the mixed state of Bi-2212 and 2201, are present in the microstructures at 850°C. The subsequent annealing in oxygen leads to a limited dissolution of 014x24 phase and the curing of 4413 to Bi-2212 [2]. Hallstedt et al. [3] show that the stability range of 014x24 depends on the oxygen partial pressure (pO2) in the Sr-Ca-Cu-O system. Calculation of BiO3/2-Sr2/3Ca1/3O-CuO cross-sections at 850°C at different pO2 were performed by Calphad. From these calculations the area of stability of 014x24 is derived, showing that its stability range is substantially reduced with decreasing pO2. These results correlate well with the experiments. By annealing at low pO2 after recrystallization, the amount of residual phases is reduced, increasing the critical current density of the fully processed material up to 65%. This increase is attributed to a gain in current carrying cross-section as a consequence of enhanced 014x24 dissolution. [1] M.O. Rikel , E.E. Hellstrom, Physica C 357-360 (2001) 1081-1090 [2] D. Buhl, L.J. Gauckler et al. Physica C 257 (1996) 151-157. [3] D. Risold, B. Hallstedt, L.J. Gauckler, J. Am. Ceram. Soc.80(3) (1997) 537-550

9:45 AM EE6.4
Correlation of AC Loss Data from Magnetic Susceptibility Measurements with YBCO Film Quality. Paul N Barnes[1], Timothy J Haugan[1], Srinivas Sathiraju[1], Iman Maartense[2], Amanda L Westerfield[1], Rama M Nekkanti[3,1], Lyle B Brunke[3,1], Timothy L Peterson[2], Juliana M Evans[1] and Justin C Tolliver[1]; [1]Propulsion Research Power Generation Group, Air Force Research Laboratories, Wright-Patterson AFB, Ohio; [2]MLPO, Air Force Research Laboratories, Wright-Patterson AFB, Ohio; [3]UES, Inc. at WPAFB, Air Force Research Laboratories, Wright-Patterson AFB, Ohio.

For HTS films a sharp transition in resistivity vs. temperature at T_c, as well as a T_c close to the maximum value, are typically desired for better quality films. Further, it has been previously observed that with spreading of the temperature-dependent ac susceptibility curves with increasing applied magnetic field, the quality of the YBCO film generally decreases[1]. However, a documented study of this correlation to current transport properties using the loss component of ac susceptibility data has not been published, making it unclear how effective this correlation is. A correlation on this level may prove useful as a preliminary screen of YBCO film quality, especially as good YBCO films can now be routinely made. A detailed study was performed using the available data on YBCO films produced by pulsed laser deposition on different substrates which included LAO, STO, and buffered metallic substrates. A few additional samples of YBCO coated conductor prepared by alternative methods were included in this study for comparison. The ΔT between the temperatures at which the maxima in the ac loss occurs for 0.025 and 2.2 Oe applied magnetic fields (peak to peak of χ") was determined. In addition, the full-width at half- maximum (FWHM) of the χ" vs. T width (ΔT) of the loss component of susceptibility data was determined for the 0.025 Oe magnetic field data and the 2.2 Oe magnetic field data for comparison. Results will be presented comparing analysis of the ac loss data from magnetic susceptibility measurements to the critical current density (J_c) as determined by current transport measurements and inferred J_c as determined by M-H loops derived from vibrating sample magnetometry. [1] I. Maartense and A. K. Sarkar, J. Mater. Res., Vol. 8, 2177 (1993).

10:30 AM *EE6.5
Comparison Between Bi-2223 and Y-123 Conductors for Moderate-Field HTS Devices. Marijn P. Oomen, Martino Leghissa, Bernd Utz and Heinz-Werner Neumueller; CT PS3, Siemens AG, Erlangen, Germany.

We investigate high-temperature superconducting materials for use in transformers, fault current limiters, motors / generators and MRI magnets. All these devices operate with moderate magnetic fields (up to a few T) and they require the production of coils comprising long lengths of HTS conductor. Materials manufacturers presently envisage two different long-length conductor systems: Bi-2223 powder-in-tube multi-filamentary tapes and Y-123 coated conductors. This presentation compares the presently known state-of-the-art in the two conductor systems. The current density that can be attained in a winding under operating conditions is similar for the Bi-2223 and Y-123 systems. The temperature-dependence of the current density determines the optimum operating temperature for a given device. The AC loss in an Y-123 tape can be much lower than in a Bi-2223 tape; the loss in an operating coil depends on conductor and coil architecture. The mechanical properties of Y-123 tapes can be made clearly better than for Bi-2223 tapes. However, for coil production we must also address practical issues like conductor homogeneity, stabilisation against quench, insulation, contacting, handling and thermal contraction during cool-down. For the Bi-2223 system these issues are well understood and have mostly been solved, due to the wide availability of the tapes. Y-123 tapes are presently available only in limited lengths. The materials manufacturers have not yet agreed on the best tape architecture and production process. Pending such an agreement, all the practical coil-production issues for the Y-123 system are wide open and urgently need investigation. Therefore the planning and construction of prototype devices presently relies on the Bi-2223 conductor.

11:00 AM *EE6.6
Enhanced Performance and Manufacturing of Bi-2223 Multifilamentary Composite Wire. Yibing Huang[1], M. Aviza[1], B. Carter[1], K. Demoranville[1], C. King[1], S. Fleshler[1], A. Otto[1], R. Parrella[1], E. Podtburg[1], J. Schreiber[1], A. P. Malozemoff[1], X. Y. Cai[2], E. Hellstrom[2], D. Larbalestier[2], T. Holesinger[3] and V. A. Maroni[4]; [1]American Superconductor, Westborough, Massachusetts; [2]Applied Superconductivity Center, University of Wisconsin-Madison, Madison, Wisconsin; [3]Los Alamos National Laboratory, Los Alamos, New Mexico; [4]Argonne National Laboratory, Argonne, Illinois.

Progress in the performance and large-scale production of multifilamentary composite Bi-2223 wire is reviewed. Critical current (I_c) of 185 A and critical current density (J_c) of 62.4 kA/cm^2 at 77 K and self-field have been achieved in research samples with a new overpressure process, developed at the University of Wisconsin and applied to American Superconductor (AMSC) production wires. The relative improvement over earlier wires is even greater when measured in 0.1 T field perpendicular to the tape plane because self-field suppression is no longer present. Microstructure and characterization by SQUID magnetometry, transmission XRD, SEM and TEM through the Wire Development Group, a nation-wide collaboration, shows a significant reduction of the residual 2212 intergrowths remaining in Bi-2223 grains on the higher Ic wires. Compared to its earlier pilot production facility, AMSC is achieving even higher performance and longer piece length production wire in its Devens manufacturing plant.

11:30 AM EE6.7
Overpressure Processing and Characterization of Silver Sheathed $(Bi,Pb)_2Sr_2Ca_2Cu_3O_x$ Composite Conductors.
Yongwen Yuan[1,2], Jianyi Jiang[1], Xueyu Cai[1], Anatolii Polyyanskii[1], Yibing Huang[3], Ron Parrella[3], Dmytro Abraimov[1], Sandy Liao[1,2], David Larbalestier[1,2] and Eric Hellstrom[1,2]; [1]Applied Superconductivity Center, University of Wisconsin-Madison, Madison, Wisconsin; [2]Department of Materials Science and Engineering, University of Wisconsin-Madison, Madison, Wisconsin; [3]American Superconductor Corporation, Westborough, Massachusetts.

Silver sheathed $(Bi,Pb)_2Sr_2Ca_2Cu_3O_x$ (2223) composite conductor is currently the only high temperature superconductor available in adequate lengths for industrial scale electrical applications. Porosity, deformation cracks, and low-Tc 2212 are the most deleterious current limiting factors. We have developed overpressure (OP) processing to densify the 2223. In the OP system, the 2223 conductor is heated in a high pressure isostatic flowing atmosphere (~150 bar) made up of O_2 and Ar. Extended V-I and SQUID magnetometry measurements show that OP processing substantially increases critical current density (J_c)and reduces the amount of 2212 compared to samples processed at 1 bar. J_c of 22.4 kA/cm^2 at 0.1 T and 77K has been achieved in OP samples. Electron microscopy observation and density measurement show that OP processing eliminates pores and cracks in 2223 conductors fabricated by conventional 1 bar process. Quantitative HRSEM image analysis and x-ray diffraction confirm that OP samples contain less 2212 than samples processed by identical heat tretment at 1 bar. This work is finacially supported by the DOE-EERE program and partially benefited by the facilities support from NSF-MRSEC.

11:45 AM EE6.8
Defect Influence On The Critical Parameters in Bi-2212 High Tc Superconductors. Predrag Kisa and Nicholas G Eror; University Of Pittsburgh, Pittsburgh, Pennsylvania.

This study investigated the structural characteristics and flux pinning in $Bi_2Sr_2CaCu_2O_8$ (Bi-2212) high temperature superconductors by selective doping. Flux pinning, change in critical temperature as well as the change in lattice parameters and melting temperature were determined for Cr ions on Cu (2+/3+) and Ca (2+) sites and is compared to flux pinning achieved by the introduction of MgO three-dimensional defects, as well as controlled doping with $SrCuO_2$. Differential thermal analysis (DTA), X-ray diffraction analysis (XRD), scanning electron microscopy (SEM), X-ray photoelectron spectroscopy (XPS), superconducting quantum interference device (SQUID) measurements were used to elucidate the properties. The melting temperature of the SrCuO2 doped Bi-2212 was unchanged for up to 0.4 mole % $SrCuO_2$ additions while the critical current density increased from Jc=8,000 A/cm^2 for undoped polycrystalline samples to Jc=14,500A/cm^2 for 0.1 mole % doped samples. The critical temperature increased from Tc = 83K for undoped Bi-2212 to Tc = 94K for 0.3 mole % $SrCuO_2$ additions.

SESSION EE7: MgB2
Chairs: David Larbalestier and Xiaoxing Xi
Wednesday Afternoon, December 3, 2003
Constitution B (Sheraton)

1:30 PM EE7.1
The effect of impurity scattering on the enhancement of the resistivity and the upper critical field in MgB2 bulk and thin films. Valeria Braccini[1], A. Gurevich[1], X. Song[1], Kee-Hoon Kim[2], C. H. Mielke[2], J. Gienke[1], C. B. Eom[1] and D. C. Larbalestier[1]; [1]Applied Superconductivity Center, University of Wisconsin-Madison, Madison, Wisconsin; [2]National High Magnetic Field Laboratory, Los Alamos National Laboratory, Los Alamos, New Mexico.

Gurevich has shown how one important consequence of the two-gap superconductivity in MgB2 is that is possible to remarkably enhance the upper critical field from the relatively low values found in the single crystals to a range of Hc2 values well above those of competing non-cuprate superconductors, like Nb3Sn and Nb-Ti, by tuning the impurity scattering through selective alloying on Mg and B sites. High magnetic field transport measurements have been performed at NHMFL, Tallahassee (FL) in the 33 Tesla resistive magnet and at LANL, Los Alamos (NM) in the 50 Tesla pulsed-field facility on bulks samples and thin films of very different purity. Clean limit bulk MgB2 samples have been prepared by direct synthesis from isotopically pure 11B and Mg. They present sharp transitions at 39 K, high resistivity ratio about 15 and low resistivity (ρ(40K)=1 $\mu\Omega$cm). Hc2 (0) for these samples is about 18 Tesla. The resistivity and the upper critical field of clean samples have been enhanced by alloying on both Mg and B sites: in particular, the effect of annealing in Mg vapor and C substitutions with different percentages have been studied. In particular, after annealing in Mg vapor, the samples showed an increase of the 40 K resistivity from 1 to 18 $\mu\Omega$cm and a lowering of the resistivity ratio from 15 to 3, while the critical temperature decreased by only 1-2 K. By doping with carbon, the resistivity reached 40 $\mu\Omega$cm with critical temperatures around 30 K for 5%-C doping. Several thin films, grown by means of different techniques have been studied, with resistivities ranging from 7 to 220 $\mu\Omega$cm and critical temperatures between 38 and 31 K. In all these cases, corresponding to an increase of the resistivity a significant enhancement of Hc2 has been achieved, passing from the low values reported for the single crystals (Hc2 (0)$\approx$ 3.5 T perpendicular to the ab planes and Hc2 (0)$\approx$ 18 T parallel to the ab planes) to values of about 34 T and 49 T respectively in the two configurations for a high resistivity film and Hc2 (0)$\approx$ 29 T for one of the untextured bulk polycrystals.

1:45 PM EE7.2
Superconducting Properties and Microstructure of MgB_2 Thin Films Prepared by Post Annealing of Co-evaporated MgB_x (x = 2.3, 3, and 4.3) Films. Sung-Soo Yim[1], Hyun-Mi Kim[1], Ki-Bum Kim[1], Dae-Hwan Kang[1], Seung-Hyun Moon[1], Young-Woon Kim[1] and Ho-Nyun Lee[2]; [1]School of Materials Science and Engineering, Seoul National University, Seoul, South Korea; [2]LG Electronics Institute of Technology, Seoul, South Korea.

Magnesium diboride, since the discovery of its superconductivity at 39 K, has been highlighted as one of the most promising materials for superconducting devices due to its high critical temperature (T_c), critical current density (J_c) and simple binary structure. Especially there has been large interest in MgB_2 thin films for electronic devices applications. Among the methods to prepare MgB_2 thin films, the films made from amorphous precursor films such as α-B and MgB_x via postannealing at high temperature shows excellent superconducting properties including bulk like T_c, enhanced J_c (> 1 MA/cm$_2$) and low resistivity. We report superconducting properties and surface morphology as a function of composition of precursor films and microstructure evolution during postannealing of MgB_x (x = 2.3) films as a function of annealing time. MgB_x films of about 500 nm were deposited on Al_2O_3 (0001) substrates by e-beam evaporation at room temperature. As-deposited precursor films have composition of $MgB_{2.3}$, MgB_3 and $MgB_{4.3}$, which were confirmed by Rutherford backscattering spectroscopy (RBS), and the oxygen content of all films are less than 5 %. Precursor films were annealed in evacuated quartz tube under Mg vapor at 800 °C for 30 min. The films made from the Mg-rich precursor films shows slightly better superconducting properties. The onset T_cs (T_{con}) of MgB_2 films after annealing of $MgB_{2.3}$, MgB_3 and $MgB_{4.3}$ are 38.6, 38.5 and 38.3 K. Corresponding superconducting transition widths (ΔT_c) are 0.3, 0.6 and 0.9 respectively. The little relation between composition of the precursor films and resistivity can be found. The resistivities at room temperature of the films are 26.6, 22.15 and 25.8 $\mu\Omega$·cm and residual resistivity ratio (RRR) values are 2.81, 1.71 and 1.70 as a composition of B increases. It is worth noting that the films made from the $MgB_{2.3}$ precursor films have remarkably reduced surface roughness. Microstructure evolution during postannealing of $MgB_{2.3}$ precursor films, which shows best properties and surface morphology, are investigated by using transmission electron microscopy (TEM). The annealing times were varied from 10 to 30 min. The films annealed below 20 min have a nanocrystalline microstructure. It is observed, however, that there have large grains in the films annealed for 30 min. Therefore, the nanocrystalline MgB_2 phases are formed in early stage of annealing and then grow. It is also noted that the nanocrystalline MgB_2 films have c-axis oriented microstructure which is confirmed by electron diffraction pattern in TEM.

2:00 PM *EE7.3
Epitaxial Growth Of Magnesium Diboride Thin Films By Hybrid Physical-Chemical Vapor Deposition.
Joan M. Redwing[1,3], A. Pogrebnyakov[2], S. Raghavan[1], J. D. Acord[1], J. E. Jones[2], X. X. Xi[1,2,3], S. Y. Xu[2], Qi Li[2,3], Z. K. Liu[1,3], V. Vaithyanathan[1] and D. G. Schlom[1,3]; [1]Department of Materials Science and Engineerng, Pennsylvania State University, University Park, Pennsylvania; [2]Department of Physics, Pennsylvania State University, University Park, Pennsylvania; [3]Materials Research Institute, Pennsylvania State University, University Park, Pennsylvania.

A hybrid physical-chemical technique was developed to deposit epitaxial thin films of superconducting MgB_2. In this process, Mg evaporation is used in combination with the thermal decomposition of diborane gas in hydrogen to deposit MgB_2 at growth temperatures of 720-760°C and pressures ranging from 100-700 Torr. The presence of hydrogen serves to inhibit the formation of MgO within the bulk of the film, as determined by x-ray diffraction measurements. Epitaxial growth of MgB_2 on various substrates including sapphire, 4H and 6H SiC and MOCVD grown layers of AlN and GaN was investigated. The lattice constant and thermal expansion coefficient of the substrate as well as its chemical stability with Mg at elevated temperature are all important considerations when selecting a substrate for MgB_2 deposition. Epitaxial layers of MgB_2 were obtained on sapphire and SiC substrates as well as on the AlN epitaxial layers. Direct deposition of MgB_2 on GaN, however, resulted in poor film morphology due to a reaction between Mg vapor and the GaN surface at the growth temperature. In the case of SiC and AlN, the hexagonal lattice of MgB_2 grows directly on top of the hexagonal lattice of the substrate, due to the small lattice mismatch between these materials. On sapphire, MgB_2 rotates 30° relative to the substrate lattice to accommodate the larger lattice mismatch. Lattice constant measurements of MgB_2 films deposited on SiC and sapphire indicate

that the films are under tension and compression, respectively, due to differences in thermal expansion between the films and substrate. The difference in residual stress was found to impact the superconducting properties of the MgB_2 films.

2:30 PM *EE7.4
Growth of High Quality *In – Situ* MgB_2 Thin Films by Reactive Coevaporation. Brian H. Moeckly and Ward S. Ruby; Superconductor Technologies, Sunnyvale, California.

The growth of completely *in – situ* MgB_2 thin films has been difficult primarily due to the high vapor pressure and oxygen affinity of Mg. To overcome these problems, we have developed a reactive coevaporation deposition technique that utilizes a localized source of Mg vapor. Using this method, we have grown MgB_2 films on a variety of single-crystal substrates including MgO, $LaAlO_3$, $SrTiO_3$, c-, m-, and r-plane sapphire, LSAT, YSZ, and 4H-SiC. In all cases the films exhibit low resistivity values and T_c values over 37 K. We have also grown MgB_2 films on polycrystalline alumina and unpolished flexible stainless steel shim stock; these films display properties similar to those on single-crystal substrates. It thus appears that lattice matching is not required using our growth technique. We have thus far explored the growth temperature range of 400 to 600 °C with no in-situ annealing and equally good results. In addition to the relative ease with which we are able to obtain high quality MgB_2 films, this technique also allows us the ability to deposit films of up to 4" in diameter and to grow double-sided films. We will report on the morphology, current-carrying capacity, and microstructure of these films. This work was partially supported by ONR, Contract No. N00014-03-M-0005.

3:30 PM EE7.5
In-situ Fabrication and Characterization of All MgB_2 Josephson Junctions with Various Barriers and Their Electrical Characteristics. Jihoon Kim, Raghuram Gandikota, Rakesh Singh, Brett Strawbridge, John Rowell and Nathan Newman; Chemical and Materials Engineering, Arizona State University, Tempe, Arizona.

We have optimized the synthesis of MgB_2 thin films by Molecular Beam Epitaxy using a novel thermochemical approach. The Mg sticking coefficient is found to strongly depend upon the B flux. By enhancing the incorporation rate of Mg on the surface using a high Mg flux and precise control of the B flux, we have been able to extend the process window to higher temperature. Transition temperatures of 37∼38K and surface roughness' of $< 50\AA$ are obtained for films grown at 300°C. We have produced in-situ trilayer structures to explore the properties of MgB_2 tunneling and Josephson junctions. We have studied a variety of barrier layers including the MgBx thermal oxide, TaxN, AlN, and GaN. MgB_2/AlN/MgB_2 and MgB_2/MgBx thermal oxide/MgB_2 trilayer structures have been fabricated which exhibit RSJ (resistively shunted junction) characteristics. To date, no tunneling characteristics have been seen, indicating that the barriers that are insulators probably have pinholes. Results to date indicate that the IcRn product of the AlN and the MgBx thermal oxide barrier junctions are 6mV and 0.35mV, respectively. The temperature at which the critical current vanishes is about 36K in MgBx thermal oxide barrier junctions and 26K in AlN-barrier junctions. Results for other barriers, including TaxN and GaN, will also be presented

3:45 PM EE7.6
Superconducting Properties of Electroplated MgB2 Films. Hideki Abe[1], Kenji Nishida[1], Motoharu Imai[1], Hideaki Kitazawa[1] and Kenji Yoshii[2]; [1]NIMS, Tsukuba, Japan; [2]JAERI, Mikadzuki.

The superconductive boride MgB2 is one of the most promising practical superconductive materials because of its high superconducting transition temperature of 39 K and high critical current density (Jc) under magnetic fields. A number of fabrication methods of superconducting wires or thin films out of MgB2 have been reported so far. In recent, we have developed an electroplating technique of superconducting MgB2-films with a transition temperature of 37 K by means of electrolysis on a fused mixture of MgCl2, KCl, NaCl and MgB2O4. The superconducting MgB2-films with tens micrometer thickness were successfully electroplated on graphite substrates by optimizing the shapes and configuration of the electrodes [*]. We report the superconducting properties of electroplated MgB2-films in this paper. Electrical transport measurements have revealed that the electroplated MgB2-films show superconducting transition at 37 K and zero-resisitvity below 33 K under the zero-field. I/V characteristic measurements have shown that Jc of the electroplated MgB2-films reaches to an order of 10000 A/cm2 at 5 K at the highest. The magnetic field dependence of Jc of the electroplated MgB2-films will be discussed at the conference. [*]... H. Abe, K. Nishida, K. Yoshii and M. Imai, Cond-mat/0211310

4:00 PM *EE7.7
A Role for MgB2 in Superconducting Electronics?
John M. Rowell, Department of Chemical and Materials Engineering, Arizona State University, Tempe, Arizona.

The 39K transition temperature of MgB2 makes this material of potential interest in a number of superconducting electronics applications. I do not expect MgB2 to replace HTS materials in commercial wireless filter systems, which now operate at or near 77K. However, if an RSFQ digital technology could be developed operating at 20 to 25K, the cryocoolers required would be much smaller and more efficient than those now used with today's Nb technology at 5K. Tunnel junctions of MgB2 would allow higher frequency operation of SIS detectors than junctions of Nb or NbN. I will review progress towards the development of such thin film and junction technologies. In the past year, novel deposition techniques have allowed the synthesis of very good films of MgB2. Their resistivity is now as low as that of the best bulk samples. Also, uniform films on large area substrates have been made. Epitaxial growth is not necessary, so inexpensive substrates can be used. Progress towards a junction technology, of either the SNS or SIS type, has not been as rapid. Weak link junctions have been reported, but, to date, MgB2/barrier/MgB2 junctions appear to have pinholes through the barriers. As good films and multilayers can be grown at temperatures as low as 300C, I am hopeful that a junction technology at 20 to 25K will be made possible soon.

4:30 PM EE7.8
Tunneling Spectroscopy of Polycrystalline MgB_2 Micro-wires. Thomas W Heitmann[1], Paul C. Canfield[2,3], Douglas Finnemore[2,3] and Mark S. Rzchowsi[1]; [1]Physics Department, University of Wisconsin, Madison, Wisconsin; [2]Department of Physics and Astronomy, Iowa State University, Ames, Iowa; [3]Ames Laboratory, Ames, Iowa.

We report scanning tunneling spectroscopy of polycrystalline MgB_2 micro-wires using both normal metal-insulator-superconductor (N-I-S) and superconductor-insulator-superconductor (S-I-S) tunnel junctions. A segment of the micro-wire was affixed to a normal Pt-Ir STM tip and approached to a Au film in the first case and to another segment of the micro-wire in the latter case. In each configuration we observe both gaps, Δ_π and Δ_σ, and for the S-I-S junctions we observe a directional dependence of the dI/dV on the relative orientation of the grains in each superconducting electrode. In particular, we found that for a certain orientation of the grains, which we infer to be perpendicular, tunneling between π-bands and between σ-bands is strongly suppressed. This leaves only features in the dI/dV associated with tunneling from the π-band in one electrode to the σ-band in the other.

4:45 PM EE7.9
Processing and Characterization of Powder in Tube MgB_2 Wires. Adriana C. Serquis[1], Leonardo Civale[1], Xiaozhou Liao[1], Duncan L. Hammon[2], J. Yates Coulter[1], Vitali F. Nesterenko[3], Yuntian T. Zhu[1], Fred M. Mueller[1] and Dean E. Peterson[1]; [1]MST-STC, Los Alamos National Laboratory, Los Alamos, New Mexico; [2]MST-6, Los Alamos National Laboratory, Los Alamos, New Mexico; [3]Department of Structural Engineering, University of California, San Diego, La Jolla, California.

Since superconductivity in MgB_2 was reported, considerable progress has been made in the understanding of fundamental properties of this material and its possibilities for applications. However, to make practical devices, it is essential to enhance the pinning properties in order to increase the current carrying capability of MgB_2. We present a detailed analysis of the effect of heat treatments, including hot isostatic pressing (HIP), on the microstructure, magnetization and transport properties of MgB_2 wires and coils prepared by the powder in tube (PIT) method. We also present data of the bulk pinning force as a function of field derived from the magnetization data. We discuss the optimization of the annealing conditions that strongly improve the connectivity by eliminating most of the micro-cracks present in the un-annealed wires. The HIPed wires have a higher critical current density than the annealed wires, especially at high temperatures and magnetic fields, and higher irreversibility field (H_{irr}∼ 17 T at 4 K). The H_{irr} value is the largest reported in PIT MgB_2 wires or tapes. The improvement was attributed to a high density of structural defects, which are the likely source of vortex pinning.

SESSION EE8: Poster Session
Chairs: Juergen Halbritter and Joan Redwing
Wednesday Evening, December 3, 2003
8:00 PM
Exhibition Hall D (Hynes)

EE8.1
All-HTS Capacitive MEMS Switch Development.
Abigail Kirschenbaum, J Talvacchio, D A Kahler and J M Murduck; Northrop Grumman Corporation, Baltimore, Maryland.

We are developing a technology for high-Q tunable filters from MEMS capacitive switches using the high transition-temperature superconductor (HTS) $YBa_2Cu_3O_{7-x}$ (YBCO) for both the static and movable capacitor electrodes. Northrop Grumman has demonstrated a low insertion loss tunable two-pole bandpass filter (1.9 dB for 7% passband) with a tuning range of one octave (812-1752 MHz) using room-temperature versions of such switches,** so the path from HTS capacitive switches to tunable filters is well defined. Our MEMS switch approach for developing tunable filters is attractive since switching times are a couple of microseconds and passband shape can either be maintained or controllably changed over the octave tuning range. The capacitive switch is an electrostatically-driven MEMS bridge. In our design, the mechanical and electrical functions of the bridge are decoupled so that an electrically floating bridge of YBCO can move up and down rigidly as the normal-metal supports, located away from radio frequency (RF) fields, are flexed. The bridge consists of the following epitaxial layers: YBCO, a dielectric, a second dielectric serving as the sacrificial layer, YBCO, and non-epitaxial gold. The most critical part of process development is a differential etchant capable of removing the sacrificial layer without destroying the YBCO top electrode or the other dielectric layer. We are using SrTiO3 as the sacrificial layer. We will show results of our experiments to chem-mechanically polish the surface of the lower YBCO electrode to avoid having the switch stick when it is closed. Supported in part by AFOSR Agreement F49620-02-1-0046 **R. M. Young, et al., IEEE MTT-S Intl. Microwave Symposium, pp. 1781-1784 (2003).

EE8.2
Influence of Cu Doping on the Magnetic and Superconducting Properties of Single Crystals of Ba2PrRu1-xCuxO6 Grown from High Temperature Solutions. Muralidhara Rao Sistla[1], S. M. D. Raol[1], M. K. Wu[1], B. H. Mok[2] and C. Y. Lu[2]; [1]Institute of Physics, Academia Sinica, Taipei, Taiwan; [2]Materials Science Center, National Tsing Hua University, Hsinchu, Taiwan.

Single crystals of the double perovskites Ba2PrRu1-xCuxO6 were grown from high temperature solutions of mixed PbO-PbF2 chosen from several solutions tried. Crystals were grown at different temperature in the range 1100 to 1200°C. The changes in the morphology and superconducting properties of the resulting crystals are presented. The crystals were found to grow with triangular and hexagonal plate like habit. The crystals exhibit a superconducting like transition in the zero field cooled state. This transition was found to depend both on the Cu concentration and temperature of growth. The transition temperature is found to vary from 7 to 11.5 K with either. Details of these investigations including X-ray, SEM and EDX analysis are presented. This is behavior similar to the Sr and Y based ruthenates of the same family produced in our laboratory and is interesting as the Pr123 is not known to be superconducting.

EE8.3
Structure and EELS analysis of NaxCoO2 yH2O superconducting system. Jianqi Li and Y.G. Shi; Beijing labortary of Electron Microscopy, Beijing, China.

The structural properties and electron-energy-loss spectra (EELS) of NaxCoO2 and NaxCoO2 yH2O materials have been investigated. The NaxCoO2 yH2O samples in general undergo superconducting transitions at around 3.5K. EDAX analyses suggest our samples have the average compositions of Na0.65CoO2 for the parent compounds and Na0.26CoO2 yH2O for the superconducting oxyhydrates. TEM observation reveals a new superstructure with wave vector q=<1/2,0, 0> in the parent materials. This superstructure becomes very weak in the superconducting samples. EELS analyses show that the Co ions have the valence states of around +3.3 in the Na0.65CoO2 materials and around +3.7 in the superconducting materials.

EE8.4
Phase Equilibria in the SrO-CuO-TiO2 System; Application to High-Temperature Superconductors (HTS) via Chemical Solution Deposition (CSD). A. Ayala and T.G. Holesinger, Superconductivity Technology Center, Materials Science and Technology Division, Los Alamos National Laboratory, Los Alamos, NM 87545. Alicia Ayala and Terry G Holesinger; Superconductivity Technology Center, Los Alamos National Laboratory, Los Alamos, New Mexico.

SrTiO3 (STO) is a candidate buffer layer for use in YBa2Cu3Oy (YBCO) coated conductors based on the ion-beam-assisted deposition (IBAD) MgO process. Deposition methods such as sputtering, reactive coevaporation, pulsed laser deposition, and metallo-organic deposition have been used to prepare STO thin films. Chemical solution deposition (CSD) is an alternate means of thin film fabrication at a lower cost when compared to in situ methods. However, some aspects of the interfacial interactions between YBCO and the proposed buffer layer are still unclear. In order to identify optimum STO thin film compositions and deposition conditions, a portion of the phase diagram of SrO-CuO-TiO2 system along the STO/SrCuO2 tie line was determined. Initial compositions ranged from x=0 to x=1 for Cu in Sr1CuxTi1-xOy. Solubility studies show that a small amount of copper substitutes into the STO crystal structure whereas the SrCuO2 phase does not accommodate Ti into its structure. For sufficiently high Cu concentrations, partial melts can form in the temperature range of interest for CSD. These aspects of the phase diagram and CSD were combined to determine deposition conditions for high-quality Cu-substituted STO films on single crystal MgO and IBAD MgO substrates.

EE8.5
Photocarrier injection to $YBa_2Cu_3O_{7-x}$ thin films. Yuji Muraoka, Takaki Muramatsu, Toru Yamauchi, Jun-ichi Yamaura and Zenji Hiroi; ISSP, Univ. of Tokyo, Chiba, Japan.

It is well known that superconducting properties in high-T_c cuprates change as a function of hole carrier concentration. The commonest method to dope them with hole carriers is the chemical substitution of constituent elements, as seen in $(La,Sr)_2CuO_4$. However, randomness accompanied by the atomic substitution is introduced inevitably into a crystal, which has often obscured the physical interpretation of phenomena. It would be of great advantage if one could establish an efficient and reliable method to control hole density by applying certain external fields. Recently, we presented a highly efficient and tunable photocarrier injection (PCI) method by using transition metal oxide (TMO) heterostructures [1,2]. We prepared insulating and semiconducting thin films such as VO_2 and $(La,Sr)MnO_3$ on n-type titanium oxide substrates doped with Nb, and found that the resistance decreased under ultraviolet (UV) light irradiation. We also observed a positive photovoltage to the films, which evidences a hole carrier injection to the films. To explain this observation, we have proposed a simple picture where only hole carriers created by absorbing a light in the substrates are injected into the films through the interface, resulting in the large change in resistance. Here we apply the PCI method to a $YBa_2Cu_3O_{7-x}/SrTiO_3$:Nb heterostructure. We fabricated $YBa_2Cu_3O_{7-x}$ films on n-type $SrTiO_3$:Nb (100) (Nb: 0.05 wt%) substrates. The film thickness was 400 $\AA$. The film deposition was carried out in a vacuum chamber by using a pulsed laser deposition technique with a KrF excimer laser (λ = 248 nm). We measured the temperature dependence of in-plane resistance in the dark and under light irradiation. In the dark, the film exhibits superconductivity below a critical temperature T_c = 25 K. The T_c is lower than the optimum value (T_c = 90 K) of this material, suggesting that the film is underdoped with certain amount of oxygen vacancies. Under an UV light irradiation, the enhancement of T_c is observed up to T_c = 30 K with increasing light irradiance, accompanied with a decrease in resistance. These changes can be understood as a result of hole carrier injection to the film in the underdoping state by light irradiation. In fact, out-of-plane voltage measurements upon light irradiation reveal a large photovoltage of 1.2 V at room temperature, indicating that hole carriers are injected from the substrate to the film. The number of injected hole carriers into the film is estimated from the change of T_c to be 0.02 per Cu in $YBa_2Cu_3O_{7-x}$. The present PCI method would apply to many TMOs or other materials as a novel way for achieving dynamical hole doping or controlling phase transitions. **References** [1] Y. Muraoka *etal.*, J. Phys.: Condens. Matter **14** (2002) L757. [2] Y. Muraoka and Z. Hiroi, J. Phys. Soc. Jpn. **72** (2003) 781.

EE8.6
Long Range Ferromagnetic/Superconducting Proximity Effect in La0.3Ca0.7 MnO3/ YBa2Cu3O7 Superlattices. V. Pena[1], Z. Sefrioui[1], M. Varela[3], D. Arias[1], C. Leon[1], J.L. Martinez[2], S.J. Pennycook[3] and jacobo santamaria[1]; [1]GFMC. Fisica Aplicada III, U. Complutense, Madrid, Spain; [2]Instituto de Ciencia de Materiales de Madrid (ICMM-CSIC)., 28049 Cantoblanco. Madrid., Spain; [3]Condensed Matter Sciences Division, Oak Ridge National Laboratory, Oak Ridge,, Tennessee.

We have grown La0.3Ca0.7 MnO3(LCMO)/ YBa2Cu3O7 (YBCO) superlattices by high oxygen pressure sputtering technique epitaxially on (100) SrTiO3 changing the thickness of the individual layers between 1 and 15 nm]. A structural study using x-ray refinement and transmission electron microscopy shows sharp interfaces with a high degree of structural perfection]. Magnetization (SQUID) and transport measurements show the "coexistence" of magnetism and superconductivity. While the thinnest LCMO layers (3 unit cells) leaved the superconducting critical temperature almost unchanged, thicker LCMO layers result in a systematic reduction of the critical temperature over a wide thickness interval of the manganite layer.

These results suggest a long nanometer scale length for superconductivity depression into the ferromagnet We discuss this result in terms of the ferromagnetic /superconducting proximity effect. + Work supported by MCYT MAT 2000- 1468, Fundacion Ramon Areces, CAM.

EE8.7

Growth and Microstructural studies of YBa_2NbO_6 thin films. Srinivas Sathiraju[1,2], Kerry D Fields[2], Nicholas A Yust[2], Rama M Nekkanti[3,2], Lyle B Brunke[3,2], Angela L Campbell[4], Timothy J Haugan[2], Justin C Tolliver[2] and Paul N Barnes[2]; [1]National Research Council, Air Force Research Laboratory, Wright-Patterson AFB, Ohio; [2]Propulsion Research and Power Generation Branch, Air Force Research Laboratory, Wright-Patterson AFB, Ohio; [3]UES Inc. @WPAFB, Air Force Research Laboratory, Wright-Patterson AFB, Ohio; [4]MLPJE, Air Force Research Laboratory, Wright-Patterson AFB, Ohio.

The quality of superconducting films epitaxially grown highly depends on the substrate choice. It is well known that $SrTiO_3(100)$, $LaAlO_3(100)$, YSZ(100) and MgO(100) are suitable substrates for producing high quality superconducting thin films, especially $YBa_2Cu_3O_{7-x}$ (Y123). However, it has been reported that for 123 films deposited on MgO substrate, an interlayer of barium salt is formed at the interface if the processing temperature is above 700 ^oC [1] Also, another problem reported with the films grown on MgO is the presence of 45o in-plane misaligned grains [2,3] which degrades the crystalline quality of the deposited $RBa_2Cu_3O_{7-x}$(where R = Y, rare earths). A possible solution is to use a suitable buffer layer on the MgO substrate for the growth of the subsequent Y123 superconductor films. The same concept can be extended to coated conductor applications too. In this paper, we report the epitaxial growth of YBa_2NbO_6 (YBNO) as a new dielectric buffer layer on MgO (100) substrates for the subsequent deposition of Y123 thin films. YBNO has a cubic (a $\sim$ .82 nm) perovskite structure and has moderate dielectric properties [4]. Our results on the growth and microstructural characterization of Y-123 thin film on YBNO buffered MgO substrate will be discussed in detail. Extension of this buffer layer to other substrates will be considered.

EE8.8

Quantum Coherence In Y-Ba-Cu-O Superconducting Photoresponse. Ying Xu[1], Carlo Williams[2], Jan Mostowski[3] and Roman Sobolewski[1,3]; [1]Department of Electrical and Computer Engineering and Laboratory for Laser Energetics, University of Rochester, Rochester, New York; [2]Corning Inc, Corning, New York; [3]Institute of Physics, Polish Academy of Science, Warsaw, Poland.

Ultrafast optoelectronic photoresponse of high temperature superconductors (HTS) has been the subject of intensive studies since the discovery of these materials. The basic-physics research is focused on better understanding of the carrier dynamics in HTS materials, while applied-oriented work is aimed at promising applications, such as ultrafast photo-detection and photo-mixing. At temperatures far below the critical temperature, nonequilibrium kinetic inductive response has been observed in optimally doped, epitaxial Y-Ba-Cu-O microbridges, biased with the current lower than the bridge critical current and excited with 100-fs-wide optical pulses. The time-resolved voltage photoresponse signal consists of very pronounced, fast-damped picosecond oscillations. Only the initial, below 2-ps-wide bipolar transient, typical for the inductive signal, can be successfully simulated using the phenomenological Rothwarf-Taylor equations. We propose here a novel quantum coherence model to explain the picosecond time scale Cooper pair dynamics in Y-Ba-Cu-O thin films. Our model describes the coherent interaction between quasiparticles and the Cooper-pair boson exchange field and is in excellent agreement with our experimental results. The coherence between the quasiparticle and the boson subsystems is significant, with the coherence time of around 1 ps. The presented formulation can be regarded as a quantum-mechanical equivalent of the Rothwarf-Taylor equations. This work was supported by the NSF grant DMR-0073366. Y. X. acknowledges support from the Frank Horton Graduate Fellowship Program in Laser Energetics.

EE8.9

Magneto-Optical Studies of Thickness Dependence of Flux Pinning in YBCO Films Grown on Twinned LaAlO3 Substrates. Zu Xin Ye, Qiang Li and Weidong Si; Brookhaven National Lab, Upton, New York.

To investigate the pinning mechanisms which may be responsible for the generally observed thickness dependence of critical current density in YBCO coated conductors, we prepared a series of YBCO epitaxial films (0.2 to 1.6 micron thick) on heavily twined LaALO3 substrates by pulsed laser deposition. Magneto-optical imaging (MOI) techniques were used to map the pinning strength of the film at various magnetic field and temperature. A decrease of the averaged critical current density over the entire films was observed. At the location of the substrate twin boundaries, enhanced pinning in the thin films was observed, while a substantially weakened pinning was found in the 1.6 micron thick film. This remarkable evolution of pinning strength from strong to weak as the film thickness increases suggests that structural defects on the substrate played an important role in the critical current carrying capabilities of YBCO thick films. The nature of structural defects in YBCO films induced by these substrate twins is currently being investigated by the TEM on the same samples. We will discuss the correlation of the pinning behavior with the structural defects found in these films. *This work was supported by the U. S. Department of Energy, Division of Materials Sciences, Office of Basic Energy Sciences under contract No. DE-AC02-98CH10886.

EE8.10

99Ru Mossbauer Effect Studies of SrRuO3 Prepared with a Tc of 90K and 160K. Michael Joseph De Marco[1,2], Piotr W. Klamut[3,4], Dermot Coffey[1], Michael Haka[2], Steve Toorongian[2], Michael Maxwell[3] and Bogdan Dabrowski[3,4]; [1]Physics, Buffalo State College, Buffalo, New York; [2]Physics, University at Buffalo, Buffalo, New York; [3]Physics, Northern Illinois University, DeKalb, Illinois; [4]Material Science, Argonne National Laboratory, Argonne, Illinois.

SrRuO3 has a crystal structure which is compatible with high Tc and ferroelectric compounds and has become a candidate for technological applications as a substrate. It also is similar in structure to Sr2RuO4 and other ruthenate cuprate superconductors. In this study SrRuO3 has been prepared in the standard manner and has a TC of 160K as measured by magnetization. The 99Ru Mossbauer effect shows a well-resolved hyperfine magnetic field of 33T at 4.2K and a single narrow line at 160.4(.4)K. SrRuO3 prepared under pressure produces a TC = 90K as measured by magnetization. The Mossbauer measurement shows a distribution of hyperfine magnetic fields at 4.2K. Mossbauer measurements were made for both TC samples at 97K. The TC =160K sample showed a hyperfine magnetic field while the reduced TC sample showed a single broadened line indicative of a phase transition. The SrRuO3 sample with a TC = 90K was annealed at ambient pressure to reproduce a TC =155K as measured by ac and dc magnetization. Mossbauer measurements show a well-resolved hyperfine magnetic field at 4.2K and a single narrow line at 160.7(0.5K) above the critical temperature.

EE8.11

Photoemission Studies of $YBa_2Cu_3O_{7-\delta}$ Single Crystals Employing X-ray Standing Waves. Sebastian Thiess[1], Tien-Lin Lee[1], Chengtian T. Lin[2], Bruce C.C. Cowie[1], Nicholas Brookes[1], Christof Kunz[1] and Joerg Zegenhagen[1]; [1]ESRF, Grenoble, France; [2]MPI-FKF, Stuttgart, Germany.

The x-ray standing wave (XSW) technique uses an interference field typically generated by the superposition of the incident and the reflected x-ray beam during Bragg reflection. Monitoring the photoabsorption process via e.g. photoemission, real space structural information about specific elements inside or on the surface of a crystal can be obtained. Monitoring photoemission from the valence band, the partial density of states of the valence band at particular sites within the unit cell can be determined. We have measured core level and valence band photoemission excited by an XSW from high temperature superconductor $YBa_2Cu_3O_{7-\delta}$ (YBCO) single crystals. Clean crystal surfaces were prepared by cleavage in UHV at temperatures below 40K. XSW measurements were performed at low temperature and at room temperature using several YBCO(00l) reflections ranging from l = 1 at 0.5 keV up to l = 7 at 3.7 keV photon energy. XSW results for core level and valence band emission will be presented. The results of different surface preparation procedures will be discussed.

EE8.12

Search for Time-Reversal Symmetry-Breaking States in Cuprate Superconductors. Sheng-Chiang Lee and Steven M. Anlage; Physics, Center for Superconductivity Research, University of Maryland, College Park, Maryland.

Many theories predict a Time-Reversal Symmetry Broken (TRSB) state in unconventional superconductors. For example, Varma's micro-current model in under-doped high temperature superconductors (HTSC), and Andreev bound states on certain surfaces of HTSC, are expected to show some manifestations of TRSB, perhaps only near surfaces and interfaces. However, experimentally, the question of TRSB in HTSC is still controversial. Previous work has shown that our magnetically enhanced Near-Field Microwave Microscope is sensitive to TRSB arising from Josephson vortices in a long bi-crystal grain boundary junction, through measurement of second harmonic generation. [Appl. Phys. Lett. 82, 1893 (2003)] Taking advantage of this microscope, this work presents our study of [001] surfaces of under-doped $YBa_2Cu_3O_{7-\delta}$ (YBCO), and [110] surface of YBCO, which are proposed to display TRSB in

harmonic response. The oxygen content of the under-doped YBCO is adjusted so that the change due to different doping level is also explored. We find that under-doped YBCO films are inherently more nonlinear in both TRS (cond-mat/0306416) and TRSB channels. We will demonstrate the doping-dependent temperature and power dependencies of the locally generated second and third order harmonic generation measured from the films with relevant models. We acknowledge the support of NSF GOALI DMR-0201261, and the Maryland/Rutgers/NSF MRSEC DMR-0080008.

EE8.13
Crystal Growth and Superconductivity of La-2126 Superconducting Materials. Genda Gu[1], M. Hucker[1], Y-J. Kim[1], H. Dabkowska[3], G.M. Luke[3], T. Timusk[3], B.D. Gaulin[3], Q. Li[2], A.R. Moodenbaugh[2] and J.M. Tranquada[1]; [1]Physics Department, Brookhaven National Laboratory, Upton, New York; [2]. Materials Science Department, Brookhaven National Laboratory, Upton, New York; [3]Department of Physics and Astronomy, McMaster University, Hamilton, Ontario, Canada.

The effect of growth condition and composition on the crystal growth of La-2126 phase superconducting materials has been studied by the floating zone method. The compositions of La-2126 phase single crystals prepared were$(La_{1-x}Ca_x)_2CaCu_2O_{6+y}$ (x = 0.05 to 0.09) and $(La_{1-x}Sr_x)_2CaCu_2O_{6+y}$ (x =0.075 to 0.25). The crystals were grown under oxygen pressures of 1 and 11bars. A planar solid-liquid growth interface of $(La_{1-x}Ca_x)_2CaCu_2O_{6+y}$ (x = 0.05 to 0.06) and $(La_{1-x}Sr_x)_2CaCu_2O_{6+y}$ (x =0.075) tended to break down into a cellular interface when the growth velocity was higher than 0.5 mm/h. When the planar solid-liquid growth interface broke down into a cellular interface, the single crystal size in an as-grown rod decreased abruptly and the as-grown rod was not of single phase. Various small sizes of CaO second phases were found inside the as-grown single crystals of $(La_{1-x}Ca_x)_2CaCu_2O_{6+y}$ (x >=0.075) and $(La_{1-x}Sr_x)_2CaCu_2O_{6+y}$ (x >=0.125). Based on the occurrence of these second phases CaO inside the as-grown crystals, the estimated solubility of as-grown single crystals is x <0.075 for $(La_{1-x}Ca_x)_2CaCu_2O_{6+y}$ and x<=0.125 for $(La_{1-x}Sr_x)_2CaCu_2O_{6+y}$ respectively. The melting point of the La-2126 materials increases with increasing oxygen pressure. Cubic centimeter size single crystals were successfully grown for both $(La_{1-x}Ca_x)_2CaCu_2O_{6+y}$ (x <0.075) and $(La_{1-x}Sr_x)_2CaCu_2O_{6+y}$ (x =0.075). The as-grown single crystals of $(La_{1-x}Ca_x)_2CaCu_2O_{6+y}$ under 1 bar pressure of oxygen were not superconducting. The superconducting transition temperature of the as-grown $(La_{1-x}Sr_x)_2CaCu_2O_{6+y}$ single crystals, grown at 11 bars oxygen pressure increases with increasing the Sr concentration x from Tc = 28K (x=0.075) to Tc =46K (x=0.25). The work was supported by the DOE under contract No. DE-AC02-98CH10886.

EE8.14
$Ru_{1-x}Sr_2Eu_{1.5}Ce_{0.5}Cu_{2+x}O_{10-d}$ 1222-type ruthenocuprates. Tuning the magnetic and superconducting properties with Cu→Ru substitution and oxygen content. Piotr W. Klamut[1,2], J Mais[1], M Maxwell[1], B Dabrowski[1,2], I Felner[3], U Asaf[3] and F Ritter[3]; [1]Department of Physics, Northern Illinois University, DeKalb, Illinois; [2]Materials Science Division, Argonne National Laboratory, Argonne, Illinois; [3]Racah Institute of Physics, The Hebrew University of Jeruzalem, Jeruzalem, Israel.

The 1222-type magnetic superconductors are extensively investigated for the microscopic coexistence of magnetism and superconductivity observed therein. In superconducting (T_c=47 K) $RuSr_2Eu_{1.5}Ce_{0.5}Cu_2O_{10-d}$ the magnetically ordered state develops below 120 K with transition to weak ferromagnet characteristics at approx. 90 K. In analogy to previously found $Ru_{1-x}Sr_2RECu_{2+x}O_{8-y}$ (RE=Gd, Eu) phases of the 1212-type, we have performed high pressure oxygen annealing for stabilizing the 1222-type structure of the $Ru_{1-x}Sr_2Eu_{1.5}Ce_{0.5}Cu_{2+x}O_{10-d}$ system. Accomplishing dilution of the Ru sublattice with Cu atoms leads to progressive weakening of the magnetic order and as a consequence the compound becomes a nonmagnetic superconductor for x=0.4. Subsequent change of the oxygen content d, traced in thermogravimetric annealings at various partial pressures of oxygen, tunes the T_c, and affects magnetic characteristics of the series. Measurements of ac susceptibility in the superimposed dc field led us to the field dependence of the critical currents, as well as the inter- vs. intragranular superconducting characteristics of these systems. Research at Northern Illinois University was supported by the National Science Foundation (DMR-0105398), and at Hebrew University by the Israel Science Foundation (2000).

EE8.15
Superconductor Properties of NbSe2 Samples After Submitted to Different Doses of Electron Irradiation. Donald H. Galvan[1,2], William Yuhasz[2], Jun Ho Kim[3], Esbaide Adem[4] and M. Bryan Maple[2]; [1]Fisico Quimica, Centro de Ciencias de la Materia Condensada-UNAM, Ensenada, Baja California Norte, Mexico; [2]Physics Department and Institute of Pure and Applied Physical Sciences, University of California, San Diego, California; [3]Telecommunication Basic Research Laboratory, 161 Kajong-Long Yusong-Gu 305-350, Korea, South Korea; [4]Instituto de Fisica-UNAM, Mexico, D. F., Mexico.

We present experimental evidence for an increased pinning effect in the superconductor NbSe2. NbSe2 samples underwent 100, 250 and 500 Mrad of electron irradiation and then were studied with x-ray diffraction and magnetic susceptibility measurements. The magnetization measurements of the NbSe2 samples revealed an enhancement in the critical current density with radiation dosage. This enhancement reached a maximum value at 500 Mrad with almost double the Jc of the unirradiated material. This enhancement indicates that the irradiation is causing more effective flux pinning in the material. Furthermore, the Tc (superconductor transition temperature) was continuously monitored for all samples with no observable change due to irradiation.

EE8.16
Single Domain YBa2Cu3Ox for RF Cavity Filters. Altan Feredeci[1], Hari Babu[2], David Cardwell[2], David Mast[1] and Donglu Shi[1]; [1]Chemical and Materials Engineering, University of Cincinnati, Cincinnati, Ohio; [2]IRC in Superconductivity, University of Cambridge, Cambridge, United Kingdom.

Large single domain YBa2Cu3Ox materials have been successfully fabricated with superb RF properties by employing the seeded-melt growth (SMG) method. Commercially available Y-123 and Y-211 phase precursor powders were mixed thoroughly and pressed into various cylindrical cavity shapes. Following the growth procedure, the cavities were then oxygenated in an oven for at least 7 days. The cavities were then tested in a closed cycle cryocooler from room temperature down to 20K. Using a Vector Network Analyzer, the cavity resonance frequencies and the quality factors (Q values) were measured. Two cavity modes, TM010 and TE111 modes, were used for the measurements. From the measured Q values, the surface resistances of the cavity surfaces were calculated. Measured results and various combinations of cavity structures for realizing highly selective RF filters will be presented.

EE8.17
The Internal Oxidation in Solid Solutions Based on Bi2Sr2CaCu2O8 with Simultaneous Substitution Bi on Pb and Ca or Sr on Rare Earth Elements. Alexander V Knotko[1], Farit G Shayhutdinov[1], Valery I Putlayev[1], Alexey V Garshev[2], Maxim N Pulkin[2], Natalya M Privalova[3] and Serguey I Morozov[4]; [1]Dept of Chemistry, Moscow State Univ, Moscow, Russian Federation; [2]Dept of Material Sciences, Moscow State Univ, Moscow, Russian Federation; [3]Russian Univ of Chemistry and Technology, Moscow, Russian Federation; [4]Inst of Physics and Power Engineering, Obninsk, Kaluga reg., Russian Federation.

Phase transformations in high-Tc materials leading to a formation of "superconductor(matrix)/non-superconductive inclusion" composite is a prospective way to improve pinning properties of the materials. Since a cation diffusion in Bi2Sr2CaCu2O8 (Bi-2212) based compounds is quite sluggish at under-melting temperature, phase transformations in Bi-2212 solid soluions can be triggered off by oxidation of aliovalent cations incorporated into such solutions. To control the process one can perform simultaneous substitution in different cation sites (e.g., Bi on Pb and Ca or Sr on rare earth elements). Solid solutions of Bi(2-x)Pb(x)Sr2Ca(1-y-z)Y(y)Nd(z)Cu2O(8+d) (x = 0.6, y = 0; x = 0.4 - 0.8, y(z) = 0.2 - 0.4) were fabricated at 760C in N2-flow. Samples were tested with XRD, TEM, inelastic neutron scattering and AC-susceptibility measurement. Earlier for solid solutions Bi(2-x)Pb(x)Sr2CaCu2O(8+d) the two-stage oxidation process was found, at that the first stage can related to the oxygen redistribution and second - to cationic one. The substitution of Ca on Y or Nd significantly decelerates of the first stage of the oxidation and therefore allows to escape the a coarsening of the obtained spinodal decomposition microstructure. A difference between the homogeneity areas of Pb - containing solid solutions based on Bi-2212 with substitution Ca on Y and Nd was established. This difference probably related to the several distribution of Y and Nd in crystallographic cationic sites of Bi-2212 structure (because to the distinction of its ionic radiuses). The phonon spectra of solid solution Bi(2-x)Pb(x)Sr2Ca(1-y)Y(y)Cu2O(8+d) (x = 0.6, y = 0 and x = 0.8, y = 0.2) was investigated by the inelastic neutron scattering on the direct geometry spectrometer DIN-2PI (installed on neutron beam of pulse reactor IBR-2, FLNP JINR, Dubna, Russia). Comparison of the high frequency parts of phonon density of states spectra (related to oxygen vibrations) allows to make the conclusion concerning the nature of substitution effect on oxidation kinetics of Pb-doped solutions. The work was supported by Russian Foundation for Basic Research (grant #02-03-33270a), National Program "High-priority

problems of condensed matter" (subprogram "Neutron researches of condensed matter").

EE8.18
Atomic force microscopy and transmission electron microscopy studies on (Hg,Re)Ba2CaCu2Oy thin films deposited on Ag via laser ablation. Jianhua Su[1,2] and Justin Schwartz[1,2,3]; [1]Magnet Science and Technology, National High Magnetic Field Laboratory, Tallahassee, Florida; [2]Mechanical Engineering, FAMU-FSU College of Engineering, Tallahassee, Florida; [3]Center for Advanced Power Systems, Tallahassee, Florida.

(Hg,Re)Ba2CaCu2Oy ((Hg,Re)-1212) thin films were fabricated on Ag by reacting laser deposited Re0.2Ba2CaCu2Oy precursor films with CaHgO2 in sealed quartz tubes. The as-prepared thin films with thickness up to 1 micron exhibited good c-axis-oriented texture and an on-set superconducting transition temperature (Tc) of 124 K. The influence of the Ag interface on the nucleation and growth of the (Hg,Re)-1212 thin films have been analyzed using transmission electron microscopy (TEM). The TEM investigation showed that the (Hg,Re)-1212 thin film usually nucleates and grows on the flat areas of the Ag surface with its a-b plane simply parallel to the Ag-surface plane, regardless of whether the Ag-surface is a low-index or high-index crystal plane. On defective surfaces, such as surface valleys or hills, however, the (Hg, Re)-1212 thin film cannot grow directly, instead, there is an intermediate layer with some other oxide phases. The atomic force microscope (AFM) images of thin films showed a two-dimensional terraced layer-by-layer growth mode. The growth unit is multiple-unit-cell in the c direction. No example of spiral growth, which was thought to be the typical structure of YBCO thin films, was found in these thin films.

EE8.19
Abstract Withdrawn

EE8.20
Transport properties of Ag and Au doped YBCO superconducting samples. Julio E. Rodriguez and Alvaro Marino; Department of Physics, Universidad Nacional de Colombia, Bogota, Colombia.

Polycrystalline samples of Ag and Au doped YBCO superconducting samples were synthetized from oxides by solid-state reaction. Electrical resistivity, ρ(T), thermoelectric power, S(T) and thermal conductivity, k(T) were measured in the temperature range between 77K and 300K. The doping content increases both ρ(T) and S(T) while the thermal conductivity decreases. On the other hand the dimensionless figure of merit ZT(T) shows an enhancement more than one order of magnitude with the doping.

EE8.21
Abstract Withdrawn

EE8.22
In-situ RHEED observation of yttria incorporation in laser-ablated YBCO thin films. Radoslav A Chakalov[1], Chris Jeynes[2], Pavel Mikheenko[1], Mark S Colclough[1] and Chris M Muirhead[1]; [1]Physics and Astronomy, The University of Birmingham, Birmingham, United Kingdom; [2]University of Surrey Ion Beam Centre, University of Surrey, Guildford, United Kingdom.

Pulsed laser ablation of single stoichiometric target is widely used as gainful method for deposition of excellent YBCO thin films. However, the crystal lattice quality at microscopic level still needs improvement. Common problem is the formation of secondary phase inclusions in a stoichiometric film matrix, especially as the technique is limited in means of elemental composition variation. We have used in-situ RHEED observation of YBCO thin film growth in combination with post-deposition analysis by XRD and RBS to study film compositional and crystallographic peculiarities. It was found that samples prepared under optimal conditions (in terms of high critical temperature and high critical current density) show additional set of diffraction spots in the RHEED patterns. We were not successful in correlating these spots with any feasible YBCO surface reconstruction. While XRD evidenced for highly-oriented YBCO crystal lattice with no secondary phases, elemental depth profiling by RBS clearly showed small excess of yttria distributed homogeneously over the film thickness. More detailed consideration of the electron diffractograms proved that the two sets of spots originate from YBCO and yttria sublattices epitaxially related as (001)YBCO/(001)yttria, [100]YBCO/[110] yttria. Such ordered incorporations may have acted as pinning centres and resulted in the best superconducting properties observed.

EE8.23
YBa2Cu3O7 and DyBa2Cu3O7 superconducting thick films produced by an electrophoretic deposition method: investigation of a new process for getting optimised large-scale magnetic screening systems. Rudi G. Cloots[1], Laurent Dusoulier[1], Philippe Vanderbemden[3] and Marcel Ausloos[2]; [1]Chemistry department, University of Liege, Sart-Tilman, Belgium; [2]Physics department, University of Liege, Sart-Tilman, Belgium; [3]Electricity department, University of Liege, Sart-Tilman, Belgium.

Thick films of superconducting materials were fabricated by an electrophoretic deposition method. This technique allows us to produce complex shape of superconducting devices for magnetic screening. Nickel or stainless steel electrodes were used in the presence or not of a buffer layer. YBCO and DyBCO powders were prepared by a classical solid state reaction and dispersed in acetone for electrophoretic deposition. Experimental parameters (e.g. voltage, size of the electrodes, size distribution of the superconducting particles) were investigated and the process has been optimised based on microstructure analyses, leading to a crack-free adherent deposit at the surface of the electrodes. Superconducting properties have been reported for the best samples.

EE8.24
Nd-422 doped Dy-123 superconducting single domain produced by the top-seeded melt-growth process: a better control of the dissolution of the Nd-123 single crystal seed. Philippe Vanderbemden[3], Jean-Philippe Mathieu[1], Jean-Francois Fagnard[3], Marcel Ausloos[2] and Rudi G. Cloots[1]; [1]Chemistry Department, University of Liege, Sart-Tilman, Belgium; [2]Physics Department, University of Liege, Sart-Tilman, Belgium; [3]Electricity Department, University of Liege, Sart-Tilman, Belgium.

Several factors limit the manufacture of large 123 superconducting single domains produced by an isothermal top-seeded melt-growth process. The partial dissolution of the Nd-123 single crystal seed leads to secondary nucleation sites which limit severely the growth of the 123 single-domain. The addition of a few percent of Nd-422 to the bulk is proved as a beneficial action to avoid the dissolution of the seed. Perfectly oriented 123 single-domains in a square shape can be manufactured and are characterized by good superconducting properties. Levitation forces and critical current density are reported for the best samples. A microstructural investigation of the distribution of the Nd-422 particles and their reactivity with the 123 matrix and Dy-211 particles is also presented

EE8.25
Comparative studies on the properties of Y1Ba2Cu3O7 films and Sm1Ba2Cu3O7 films. Dojun Youm, Physics, KAIST, Daejon, South Korea.

We comparatively studied the growth properties and the superconducting properties of Y1Ba2Cu3O7 (YBCO) films and Sm1Ba2Cu3O7 (SBCO) films deposited on buffered and biaxially textured Ni tapes. The window of substrate temperature for proper growth of SBCO films was several times wider than that of YBCO. The appropriate oxygen pressure for SBCO film growth was about 20 times lower than that of YBCO. The critical current density (Jc) of SBCO film at zero field was 2 times smaller than that of YBCO. However, above 3 teslar of external field, Jc of SBCO was always larger than that of YBCO. The reduction rate of Jc of SBCO film at the grain boundaries of high angle misorientation was one order of magnitude smaller than that of YBCO. All of these properties indicate that it should be considered to develope the fabrication technology of SBCO based coated conductors in stead of YBCO based coated conductors.

EE8.26
Fabrication and Transport Properties of High Quality ErBa2Cu3O7-d Films By Pulsed Laser Deposition. Masashi Mukaida[1,6], Tall Ohazama[1,6], Shigeru Horii[2,6], Kaname Matsumoto[3,6], Yutaka Yoshida[4,6], Ataru Ichinose[5,6], Atsushi Saito[1] and Shigetoshi Ohshima[1]; [1]Electrical Engineering, Yamagata University, Yonezawa, Yamagata, Japan; [2]Supercond., University of Tokyo, Bunkyo-ku, Tokyo, Japan; [3]Materials Sci. and Eng., Kyoto University, Sakyo-ku, Kyoto, Japan; [4]Energy Eng. and Sci., Nagoya University, Chikusa-ku, Aichi, Japan; [5]Electrical Phys., CRIEPI, Komae, Tokyo, Japan; [6]JST Corporation, Kawaguchi, Saitama, Japan.

Fabrication and transport property measurements of ErBa2Cu3O7-d films are discussed. Since the discovery of REBa2Cu3O7-d superconductors superconducting thin films have been fabricated to achieve high JC. In order to attain high JC, the superconductors must be high quality and they have strong pinning centers. Among the REBa2Cu3O7-d superconductors, ErBa2Cu3O7-d is one of the easiest materials to dope carriers with oxidization.* In other words, homogeneous films are easy to obtain for ErBa2Cu3O7-d films with respect to carrier doping. Then we selected ErBa2Cu3O7-d as a mother film for introduction of strong pinning centers. ErBa2Cu3O7-d films are grown by conventional pulsed laser deposition with ArF

excimer laser on (100) SrTiO3 substrates. Crystallinity of ErBa2Cu3O7-d films is examined by x-ray diffraction and x-ray phi-scan for crystal orientation, AFM and FE-SEM observation for surface morphologies. Superconductive shielding characteristics are evaluated by MO images. Transport properties are characterized by a four-probe-method in a magnetic field. Surface resistance of the films is measured by a dielectric resonator method at 38GHz. Consequently, obtained as-grown ErBa2Cu3O7-d films were homogeneous in superconductive shielding characteristics as observed by MO images and showed low surface resistance around, however the JC of the films was very low around 0.3MA/cm2. We believe there are no effective pinning centers in the as-grown films. We have increased the JC of the film by oxygen annealing. At the optimum annealing condition, the JC of the film was almost one order of magnitude enlarged to ~3MA/cm2. In this presentation we will also discuss preliminary results on the artificial pinning center introduction to the films by electron beam lithography. Reference: *J. Shimoyama et al., Mat. Res. Soc. Symp. Proc., 659 (2001) 265-270.

EE8.27
Phase Relations in the Ba-R-Cu-O (R = Nd, Sm, Eu, Gd, Ho, Y, and Er) Systems Prepared Under Atmospherically-Controlled Conditions.
Winnie Kwai-Wah Wong-Ng, Julia Suh and Lawrence P. Cook; Ceramics, NIST, Gaithersburg, Maryland.

Phase diagrams provide guidelines for processing of high-temperature materials. For the applications of the second-generation coated conductors, it is critical to build a phase diagram database for the barium-yttrium-copper-oxide and the lanthanide-substituted materials. Research is being carried out at NIST as part of a DoE-funded project to construct phase diagrams of the carbonate-free Ba-R-Cu-O (R=Nd, Sm, Eu, Gd, Ho, Y, and Er) systems under atmospherically-controlled conditions (purified air and 100 Pa oxygen partial pressure). A special experimental procedure was used for preparing BaO starting material and for the handling and heat-treatment of samples. In this paper, a discussion of the crystal chemistry and phase relationships of phases found in these systems will be presented. A comprehensive comparison of these diagrams as well as with those that were prepared under different atmospheric conditions will be summarized.

EE8.28
Femtosecond Carrier Dynamics In Hg-Based Superconducting Thin Films. Ying Xu[1], Xia Li[1], Stefan Chromik[2], Vladimir Strbik[2], Dominique De Barros[4], Philippe Odier[4] and Roman Sobolewski[1,3]; [1]Department of Electrical and Computer Engineering and Laboratory for Laser Energetics, University of Rochester, Rochester, New York; [2]Institute of Electrical Engineering, Slovak Academy of Science, Bratislava, Slovakia; [3]Institute of Physics, Polish Academy of Science, Bratislava, Poland; [4]Laboratoire de Cristallographie-CNRS, Grenoble, France.

Superconducting thin films of Hg-based cuprates were fabricated and tested using a time-resolved, femtosecond optical pump and probe spectroscopy. The films (500-nm thick) were prepared from rf-magnetron sputtered Re-Ba-Ca-Cu-O precursor films, followed by an ex-situ mercuration process to form the superconducting phase. The XRD analyses indicated that the resulting films were predominantly composed of c-axis oriented Hg-1212 and Hg-1223 phases. Their superconducting transition was rather broad with the onset at 136 K and the zero resistance value at 116 K. The time-resolved optical pump-probe measurements were performed using 100-fs-wide pulses, generated from a Ti:sapphire laser operating at the 800-nm wavelength. The relative change of the probe-beam reflectivity was measured in the temperature range between room temperature and 10 K. The room temperature signal was characterized as a single-exponential subpicosend relaxation and was independent of the incident optical excitation power. With decreasing the temperature below the superconducting transition, the carrier relaxation process became significant slower. At 10 K, at the lowest optical excitation power (1 mW), the relaxation was characterized by a decay time constant of ~10 ps. The increase of the optical power lead to a gradual change in the quasiparticle relaxation process, eventually leading at 10 mW to the bi-exponential relaxation with the initial decay time of <3 ps, followed the >10-ps component. This work was supported by the NSF grant DMR-0073366 (Rochester) and the Slovak Scientific Grant Agency (grant VEGA 2/2068/22). Y. X. acknowledges support from the Frank Horton Graduate Fellowship Program in Laser Energetics and X. L. acknowledges support from the Sproull Fellowship.

EE8.29
Enhancement of Flux Pinning Properties on Impurity-Doped Bi(Pb)2212 Single Crystals. Shigeru Horii[1], Masanao Shigemori[1], Satoshi Uchida[1], Takenari Sugioka[1], Jun-ichi Shimoyama[1,2] and Kohji Kishio[1]; [1]Dept. of Superconductivity, Univ. of Tokyo, Tokyo, Japan; [2]PRESTO-JST, Saitama, Japan.

Critical current properties of Bi2212 were dramatically improved by heavily lead-doping and control of oxygen contents. This improvement can be understood in terms of decrease of electromagnetic anisotropy and generation of lamella structures. For further improvement of critical current properties in Bi(Pb)2212 system, in the present study, doping of small amount of impurities in CuO_2 plane which generates locally weak superconducting region were attempted. Critical temperatures of grown crystals by the floating zone method with nominal compositions of $Bi_{1.6}Pb_{0.6}Sr_{1.8}Ca(Cu_{1-x}M_x)_2O_y$ (M = Co, Ni, Fe; x = 0, 0.002, 0.005, 0.02) were drastically decreased with the M-doping levels, while the Bi(Pb)2212 crystals with x = 0.002 and 0.005 showed remarkably enhanced flux pinning properties below 50 K. This is indicating that point-defect-type pinning sites were successfully introduced by small amount of M-doping. Similarly with x = 0, these crystals showed both anisotropic behavior of inplane J_c and temperature-induced pinning effect.

EE8.30
Substitution of Yttrium Atoms in $YBa_2Cu_3O_{7-\delta}$ by Rare Earth Elements: An Investigation into the Impact on Critical Current Density and Superconducting Transition Temperature. Joan Marie Raitano[1], Siu-Wai Chan[1], Robert Laibowitz[2] and Hao-Yung Chao[1]; [1]Department of Applied Physics and Applied Mathematics, Columbia University, New York, New York; [2]Department of Electrical Engineering, Columbia University, New York, New York.

Using the trifluoroacetic acid and metal organic deposition (TFA and MOD) methods, thin films of $YBa_2Cu_3O_{7-\delta}$ (Y123) with yttrium substituted by rare earth elements having 3+ oxidation states, including samarium, dysprosium and erbium, were prepared. With the differences in radii of the dopants and orthorhombicity of each unit cell in mind, the resulting films were compared to each other and to undoped samples by x-ray diffraction, scanning electron microscopy, and transmission electron microscopy (i.e., XRD, SEM, and TEM, respectively). The superconducting transition temperatures and critical current densities, measured with a four-probe setup, were determined as well. The results and their implications will be discussed.

EE8.31
Inclusion of 211 Nanoparticles by Island-growth in $(211_{\sim 1nm}/123_{\sim 10nm})$xN Multilayer Composite Structures to Enhance the Physical-Electrical-Magnetic Properties of $YBa_2Cu_3O_{7-x}$ Thin Films. Timothy John Haugan[1], P. N. Barnes[1], J. C. Tolliver[1], R. M. Nekkanti[1], J. P. Murphy[1], J. M. Evans[1], L. B. Brunke[1], A. L. Westerfield[1], S. Sathiraju[1], I. Maartense[1], T. L. Peterson[1], M. Sumption[2], L. Heatherly[3] and A. Goyal[3]; [1]Propulsion Directorate, Power Group, U.S. Air Force Research Laboratory, Wright-Patterson AFB, Ohio; [2]Department of Materials Science and Engineering, Ohio State University, Columbus, Ohio; [3]Superconducting Materials Group, Oak Ridge National Laboratories, Oak Ridge, Tennessee.

The inclusion of Y_2BaCuO_5 (211) phase nanoparticles by island-growth deposition into multilayer nanosized structures was investigated to enhance the physical-mechanical, electrical and magnetic properties of $YBa_2Cu_3O_{7-x}$ (123) thin films, for possible use in coated conductor superconductor applications. Multilayer (211/123)xN composite films were deposited by pulsed laser deposition onto $LaAlO_3$, $SrTiO_3$, or buffer-coated biaxially textured Ni or Ni-alloy substrates. The 211 average particle thickness was between 1.0-4.0 nm, with the 123 layer thickness varying from 4-20 nm and the total composite film thickness up to 3 microns (N=200 bi-layers). The inclusion of 211 nanoparticles into 123 films was observed to enhance film properties including providing an unusually smooth surface allowing thicker film growth. Improvement of transport critical current densities Jc(H,T) properties ranged from 100-500 % in magnetic fields of about 1.5 T and temperatures between 20-70 K. Additional enhancements of these film structures will be presented including the dependence of J_c (H,Θ) on angle variations, as well as mechanical strength and crack resistance properties of the films.

EE8.32
Atomic Structure of $GdBa_2Cu_3O_{7-\delta}$/ $NdGaO_3$(001) Interface Probed by Photoemission and X-ray Standing Waves. Sebastian Thiess[1], Tien-Lin Lee[1], Lixin Cao[1], Samantha Warren[1], Bruce C.C. Cowie[1] and Joerg Zegenhagen[1]; [1]ESRF, Grenoble, France; [2]MPI-FKF, Stuttgart, Germany.

Understanding the relationship between growth, structure and electronic properties of high temperature superconductor (HTS) epitaxial thin films is of prime importance from a fundamental point of view as well as for future applications. For probing electronic properties of materials photoemission has been widely used. With photoemission from core states and the valence-band excited by an

x-ray standing wave (XSW) field, lattice-site-specific electronic information - originally not available from standard XPS - can be obtained. The XSW method allows identifying the chemical origin of different features observed in photoemission spectra. In the present study, we employed the XSW technique to characterize the interfacial structure as well as the electronic properties of epitaxial HTS films. Ultra-thin films of 90K superconductors $ReBa_2Cu_3O_{7-\delta}$ (Re = Gd, Y) were grown by pulsed-laser deposition on perovskite $NdGaO_3(001)$ and $SrTiO_3(001)$ single crystal substrates. Measurements were carried out at room temperature at beamline ID32 of the ESRF using a photon energy of 3.2 keV. The XSW analysis determines the CuO-NdO interfacial distance to be 0.19 nm, which is identical to the NdO-GaO_2 spacing of $NdGaO_3(001)$. The GdBCO valence band and the Cu2p core level signals show identical XSW modulations; this suggests a dominating Cu contribution to the valence band yield. A chemically shifted O1s peak towards higher binding energy is indicative of surface contamination due to air exposure during the transfer.

EE8.33
Flux pinning behavior and positron annihilation study on (Pb,Sn)-doped Bi-2212 superconductors. Yang Li, [1]Department of Materials Physics, University of Science and Technology Beijing, Beijing, China; [2]Laboratory of Nuclear Analysis Techniques, Chinese Academy of Science, Beijing, China; [3]Physics, Texas A&M University, College Station, Texas; [4]Center for High Temperature Superconductivity, Blackett Laboratory, Imperial College of Science, Technology and Medicine, London, United Kingdom.

The flux pinning behavior of (Pb,Sn)-doping on $Bi_{1.6-x}SnxPb_{0.4}Sr_2CaCu_2O_y$ and $Bi_{2-2x}Pb_xSn_xSr_2CaCu_2O_y$ have been studied by using magnetic measurements, positron annihilation techniques (PAT), scanning electron microscopy and X-ray diffraction. Analysis shows that most of (Pb,Sn) dopants enter the Bi-2212 lattice and occupy Bi sites. The PAT result shows that the electron concentration on Bi-O layers increases with Sn doping in $Bi_{1.6-x}Sn_xPb_{0.4}Sr_2CaCu_2O_y$ samples, and Sn-doping improves the conductive property of Bi-layers. The magnetic properties of ceramic samples of $Bi_{2-2x}Pb_xSn_xSr_2CaCu_2O_y$ superconductors have been investigated using a vibrating sample magnetometer (VSM) from 20 to 50 K and up to 8 T. Magnetization hysteresis loops of the (Pb,Sn)-doped sample exhibit strong pinning behavior in the higher temperature range, close to 50 K. We discuss the experimental results within a model of (Pb,Sn)-cluster pinning in blocking layers. Doping by (Pb,Sn) clusters into the Bi-O layers provides effective pinning centers, as well as a large reduction of the resistivity anisotropy. This work supported by EYTP, Natural Science Foundation of China, UK Engineering and Physical Sciences Research Council, the Robert A. Welch Foundation and the NSF.

SESSION EE9: Basic Properties/RF Properties
Chairs: Jim Eckstein and John Talvacchio
Thursday Morning, December 4, 2003
Fairfax A (Sheraton)

8:30 AM *EE9.1
Enhanced Tc Near the Metal/Insulator Transition: A New Tool in the Search for Superconducting Materials.
Michael Osofsky and Robert J. Soulen; code 6340, Naval Research Laboratory, Washington, District of Columbia.

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 (such as Tc versus e/a or versus the residual resistance ratio for low Tc superconductors and Tc versus number of Cu-O layers in high Tc superconductors) 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 (disordered metals, oxide conductors (including high temperature superconductors), semiconducting materials, organic conductors and various forms of C60), whose only common feature is proximity to a metal/insulator transition (MIT), share a common phase diagram. This remarkable phenomenon 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. These results can be used to optimize Tc for any novel system with a MIT, thus providing the basis for a new paradigm in the search for new superconducting materials.

9:00 AM *EE9.2
Fourier Transform Scanning Tunnelling Spectroscopy (FT-STS) Studies of Electronic Structure in the Cuprates.
J. C. Seamus Davis[1], K. McElroy[1,2], J. E. Hoffman[2], D.-H. Lee[2], H. Eisaki[3] and S. Uchida[4]; [1]Dept. of Physics, Cornell University, Ithaca, New York; [2]Dept. of Physics, University of California-Berkeley, Berkeley, California; [3]AIST, Tsukuba, Ibaraki, Japan; [4]Dept. of Physics, University of Tokyo, Tokyo, Japan.

In Fourier transform scanning tunnelling spectroscopy (FT-STS) the STM tip-sample differential tunnelling conductance ($g = dI/dV$) is mapped at each bias voltage V. The result, $g(r,\omega)$, is proportional to $LDOS(r\prime,\omega)$, the local density of states at location $r\prime$and energy $\omega = eV$. The q-vectors of any spatial modulations in are then determined from the locations of peaks in $g(q,\omega)$, the Fourier transform magnitude of $g(r,\omega)$. Using FT-STS techniques, we explore the relationship between the real-space and momentum-space characteristics of the electronic structure in the cuprate $Bi_2Sr_2CaCu_2O_{8+\delta}$ (Bi-2212). Weak incommensurate LDOS-modulations which disperse with energy are ubiquitous in this system. It has been proposed that these LDOS-modulation patterns are produced by scattering-induced quasiparticle interference and that their evolution with energy is due to the momentum-space electronic structure of the system. And, indeed, analysis of our data within the context of such models yields the Fermi surface and the d-wave superconducting energy gap —$\Delta(\kappa)$— in reasonable agreement with ARPES. Our earlier observation of intense spatial variations in the superconducting electronic structure at the nanoscale was viewed in the context of granular superconductivity. However, by applying FT-STS, we can now better understand these observations as a very unusual type of electronic disorder located in a specific part of momentum-space near k=(π,0). Finally, FT-STS studies of local electronic states at individual impurity atoms are also beginning to reveal new insights.

9:30 AM EE9.3
Chemistry, Structure and Elementary Properties of the $Na_xCoO_2.1.3H_2O$ Triangular Lattice Superconductor.
Robert J. Cava[2], Maw Lin Foo[2], Raymond Schaak[2], Tomasz Klimczuk[2], Qing Huang[4], Jeffrey Lynn[4], Peter Schiffer[3], Benjamin Ueland[3], Yayu Wang[1] and Nai Phuan Ong[1]; [1]Physics, Princeton University, Princeton, New Jersey; [2]Chemistry, Princeton University, Princeton, New Jersey; [3]Physics, Pennsylvania State University, State College, Pennsylvania; [4]Center for Neutron Research, National Institute of Standards, Gaithersburg, Maryland.

The complex chemistry of the recently discovered $Na_xCoO_2.1.3H_2O$ superconductor makes determination of the structure-property relations in this and related materials unusually difficult. Here we will describe experiments that elucidate the variation of T_c with Na concentration. The data suggest that there are both similarities and differences between this material, based on triangular CoO_2 layers, and the high T_c superconductors, based on square CuO_2 layers. Structural determination by neutron diffraction will also be described, shedding light on the role of water in the superconductivity. Finally some of the elementary characteristics of the superconductor, derived from transport and specific heat measurements, will be described.

10:15 AM EE9.4
Novel Characterisation of Coupled Magnetic and Superconductor Order in Thin Film Hybrid Structures.
Stephen Lee[1], Alan J. Drew[1], Alessandro Potenza[2], Chris Marrows[2], Elvezio Morenzoni[3] and Demetris Charalambous[4]; [1]School of Physics and Astronomy, University of St. Andrews, St. Andrews, Fife, United Kingdom; [2]Department of Physics, University of Leeds, Leeds, United Kingdom; [3]LMU, Paul Scherrer Institut (PSI), Villigen, Switzerland; [4]School of Physics and Astronomy, University of Birmingham, Birmingham, United Kingdom.

The coexistence of magnetism and superconductivity is found in only a few naturally occurring compounds. For a conventional spin-singlet pairing state the exchange interaction between the conduction electrons and the ordered magnetic moments leads to a 'pair breaking' effect, which in general tends to make these two forms of quantum order mutually exclusive. There is therefore much interest in systems where both magnetism and superconductivity occur simultaneously. This is especially true where the electrons appear to reside within the same band, as has been suggested for $ZrZn_2$. Such systems hint at unconvcentional superconductivity, such as spin triplet pairing or magnetically mediated superconductivity. Over recent years there has been increasing interest in artificially fabricated thin film hybrid superconducting-magnetic systems. Theoretical treatments have suggested that in the vicinity of magnetic interfaces the superconducting order parameter may lock to an incommensurate spin density wave. This lends possible explanations to experimental observations of non-monatonic variations of the superconducting transition temperature on the ferromagnetic layer thickness. It may also lead to the existence of magnetic 'π'-junctions, at which the superconducting order parameter switches phase. We have studied thin film superconduting-magnetic hybrids using a combination of polarised neutron reflectometry (PNR) and a unique low-energy

muon-spin rotation (LEM) technique. The LEM method allows the magnetisation profile of a sample to be measured from within Angtroms of the surface to deep inside the film. In the normal state we have measured the spin density wave (SDW) inside the non-magnetic layer due to the polarisation of the conduction electrons in the vicinity of the magnetic interface. Below the superconducting transition temperature this SDW persists, and moreover is modified in such a way which suggests a strong locking to the superconducting order parameter. We will present results on both LEM and PNR measurements of these and related systems, including mesoscopic ground states for superconducting vortices in thin superconducting films.

10:30 AM *EE9.5
Thin Film HTS Materials for Wireless Filters: Status & Challenges. Robert B. Hammond, Superconductor Technologies Inc., Santa Barbara, California.

HTS thin films have begun to be widely used in commercial wireless systems. Currently more than 2500 cellular telephone base stations in the United States have superconducting filters developed and manufactured by Superconductor Technologies Inc. protecting their receivers from out of band interference. This talk will present the current status of thin film HTS materials used in the production of HTS wireless filters for cellular telephone base station receivers, and also address the material synthesis challenges and opportunities going forward. The relevant thin film and substrate properties will be discussed: microwave surface resistance, intermodulation distortion, substrate microwave loss, etc. Also, the status and plans for HTS thin film production will be reviewed.

11:00 AM EE9.6
Temperature Dependence of Intermodulation Distortion in YBCO. Sang-Hoon Park[1], Daniel E. Oates[1] and Daniel Agassi[3]; [1]MIT Lincoln Laboratory, Lexington, Massachusetts; [2]MIT Department of EECS, Cambridge, Massachusetts; [3]Naval Surface Warfare Center, Carderock Division, Bethesda, Maryland.

Intermodulation distortion (IMD) in high-Tc superconductor (HTS) devices continues to be an important limitation in practical devices. At this time, a complete understanding of IMD is lacking. In our continuing studies to better understand this aspect of the HTS materials, we have measured the third-order IMD versus power as a function of temperature from 1.7 K to Tc, for a variety of films on various substrates. The measurements used a stripline resonator at either 1.5 GHz or 2.3 GHz depending on the substrate. The conventional IMD measurement method was used, in which the input comprises two tones, closely spaced in frequency and within the bandwidth of the resonator, and the third order mixing products are measured in the output. The input power ranges from -70 to +20 dBm. The films used are YBCO of several fabrication methods, and the substrates are lanthanum aluminate and sapphire. The results show an increase in IMD at low temperatures and at low powers. At approximately -40dBm, the IMD diverges nearly as 1/T for temperatures below 5 K. At higher input powers of approximately -20 dBm, the IMD becomes independent of temperature in the low temperature range. Niobium films on the same substrates do not show the low-temperature increase. This temperature and power dependence of the IMD is, we believe, an observation of the nonlinear Meissner effect that has been predicted for superconductors with d-wave symmetry but has not been previously observed. The results will be compared with a recently completed, rigorous, many-body calculation that yields directly the lowest order correction of the nonlinear penetration depth as a function of the current. We will discuss the role of intrinsic and extrinsic properties in the IMD. We will also discuss the implications for practical devices operated at usual cryocooler temperatures. This work was supported by the Air Force Office of Scientific Research.

11:15 AM EE9.7
Microscopic Imaging of RF Current Distribution and Intermodulation Sources in Superconducting Microwave Devices. Alexander P Zhuravel[2,3], K S Harshavardhan[4], Stephen K Remillard[5], Alexey V Ustinov[3] and Steven Anlage[1]; [1]Physics Department, Center for Superconductivity Research, University of Maryland, College Park, Maryland; [2]B. I. Verkin Institute for Low Temperature Physics & Engineering, National Academy of Sciences of Ukraine, Kharkov, Ukraine; [3]Physics Institute III, University of Erlangen-Nuremberg, Erlangen, Germany; [4]Neocera, Inc., 10000 Virginia Manor Road, Suite 300, Beltsville, Maryland; [5]Agile Devices, 906 University Place, Suite A202, Evanston, Illinois.

A laser scanning microscope with a thermal spot size of about 4 μm is used to measure a quantity proportional to the rf current density in an operating superconducting co-planar waveguide microwave resonator [Appl. Phys. Lett. **81**, 4979 (2002)]. The twinning of the $LaAlO_3$ substrate produces a meandering of the current at the edges due to irregularities in the wet etching of the $YBa_2Cu_3O_{7-\delta}$ film associated with substrate twin domain blocks, and a ($\sim$ 20%) enhancement of the rf photoresponse at these locations. The effects of substrate twinning and the resulting edge features on the superconducting film are discussed and analyzed. We have developed a new version of this microscope that images changes in the third-order intermodulation (IM) signal as the laser perturbation is scanned over the sample. We directly image the regions of maximum IM generation in a meandering microstrip resonator, and compare them to the simultaneously measured rf current distribution. We acknowledge the support of a NATO Collaborative Linkage Grant PST.CLG.977312, NSF GOALI DMR-0201261, the Maryland/Rutgers/NSF MRSEC DMR-0080008, and NSF/Neocera SBIR DMI-0078486.

11:30 AM EE9.8
HTS Single Coils and Phased Arrays for Clinical and Research MRI Applications. Jaroslaw Wosik[1], Krzysztof Nesteruk[2], Lei-Ming Xie[1], Lian Xue[1] and Maged Kamel[1]; [1]Electrical and Computer Engineering Dept. and Texas Center for Superconductivity and Advanced Materials, University of Houston, Houston, Texas; [2]Institute of Physics of the Polish Academy of Sciences, Warsaw, Poland.

Magnetic Resonance Imaging (MRI) is related to the phenomenon of nuclear magnetic resonance (NMR), which is based on the excitation and relaxation of nuclei (most frequently protons) within living tissues in a dc magnetic field. In a MRI set-up, a receiver probe detects such a signal. In small volume MRI, MRI microscopy, low-field MRI, and NMR spectroscopy, the Johnson noise of the rf receiver probe and/or a preamplifier determine the system noise floor. It was already demonstrated that for selected applications a significant improvement of the signal-to-noise ratio (SNR) can be achieved by cooling normal metal MRI probes or by using superconductors. Fundamentals of MRI coils? design processes, including issues pertaining to cryo-packaging, and examples of practical coils made of normal metal and superconductors will be discussed. New theoretical and practical concepts for significant shortening of the MRI acquisition time by using parallel processing SENSE (SENSisitive Encoding) technique with array of probes also will be presented. The design and fabrication of a novel planar 200 MHz four-coil array will be shown. Each one inch in diameter coil consists of patterned, double sided copper or YBCO films on 2 inches round dielectric substrate. The array was designed to-be-made out of superconducting YBCO two inches in diameter films and for easy cryo-packaging has build-in planar capacitors for both coil decoupling and capacitive connection to the matching and tuning system. The SNR enhancement expected from using cold copper or superconductors for single coil and/or phased array designs are calculated, discussed and compared with experimental results. Utilization of superconducting coils in cardiovascular medicine will be discussed for examination of aortic walls and identification of atherosclerotic plaques responsible for acute coronary syndromes (vulnerable plaque).

11:45 AM EE9.9
Percolation, Surface Impedance and Pinning in MgB_2-, Nb-, NbN-, and HTS-Superconductors. Juergen Halbritter, IMF I, Forschungszentrum Karlsruhe, Karlsruhe, Germany.

The hindrance of electric transport by grain/island boundaries in distances a_J ($\leq 1\mu$m) is well accepted in the normal conducting state, whereas related critical Josephson current densitites j_{cJ} are less well know. For a quantitative model the resistivity $\rho(T) = R_{bn}/a_J + p\ (\rho^i\ (T) + \rho^i\ (0))$ is fitted to observations yielding boundary resistances R_{bn} (Ωcm^2), residual resistivities inside grains ρ^i (0) and percolation factors $p > 1$ by current diverting boundaries with $R_{bn} \leq m\Omega cm^2$. HTS show $p > 1$ - 10, critical current densities $jc(H < H_{C1}) \leq j_{cJ}(H)$ by Josephson fluxon pinning with $j_{cJ} {R_{bn}}^2 \approx 10^{-12}$ $V\Omega m^2$, rf residual losses $R_{res} \propto \omega^2/{a_{JcJ}}^{3/2} R_{bn}$ and hysteresis losses $R_{hys} \propto \omega H/a_J j_{cJ}$. In MgB_2 films percolation with $p \leq 1$ - 20, with $j_c(H \langle H_{c1}) \leq j_{cJ}(H)$ and with $j_{cJ} R_{bn} \approx \Delta/e$ is found. For Nb-films $p \leq 1$ and pinning of Josephson fluxons at the junctions ($j_{cJ} R_{bn} \approx \Delta/e$) and of Abrikosov fluxons in the corrosion layer holds and is difficult to separate. Whereas percolation decreases conductivities via the boundary resistances R_{bn} in the normal state always, pinning of Josephson fluxons enhances $j_c(H \langle H_{c1}) \leq j_{cJ}(H)$ dominated in dc transport by the strongest links. In contrast surface impedances via $R_{res} \propto {j_{cJ}}^{-3/2}$ and $R_{hys} \propto {j_{cJ}}^{-1}$ are dominated by the weakest links and deteriorate by weak links always. But in all cases RRR values don't yield the material quality, but a proper percolation analysis allows via $R_{bn} \propto {j_{cJ}}^{-n}$ ($n \leq 1$ -2) to forcast superconducting properties in dc and rf. [1] J. Halbritter, Phys. Rev. B 48, 9735 (1993) and Supercond. Sci. Technol. 12, 883 (1999) [2] J. Rowell et al., submitted to Appl. Phys. Lett.

SESSION EE10: Films and Josephson Junctions
Chairs: Brian Moeckly and John Rowell
Thursday Afternoon, December 4, 2003
Fairfax A (Sheraton)

1:30 PM *EE10.1
Triphase Epitaxy and Interface Dislocation Engineering for Fabricating Oxide Thin Films Free From Defects or Strain.
Masashi Kawasaki, Institute for Materials Research, Tohoku University, Sendai, Japan.

Making thin films as prefect crystallinity as possible has long been an issue. Vapor phase deposition usually gives many kinds of defects due to non-equilibrium nature. Heteroepitaxy on lattice mismatched substrate gives strain in the films. We present our originally developed techniques for solving these problems. By giving a molten solvent on the growing thin films, where solvent and film crystal can thermodynamically co-exit, one can make liquid phase epitaxy quality films through vapor phase precursor supply. An example is shown for this tri-phase epitaxy of NdBa2Cu3O7 films with using Ba-Cu-O solvent. Epitaxial strain can be minimized for developing proper buffer layer. The concept and examples of dislocation engineered buffer later is shown to give tunable lattice constants and atomically flat surface. This buffer layer enables arbitrarily tuning of lattice strain for well regulated epitaxial thin films. Collaboration has been carried out with K. S. Yun, H. Koinuma, and M. Lippmaa.

2:00 PM *EE10.2
What Happens at Cuprate-Titanate Heterointerfaces?
Jim Eckstein, Department of Physics and Materials Research Laboratory, University of Illinois, Urbana, Illinois.

We have studied the growth and properties of single crystal samples containing cuprate phases and insulating titanate layers making a wide range of heterointerfaces. The materials we have studied include YBCO, BSCCO and infinite compound cuprate phases, and perovskite titanates including Sr, Ca and Ba. We have employed atomic layer by layer molecular beam epitaxy to grow these samples. We have found that the local electronic structure of the cuprate layers changes significantly because of the proximity to the insulating titanate layers in a way that depends strongly on the CuO2 plane orientation. In a-axis YBCO heterostructures, the electronic structure is strongly influenced by interfaces to insulating titanate tunnel barrier layers, leading to significantly broken electron hole symmetry in single crystal tunnel junctions. In junctions to c-axis planes, charge that would be mobile in bulk is localized in the interfacial CuO2 plane. All things considered, it seems that a detailed understanding of interface effects, such as charge transfer, internal electric fields, band line-up, bond distortion and interface states is required to design new devices involving interfaces with atomic scale engineered properties.

2:30 PM EE10.3
MBE Growth of Electron-Doped Cuprates. Michio Naito, Yoshiharu Krockenberger, Akio Tsukada, Shin-ichi Karimoto and Hideki Yamamoto; NTT Basic Research Laboratories, Atsugi, Kanagawa, Japan.

N-type cuprates belong to a minority class of high-Tc superconductors and only two families are known: T' and infinite-layer (IL) compounds. The superconducting transition temperature (Tc) is moderate even at optimum doping (30 K for T' and 43 K for IL) and their sample preparation is difficult. Nevertheless the n-type cuprates are interesting and important from the basic physics point of view, especially as to whether electron-hole symmetry holds or not in high-Tc superconductivity. In this presentation, we describe the MBE growth of both T' and IL electron-doped cuprates, and point out the key material issues to obtain optimal superconductivity in these compounds. Our investigations on the T' family, (Ln,Ce)2CuO4, cover a range of Ln (Ln = La, Pr, Nd, Sm, Eu, and Gd). The Tc is the highest (30 K) for Ln = La, and the lowest (<4.2 K) for Ln = Gd, demonstrating a clear trend: larger Ln3+ (equivalently larger in-plane lattice constant (a0)) gives higher Tc. This trend is not in accordance with the pressure effect on Tc, which is absent in these compounds. One hint to understand the trend comes from the fact that the optimum doping level is shifted to lower for larger Ln3+: x 0.08 for La and x > 0.15 for Sm and Eu. This suggests that "intrinsic" Tc achievable only after a complete removal of interstitial apical oxygen should increase with lower doping. The intrinsic behavior is disturbed by the presence of apical oxygen, whose removal becomes more difficult for smaller Ln3+, especially in the low Ce-doping range. One can observe similar behavior in the IL cuprates. In this case, a0 cannot be changed significantly by a chemical route, but can be varied by epitaxial strain with different substrates. IL-(Sr,La)CuO2 films on SrTiO3 experience compressive strain and have a0 smaller than bulk (Sr,La)CuO2. These films are semiconducting with low Tc(end). The properties of IL films can be significantly improved by using larger a0 substrates such as KTaO3, DyScO3. Our best films show Tc(end) as high as 42 K. From the results on both of the T' and IL electron-doped cuprates, one can conclude "a larger in-plane lattice constant improves superconductivity".

2:45 PM EE10.4
Interface strain dictated oxygen deficiency and superconductivity: Strained and strain-free YBCO ultra thin film. Hye-Won Seo[1], Quark Y Chen[1], Paul A Van Der Heide[2] and Wei-Kan Chu[1]; [1]Texas Center for Superconductivity and Dept. of Physics, University of Houston, Houston, Texas; [2]Center for Materials Chemistry, University of Houston, Houston, Texas.

A fundamental question often asked about cuprate superconductivity is "can such superconductors continue to superconduct when it is below a certain thickness?" While many have attempted to answer this question, the ultimate controversy is, specifically, whether the ultra thin film cuprate retains the same stoichiometry as it thickens. This is a relevant issue as, otherwise, one can, for example, conveniently but erratically correlate the differences in properties simply to the interface strain effect, with all else being equal. In simple terms, can lattice mismatch affect the oxygen content which, in turn, dictates all superconducting properties? In this work, we took a retrospective approach by first growing a thicker full-oxygenation intended YBa2Cu3O6+x (YBCO) film and then thinning it down step by step toward a critical limit. We determined that close to the interface between the film and substrate of mismatched square lattice, the films were severely oxygen deficient but their crystallographic quality was as good as their thicker counterpart. The film would evolve from tetragonal to orthorhombic structure as it grew thicker. For ultra thin film growth on most often-used oxide substrates, there is a critical thickness (a few nanometers) beyond which interface dislocations would be created to relieve the interface strain. It has been commonly quoted in the literature that the "quality" of such cuprate superconducting thin films continually improves as the film grows thicker but then it'd become worse again beyond certain thickness. Usually, critical current (Jc), transition temperature (Tc) and the normal state resistivity were use as the criteria for the judgment of sample quality. Among these, most recognizable trends were the decrease in Tc and the eventual loss of superconductivity as film thickness decreases. In this paper, we would present the interplay of the film thickness, oxygen contents (doping levels), lattice constants, and superconducting properties. This work is supported by State of Texas through the Texas Center for Superconductivity at the University of Houston.

3:30 PM *EE10.5
Current Transport Processes in Interface-engineered Josephson Junctions. Jiro Yoshida, Advanced Materials and Devices Laboratory, Toshiba Research and Development Center, Kawasaki, Japan.

This paper reports the results of our experimental study on current transport in interface-engineered Josephson junctions (IEJs) with YbBaCuO as the counter electrode. We have fabricated IEJs with a critical current density (J_c) ranging from 10^2 to 10^6 A/cm^2 by varying various process parameters. From among a large number of junctions, only those exhibiting excellent Josephson characteristics with a magnetic field modulation of I_c exceeding 80% at 4.2 K were selected for detailed investigations. The major results are as follows. i) The I-V curve of an IEJ with J_c far exceeding 10^4 A/cm^2 contains an appreciable amount of excess current that grows rapidly within an approximate voltage range of less than 5 mV. ii) The Josephson critical current I_c exhibits good correlation with the differential resistance R_0 near zero voltage, while the normal resistance R_n defined at a current level of two to three times I_c varies appreciably even for junctions with a similar I_c. iii) The I_c versus temperature characteristics at low temperatures can be fit quite well by a clean point contact model in which the anisotropic superconductivity in high-T_c materials is taken into account. iv) The junctions with a large excess current exhibit dI/dV profiles with reproducible fine structures below 15 mV, probably due to multiple Andreev reflections. In contrast, some evidence of tunneling processes via localized states was observed for highly resistive junctions. These results suggest that the IEJs can be regarded as an array of point contacts with high transparency embedded in an insulating barrier containing a high density of localized states. The fluctuation in the number of nearly ballistic transport channels in the junction area seems to restrict the attainable minimum spread in the I_c value.

4:00 PM EE10.6
Layer-by-Layer growth of $Y_1Ba_2Cu_4O_8$ thin films.
Jung-hyuk Lee[1], Gertjan Koster[2], Theodore Geballe[2] and T. W. Noh[1]; [1]Physics, Seoul National University, Seoul, Seoul, South Korea; [2]Applied Physics, Stanford University, Palo Alto, California.

We report on the properties of thin films of the high Tc superconductor double chain compound $Y_1Ba_2Cu_4O_8$ (Y124) grown by a layer-by-layer technique. This member of the homologues YBCO

series is of interest due to its fixed oxygen stoichiometry and anisotropy in its physical properties. The goal is to obtain phase pure, highly oriented Y124 films by depositing $Y_1Ba_2Cu_3O_7$ (Y123) and CuO layers using pulsed laser deposition technique(PLD). We found that the properties of the Y124 films are very sensitive to the ratio of Y123 and CuO. In addition, the characteristic bulk diffusion lengths of the as-deposited atoms could be investigated by depositing layers with an equivalent thickness of multiple unit cell of Y123/CuO rather than single unit cell. We also have performed Transmission electron microscopy (TEM) ,X-ray diffraction(XRD) and transport measurments on our samples.

4:15 PM EE10.7
Enhancement of Flux-Line Pinning In Oxide Ferromagnet/Superconductor Heterostructures.
Hanns-Ulrich Habermeier, Joachim Albrecht and Soltan Soltan; MPI-FKF, Stuttgart, Germany.

Heterostructures and superlattices consisting of ferromagnetic and superconducting oxides are currently of increasing scientific interest and their application potential for three terminal devices and /or spin-injection devices is discussed. Additionally, the interaction of the magnetic domain structure of the ferromagnetic layers with the flux-line arrangement and the potential modification of flux-line pinning in superconductor ferromagnetic heterostructures is a topic of current concern. We have grown bilayer heterostructures of the ferromagnet SrRuO3 and the high temperature superconductor YBaCuO7 on single crystal LaSrGaO4 substrates by pulsed laser deposition. Using the quantitative magneto-optical Faradayeffect technique the critical current densities in the superconducting film is measured locally with a resolution of 5micrometer. The results show a strong dependence of the critical current on the magnetization state of the ferromagnetic layers and a hysteretic behavior strongly related to the mnagnetic hysteresis loop of the ferromagnet. The quantitative analysis of the critical currents as determined by the magneto-optical techniques shows a pronounced enhancement of jc - especially in the remanent state. The results are discussed within the frame of the magnetic interaction of the flux-lines and the ferromagnetic domain structure.

4:30 PM EE10.8
Fabrication of Faster HTS Josephson Junctions.*.
John Talvacchio, J. M. Murduck, D. A. Kahler and A. Kirschenbaum; Advanced Materials & Electronic Device Research, Northrop Grumman Corporation, Baltimore, Maryland.

This work follows well-developed principles in Josephson junction performance that were recently summarized by Kadin, et al.** We apply these general considerations for junction switching speed and critical damping to the case of HTS junctions with modeling and experiment. For LTS junctions, where junction uniformity is better, junction speed directly impacts applications in both digital signal processing and mixed-signal circuits. For HTS junctions, speed is most important for high oversampling rates in sigma-delta analog-to-digital converters. High-speed HTS junctions also have high IcRn products that make it easier to transfer bits off-chip at high data rates. All HTS junction configurations that have been used in recent years for small-scale circuits, including the typical SNS ramp-edge junctions that we fabricated in our laboratory with YBCO films, have IcRn products no greater than about 2 mV at 50 K. On the other hand, much higher IcRn products have been demonstrated with several junction configurations that could not easily be reproduced or scaled up in number. In contrast with LTS trilayer tunnel junctions, where higher current densities up to 100 kA/sq cm have yet to be achieved reproducibly, most practical HTS junctions are already at similarly current densities and need to have reproducibly higher junction resistances to increase speed. In either case, smaller junction areas are desirable and our approach has been to use several techniques to reduce the area of our SNS junctions. Another difference is that typical LTS trilayer junctions have a large capacitance and are under-damped unless shunt resistors are placed in parallel. Our HTS edge junctions are over-damped and we have been led to fabricating shunt capacitors in parallel to realize critical damping. * supported in part by AFOSR Agreement F49620-02-1-0046 ** A.M. Kadin, A.W. Kleinsasser, M. Rowell, and T. Van Duzer, Proc. Appl. Supercond. Conf, Houston, August, 2002.

4:45 PM EE10.9
Materials Development for Josephson Waveform Generator Circuits.*. David Kahler, J. Talvacchio, A. Kirschenbaum and J. M. Murduck; Advanced Materials & Electronic Device Research, Northrop Grumman Corporation, Baltimore, Maryland.

Pulse-driven Josephson arrays are being developed for voltage standards and generation of arbitrary waveforms. The primary junction requirements are a match of the IcRn product to the bit rate of the input, uniformity of critical currents, and sufficient density so the entire array of junctions appears from the output terminals as a lumped element source. We have concentrated on YBCO ramp-edge junctions with an SNS configuration and low-resistance S-N interfaces. Several innovative process steps allowed us to obtain low IcRn products of 24 mV at 60-65K with critical currents of 1-2 mA to match the Josephson frequency to input signals at 12 GHz. The process commonly used to form ramp edges limited us to about 100 junctions distributed in a fraction of a microwave wavelength so we developed new ramp-edge formation techniques to increase the number of junctions in the same area for higher output power from the circuit. A patterned Nb layer was used to selectively disrupt epitaxial growth of YBCO to reduce the spacing between the counterelectrodes of adjacent junctions to 3 microns and to shunt current through low-value silver resistors that improve Rn uniformity. Other layers include silver films and low-loss silicon dioxide depositions to form coaxial and stripline transmission lines and RF filters. A molybdenum resistor layer is also included for impedance matching resistors. *supported in part by AFOSR Agreement F49620-02-1-0046