Project Title:	**Strategic Research on IBAD MgO-Based Coated Conductors**
Organization(s):	**Los Alamos National Laboratory**
Presenters:	Paul Arendt, Steve Foltyn
FY 2004 Funding:	$1.4 M

Project Purpose and FY 2004 Objectives: This project is the Core Research part of the Los Alamos effort to improve both the performance of and commercial prospects for coated conductors based on ion-beam-assisted deposition of MgO (IBAD MgO) and pulsed-laser deposition (PLD) of YBCO. The objective is to conduct research focused on improving the performance (J_c, I_c) and/or reducing the cost of this conductor approach, in line with the overall DOE goal of minimizing cost/performance (C/P).

IBAD MgO offers several benefits in the production of coated conductors: The ion-beam assisted layer itself is very thin and can be deposited at high rate, resulting in excellent texture at a low cost; the total thickness of non-superconducting layers is also minimal, reducing "overhead" in the IBAD MgO architecture; and, finally, both texture and J_c of the YBCO layer are approaching the level obtained on single-crystal substrates, maximizing I_c through the full range of superconductor thickness.

Last year we reported several important developments. These included texture improvements resulting in IBAD/YBCO J_c levels that are equivalent to those on single-crystal substrates, initial analysis of the roles of barrier and buffer layers, replacement of $SrRuO_3$ with $SrTiO_3$ for the PLD buffer layer, observation of the role of substrate smoothness in facilitating the deposition of high-I_c thick films, and continuous processing of cm-wide tapes with I_c values of 265-425 A.

For this year we made a major change in the Core Program, reducing our effort in the continuous processing of meter-long tapes, and focusing on more basic and long-range issues aimed at reducing C/P of IBAD-based coated conductors. These issues include: process modeling to further refine and facilitate the transfer of IBAD MgO to industry; analysis of extended I-V curves to determine whether IBAD samples are likely to benefit from additional texture improvements; addressing the question of intrinsic vs. materials limitations to conductor I_c; modifications aimed at improving REBCO performance in a magnetic field; and continued cost reduction efforts for barrier and buffer layers.

FY 2004 Performance and FY 2005 Plans: Substantial progress was made on each FY 2004 objective. An IBAD texturing model has resulted from ion-channeling and damage experiments on MgO single crystals. Extended I-V curves of YBCO-on-IBAD MgO samples established a texture range for the onset of strongly-coupled behavior. Process optimization allowed us to reproducibly meet our goal of $I_c > 400$ A at a YBCO thickness of ≤ 1.5 μm. We also found several ways to improve the field-dependence of coated conductors. And finally we developed a method to systematically analyze the effect of impurities diffusing from the metal substrate. Manpower resource limitations required the goal of providing meter-lengths of buffered IBAD MgO to industrial partners to be removed. This was compensated in part by our technology transfer efforts to help SuperPower start up their own IBAD MgO template pilot line and by the Research Park providing buffered lengths of template to other industrial partners.

In FY 2005, the Core Program will continue its effort to reduce C/P of coated conductors based on IBAD MgO. This work will enhance commercial viability by improving economics and broadening the range of product applicability. Our activities will address every aspect of the IBAD MgO architecture. The first goal is to routinely achieve in-plane IBAD MgO texture of < 5° FWHM, which will give a large margin for process drift in long-length manufacturing. We will continue optimization of the nonsuperconducting layers, leading to reduced thickness, increased rate, and broader processing windows. We will also continue work begun last year to understand and engineer flux-pinning defect structures for higher performance in magnetic fields that are characteristic of DOE applications. A new area will be to follow up on some early and promising work on alternate approaches for texturing materials with ions – this offers the possibility of a simpler process and a wider range of useable materials. Another new area will be to investigate the often-observed phenomenon of texture sharpening of a heteroepitaxial layer relative to the underlying layer. This little-understood effect already offers 6 degrees or more of in-plane texture improvement over the starting RABiTS or IBAD MgO template – understanding and controlling the effect will advance the efficiency and reproducibility of all coated conductor processes.

FY 2004 Results:

- Produced many ~ 1.5 μm-thick samples with I_c > 400 A/cm-width
- Demonstrated thicker films with I_c(75 K) > 1000 A/cm-width
- Found several ways to increase J_c by a factor of 2-5 in fields > 1 T(75 K, B||c).
- Experimentally verified mechanism responsible for biaxial texturing of IBAD MgO that may allow for a more robust manufacturing process.
- Determined diffusion coefficients for substrate elements in alumina barrier layers.
- Measured the effects of transition metal impurity concentrations on superconducting properties to establish requirements for barrier layers.

Research Integration: During FY2004 we began the transfer of IBAD MgO technology to SuperPower. On site visits and sample and material exchanges resulted in substantial progress being made and we anticipate that the full transfer of IBAD MgO in the coming year will be both smooth and rapid, based on SuperPower's success with earlier IBAD technologies. In addition we participated in focused collaborations with Oak Ridge, Argonne, and Brookhaven National Laboratories, resulting in joint publications with ANL and BNL. We have also hosted a visiting staff member from Cambridge University, which has resulted in joint publications.