
Project Title:	Development of Coated Conductors Based on IBAD MgO
Organization(s):	Los Alamos National Laboratory
Presenters:	Paul Arendt and Steve Foltyn
FY 2003 Funding:	\$1,850 K

Project Purpose and FY2003 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 basic approach 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 Program goal of minimizing cost/performance.

IBAD MgO offers significant cost benefits compared to IBAD YSZ, and last year we reported several improvements that enhanced both performance and reproducibility of this process. These improvements included the use of reel-to-reel substrate electropolishing, a new IBAD nucleation layer (Y_2O_3), numerous refinements of the IBAD process itself, and development of a new buffer layer ($SrRuO_3$). For this year, we proposed to build on these advances by distributing IBAD MgO samples to our industrial partners and national laboratory collaborators and work with them to achieve optimum performance with their respective YBCO deposition processes. We also proposed to optimize each layer of the structure and minimize the nonsuperconducting layer thickness. We proposed to extend these results to the continuous processing of tapes up to 1 meter long with a goal of 100-200 A in a 1-cm-wide conductor. Finally, we planned to continue our support of both SuperPower and the Los Alamos Research Park in their efforts to scale up IBAD processes to longer length high-current conductors.

FY 2003 Performance and FY 2004 Plans: Each of our 2003 objectives was addressed during the year, with significant progress to report. Buffered IBAD MgO samples were distributed to SuperPower, Inc. and American Superconductor, and both companies were able to deposit YBCO on samples with I_c s reaching 100-200 A/cm-width. In addition, we were able to achieve similar I_c values on continuously processed, centimeter-wide tape in our research tape-coating system. We conducted an extensive investigation of the diffusion-barrier properties of the nonsuperconducting layers in our IBAD MgO architecture that was aimed at reducing the total thickness of these layers. Although it did not lead to the intended reduction, this work gave us a much better understanding of the functionality of each layer and has allowed us to engineer a more reliable conductor design. In a joint effort with the Los Alamos Research Park, we also pursued the use of the Oak Ridge-pioneered $LaMnO_3$ buffer layer, achieving small sample I_c values of over 100 A/cm-width on Research Park IBAD MgO/LMO.

In FY 2004, the Core Program will undergo a major transition: We will substantially reduce our work on continuous processing of meter-long tapes, which we began in 1995. This we believe is a rational move in light of the successes of our industrial partners and the Accelerated Coated Conductor Initiative laboratories in reel-to-reel processing of longer lengths. We will instead direct our attention to more basic and long-range issues that can impact both the cost and performance of coated conductors. These issues include: the fundamental texturing mechanisms of ion-beam-assisted deposition; improved barrier/buffer layers between the metal and superconductor; flux pinning in YBCO and the potential for improved J_c in a magnetic field; and the performance of different superconductor compositions, such as the RE123 compounds.

FY 2003 Results:

1. Distributed buffered IBAD MgO samples to SuperPower, Inc. and American Superconductor – both companies deposited high-quality YBCO on these samples.
 2. Improved the MgO texture on meter-long tapes to 6-7° FWHM, enabling the deposition of YBCO with in-plane texture of less than 3° FWHM. This resulted in J_c values exceeding those on the best IBAD YSZ and equal to those for single-crystal substrates (e.g. > 2 MA/cm² at 1.5 μm thickness).
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3. Analyzed diffusion of substrate elements into the YBCO and found that Al_2O_3 is an effective diffusion barrier. Also found that Er_2O_3 is an effective barrier that can, in addition, replace Y_2O_3 as the nucleation layer, thereby allowing two layers ($\text{Al}_2\text{O}_3 + \text{Y}_2\text{O}_3$) to be replaced by one.
 4. Made a transition from SrRuO_3 to SrTiO_3 as the buffer layer between MgO and YBCO, with no decrease in performance. The latter is less expensive, more stable, and can be fabricated into a more robust PLD target. Both materials were found to function as diffusion barriers.
 5. Discovered that the porosity problems found in thick YBCO on IBAD YSZ do not exist with IBAD MgO; believe this is due to the smoother starting surface of the latter. Produced many thick film samples with $I_c > 300$ A/cm-width.
 6. Demonstrated continuous deposition on 1-cm-wide tape with $I_c > 200$ A.

Research Integration: During FY2003 we renewed our CRADA with SuperPower, Inc., which involves the complete transfer of Los Alamos IBAD and PLD technologies through regular communication, site visits, sample exchange, and licensing of intellectual property. Substantial progress was made this year, as outlined in the SuperPower, Inc. summary. We also signed a CRADA -- after a two-year gap -- with American Superconductor. This will involve exchange and characterization of samples having mutual interest, and has already resulted in a joint paper describing ASC's results on IBAD MgO. Finally, we have collaborated, mainly through sample and information exchange, with Oak Ridge, Argonne, and Brookhaven National Laboratories, with joint papers submitted or in preparation with each Lab. Joint publications have also resulted from collaborations with California Institute of Technology and Imperial College, London, and a joint patent application has been submitted with Stanford University.
