Project Title:	Factors Affecting Critical Currents in Coated Conductors
Organization(s):	**Los Alamos National Laboratory**
Presenters:	Leonardo Civale and Quanxi Jia
FY 2003 Funding:	$450 K

Project Purpose and FY 2003 Objectives: The objective of this research is to explore the mechanisms that limit the supercurrent in coated conductors. The basic approach includes two parts. We fully characterize the transport properties of the coated conductors and investigate their microstructural properties. We then compare these results with those of YBCO films on single crystal substrates. The validity of this comparison relies on the availability of coated conductors 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.

The real challenge of this research is to correlate the structural defects with the transport properties of the coated conductors. The knowledge gained through this study can be readily used to optimize the processing conditions and to explore the new materials for high performance coated conductors. The following is a list of our main tasks for FY 2003 under the program of Strategic Research at Los Alamos.

1) To characterize Jc for a variety of coated conductors and thin films on single crystal substrates as a function of temperature, magnetic field and field orientation in order to identify and compare their pinning mechanisms.

2) To explore the microstructure of coated conductors and films on single crystal substrates using X-ray diffraction, transmission electron microscopy, scanning tunneling microscopy, and scanning electron microscopy, looking for correlations with the transport results.

FY 2003 Performance and FY 2004 Plans: This is a new initiative in our program. The results obtained so far are significant and encouraging. We have already found that, over large field and orientation ranges, the Jc in coated conductors on improved IBAD MgO templates 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 coated conductors, and that pinning in those materials can be further improved by appropriate engineering of the microstructure. We have also performed the same kind of transport studies on coated conductors produced by Superpower and American Superconductor.

During FY 2004 we expect to establish more quantitative correlations between the structural defects and the transport properties of the coated conductors. To that end, we will modify the processing conditions in order to change the defect structures. We will also develop a system that will allows us to rotate the current direction within the ab-plane, in order to investigate the in-plane pinning anisotropy associated with the correlated disorder. We will extend these studies to other rare earth superconducting materials.

FY 2003 Results: We have measured the critical current density Jc and characterized the microstructure of PLD YBCO coated conductors on improved IBAD MgO templates, and we have compared these results with those of YBCO films on MgO and STO single crystal substrates. The main findings are the following:

- We have used the angular dependence of Jc for identification of several pinning sources that are dominant at different field orientations. In particular, we have investigated in detail the peaks in Jc for applied magnetic field parallel to the c-axis and to the ab-planes, which arise from different types of correlated disorder. The widths and heights of these peaks decrease as either temperature or field increase. The analysis of these dependences provided information on the pinning properties of the correlated disorder.
- We have used an anisotropic scaling scheme to investigate the influence of the electronic mass anisotropy in the angular dependence of Jc. We found that pinning by correlated disorder is dominant

over most of the temperature – field – orientation diagram, with random defects playing only a secondary role.

- We found that the relevant sources of pinning are similar in coated conductors and films on single crystal substrates, although the relative importance of each mechanism is different, resulting in slightly different angular and field Jc dependences.
- We have identified extensive regions of the temperature - field - orientation phase diagram in which the Jc in our coated conductors is higher than in films on single crystal substrates.
- We have systematically characterized the microstructure of the improved coated conductors and compared it with films on single crystals. Improved IBAD MgO templates enabled us to deposit YBCO with in-plane texture of less than 3° FWHM.
- We have used high resolution X-ray diffraction to determine the out-of plane texture, and we correlated those results with the presence of a sharp intrinsic pinning peak at the ab-plane in some samples.

Research Integration: We provided measurement of coated conductors fabricated by SuperPower, Inc., American Superconductor, and 3M. These characterizations involved the temperature, field and angle dependent critical current density measurements. The information learned from these collaborations is critical for studying the pinning mechanisms owing to the use of different deposition techniques. We also collaborated with Argonne National Lab to study the strain and cation disorders in RE123 films. These investigations help us to understand the pinning in RE123 films and to explore new materials for coated conductors.