
Project Title:	Enhancing YBCO Performance Through Fundamental Process Evaluation and Characterization
Organization(s):	Albany NanoTech – University at Albany – State University of New York
Presenters:	Manisha Rane and Kathleen Dunn
FY 2004 Funding:	\$75 K (started Sept. '03)

Project Purpose and FY 2004 Objectives: The main goal of the program is to develop a fundamental understanding of the mechanisms which cause defects in thick YBCO films grown on multi-layered buffered, metal substrates. To elucidate these mechanisms, Albany NanoTech (ANT) utilized its expertise in film deposition and characterization using state-of-the-art processing tools and analytical characterization methods to evaluate current standards of control over film quality and performance. We have made significant progress on both of our FY2004 milestones:

- ◆ **Process Comparisons:** Evaluate ability to control characteristics of thick films prepared by Aerosol Assisted Deposition (AAD) and Metal Organic Deposition (MOD) processing methods by developing and fabricating a significant number of samples produced internally and by our national laboratory partners. Study the relationship between film microstructure, defects, thickness, YBCO deposition process used, and the critical current density (J_c)
- ◆ **Evaluation of Multilayer buffers:** Influence of metal substrate and multi-layer buffer layers on the subsequent growth and performance of thick YBCO layers

FY 2004 Performance and FY 2005 Plans: We have pursued two methods toward accomplishing FY 2004 objectives: (i) Partnership with national laboratories and industries to acquire a large number of coated conductors on a variety of templates in order to obtain relevant samplings of each type for diversified characterization, and (ii) continued internal research on the development of AAD and MOD techniques. A summary of our work includes:

- ◆ Evaluation and identification of problems associated with growth of thick YBCO on single crystal STO substrates. As the film grows thick microstructural defects such pores, a-axis grains and second phase particles start forming resulting in the degradation of the current carrying performance of the superconductor. These defects were directly observed through Focused Ion Beam (FIB) cross-sectional and plan-view imaging and their composition was determined through X-ray diffraction (XRD), Energy Dispersion Spectroscopy (EDS) and Monte-Carlo simulations.
- ◆ Delineation of microstructural differences between reel-to-reel deposited ISD-MgO tape and ISD-MgO layers on stationary substrates and probed microstructure and metal diffusion issues on subsequent deposited YBCO/buffer films. Plan-view imaging revealed a roof-tile-shaped structure for the MgO films while columnar grains nearly perpendicular to the substrate surface were observed by FIB. FIB data was also correlated to magneto-optical images (MOI) of the YBCO layer. Cracks were observed in the MgO layer. Ni diffusion profiles studied by Second Ions Mass Spectroscopy (SIMS) depth profile suggested that no Ni was diffused into the YBCO layer.
- ◆ Evaluation of YBCO films on buffer/metal substrates synthesized by the MOD-TFA process. We have investigated the fluorine concentration depth profile and microstructural evolution in precursor films as a function of the heat treatment times and conditions. A number of samples, quenched at various stages of the heat treatment process, were investigated by Nuclear Reaction Analysis (NRA) for fluorine depth profile, by Rutherford Backscattering (RBS) for film composition and density, and by Focused Ion Beam (FIB)

microscopy for top view and cross sectional interface imaging. The knowledge gained from this work is being used by AMSC to optimize processing conditions for high I_c , thick YBCO films.

- ◆ Performed depositions of YBCO films from aqueous nitrate solutions, by a rapid growth AAD technique. Non vacuum processing, at low oxygen partial pressure and high substrate temperature regime, was found to be favorable for 1 to 5 μm -thick YBCO film growth. Identification of the process parameter range leads to YBCO film deposition with a/c-axis oriented grains. In addition a low cost TFA-MOD process from trifluoroacetates precursor solution was also developed to prepare 1 μm -thick YBCO films through spin coating, followed by calcination and firing and compared to AAD films.

We propose the following future research and development for FY 2005:

- ◆ Process comparison: Continue comparison studies of YBCO deposited by various techniques on multilayer buffers to develop knowledge of the preferred orientation via innovative electron and ion microscopy (SEM, HRTEM, FIB), surface techniques (SIMS, XPS, AFM), and depth profile techniques (XPS, NRA).
- ◆ Improve flux pinning: Evaluate the effects of second phase inclusions such as the Y211 phase, yttria, or other oxide and non-oxide nanoparticulate inclusions to enhance flux pinning. The effectiveness for various methods to incorporate such inclusions will be carefully monitored through microscopic and spectroscopic studies.
- ◆ Lower ac losses: Study patterned YBCO layers with linear striations by removing strips of the superconductor through laser ablation in order to investigate reduction in hysteretic loss and identify composition changes taken place during ablation.
- ◆ Low cost processing: Develop and improve internal non-vacuum YBCO deposition schemes for faster processing and preparation of thick (1-5 μm), c-axis films on buffered substrates. Perform associated structural, chemical, and electrical characterization.

Research Integration: To better understand the relationship between film microstructure, defects, thickness, YBCO deposition process, we have established collaborations with national labs and industrial partners including Argonne National Lab. (ANL), Air Force Research Lab. (AFRL), UES, Inc., IGC-Super Power, American Superconductor (AMSC), and Wright State University (WSU) that have improved our program capabilities by providing processed films for microstructural characterization.

- ◆ ANL, UES: We are working with ANL and UES on characterization of YBCO layers on growing and stationary substrate MgO films and multi-layer buffers. We are collaborating with ANL on evaluating local texture at various stages during buffer growth, transfer of texture from buffer to conductor, and the resulting effect of conductor's electrical performance.
- ◆ AFRL: We continue to collaborate with AFRL on striation of YBCO layers through laser ablation, and delineation of the microstructural difference between striated and non-striated areas. Additional techniques to pattern long YBCO tapes are being evaluated.
- ◆ AMSC: We have collaborated closely with AMSC to obtain coated conductors prepared by solution based processes using metal trifluoroacetate (TFA) precursors. Our plans for FY 2005 are to continue this partnership, our target is to evaluate fully processed thick (1 - 2 μm) YBCO films with $J_c > 2 \text{ MA/cm}^2$.