
Project Title:	Stanford In-Situ High Rate YBCO Process: Transfer to Metal Tapes and Process Scale Up
Organization(s):	Stanford University
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FY 2004 Funding:	\$100 K

Project Purpose and FY 2004 Objectives: The objective is to further the goal of the Stanford high-rate electron-beam deposition process. The process is capable in principle of meeting the cost/performance (C/P ratio) requirement of \$10/kA-m desired for coated conductors, and if the process can be scaled up a realistic goal for this process is a C/P ratio of \$1/kA-m. The research is aimed at solving the remaining technical problems of the approach and characterizing the process requirements. There are two tasks:

Task 1 - Explore Scale-Up Issues of Stanford's High-Rate Electron-Beam deposition process in Collaboration with Los Alamos National Laboratory. This task is concerned with determining the required deposition temperature and oxygen activity for a given deposition rate in the Stanford chamber, and then assist the effort at LANL in transferring the Stanford Process to the system at LANL. Initially the rate will be the present value of 100 Å/s. Higher rates will be explored as success is demonstrated. The target critical current density is a MA/cm² and greater.

Making the process more robust is another objective. This will use RE metals added to the copper evaporation source to enable the Atomic Absorption (AA) of the RE to monitor and control the combined flux, as well to possibly reduce the number of sources from three to two.

Task 2 - Collaboration with Los Alamos National Laboratory on the application of Stanford's High-Rate Process on IBAD-MgO (LANL) tape. This task is concerned with determining the electrical characteristics of the Stanford Process deposited on the LANL IBAD—MgO tape. Specifically:

- 1) Deposition of 123 YBCO (RE123) using our existing process on metal substrates (tape) provided by LANL. Our process so far requires a high temperature. A goal will be to work with LANL to improve the diffusion and buffer layers, and to lower the temperature by additions to the liquid flux being used.
- 2) Structural characterization of samples by XRD, and electrical characterization including resistivity and $J_c(T,H)$
- 3) Provide best samples to LANL for further characterization.

The target electrical characteristics are a critical current density of a MA/cm².

FY 2004 Performance and FY 2005 Plans: The arrival of the Post Doctoral researcher in April, 2004 marked the real start of this project.

Task 1: As the LANL facility comes on line we will collaborate in determining the process parameters, in terms of Temperature, oxygen activity, O^* , and rate, etc. We have been collaborating in an effort to make the process more robust in terms of monitoring and controlling the fluxes, and reducing the number of thermal or e-beam sources from three to two. This effort could have the additional benefit of making use of RE elements to maximize the high field pinning. Copper is difficult to flux monitor using AA (Atomic Absorption). Adding or combining a RE to the copper in the same source and monitoring the AA of the RE would also control the Cu flux. This is possible because of the similarity of the vapor pressures of Cu and a number of the RE's. We are investigating several options: 1. Trace of RE in Cu—monitor the AA of the RE. A few % RE in Cu would have no effect on the YBCO superconducting performance. This would still require three sources. 2. Complete replacement of Y by RE. This results in only two sources. 3. Mixture of RE's in Cu, either with Y (three sources), or without Y (two sources). In a limited number of experiments so far the predictive equation governing the relative fluxes has been roughly validated for

the case of Nd in Cu. We will continue these tests with larger sources which will have more constant flux ratios over longer times consistent with film growth. We will deposit films of REBCO using our chopped-ion-gauge monitors and trial and error determination of T and O*. This will allow us to better assess the feasibility of this approach, and to test the properties of the REBCO superconductor made with the high rate with liquid assist. We will continue the assessment of the combined RE in Cu method for other RE which satisfy the requirements of AA (ground state transition in the range of available TDLs, transition probability favorable for absorption), vapor pressure close to Cu, and superconducting properties suitable for Coated Conductors. So far the elements Nd, Er, Dy and Ho are being considered.

Task 2: Using LMO/IBAD- MgO tape from LANL, we first investigated different methods of establishing thermal contact with the heater block. Finally after considerable effort a technique using silver paint now results in visually seeing no difference in the color of the tape compared with the block, whose temperature is monitored by a thermal couple. A FTIR has successfully measured the temperatures and reflectance on growing YBCO on LAO, and we expect this will be possible soon on tape. Deposition on tapes are being done at various temperatures of the block, from 940°C to 880°C, so far. The R vs. T curves have shown improvement as the temperature is lowered, indicating chemical diffusion and reaction at the higher temperatures. Collaboration with LANL on the source of the elements in the diffusion into the YBCO are underway.

The high temperature demanded by the liquid in our process so far has been a challenge to processing on tapes. Our best performance on LAO has been with the temperature (block) of 940°C down to about 900°C, however recently the FTIR shows the temperature is 20 to 30°C lower than the block temperature on growing YBCO on LAO. This suggests that we need to take the block with tape to lower temperatures, say 20 to 30°C lower than that optimum for LAO.

If there is still signs of reaction two paths are possible: 1. Improve the diffusion barrier on the tapes. 2. Lower the melting temperature of the BaCuO liquid, allowing a lower process temperature. As we have shown, the liquid is needed for the high quality growth at the high rates, 10 nm/s to 20 nm/s, being explored. Our AFOSR program is exploring the basic materials science of the liquid phase stability region in T and O*, and will explore reported additives that lower the melting temperature. This information will provide immediate and direct information on the program here to lower the process temperature on metal tapes. Tapes so produced will be tested at Stanford and at LANL.

Research Integration: The Stanford DOE program is charged with supporting the effort at LANL to scale up the high rate process, and there is close collaboration. We informally exchange information with the group of Judith Driscoll and Jan Evetts at Cambridge University.