Project Title:	**Laboratory Scale Dip-Coating and Vacuum Conversion of Solution-Deposited YBCO**
Organization(s):	**Oak Ridge National Laboratory and Sandia National Laboratories**
Presenters:	F. A. List (ORNL) and P. G. Clem (SNL)
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Project Purpose and FY 2003 Objectives: The purpose of this effort is to develop processing and equipment for rapid production of meter-length YBCO conductor based upon the SNL TFA-YBCO process and using the ORNL Coated Conductor Research Laboratory. In this collaboration, several objectives were pursued: (a) to develop rapid solvent pyrolysis for the TFA-YBCO dip-coating process, (b) to demonstrate continuous dip coating and solvent pyrolysis for meter-length tapes, (c) to investigate the conversion of precursor films for pressures ranging from 1.5 atm to nearly vacuum, and (d) to attempt to increase YBCO film thickness on RABiTS substrates toward 1 μm with a minimum performance of 50A/cm-width or 0.5MA/cm^2.

FY 2003 Performance and FY 2004 Plans: Concrete progress was made in all four of the FY 2003 objectives. At SNL, a nearly instant (5-20 sec) pyrolysis process for TFA precursor was developed. This process is entirely compatible with continuous conductor fabrication and appears to be suitable for precursor at least as thick as ~0.7 μm. Using existing equipment at ORNL, three meters of ~0.25-μm-thick YBCO precursor on RABiTS were continuously dip-coated and pyrolyzed. Short lengths of pyrolyzed YBCO precursor on RABiTS were converted at ORNL for a range of pressures. For ~0.25-μm YBCO, critical current densities in self-field and at 77 K varied with processing conditions and ranged from 0.5 to 1.2 MA/cm^2. *In-situ* x-ray diffraction during vacuum conversion revealed rapid development of crystalline YBCO for conditions of high ramp rate and high water vapor pressure. For a ~0.7-μm-thick precursor on RABiTS developed at SNL and converted at ORNL using 1.5 atm, a J_c of 0.5 MA/cm^2 was obtained (S.F., 77 K) in an initial trial.

In FY 2004, SNL will continue development of instant pyrolysis, TFA-type YBCO films toward 1-2 μm thick crystallized films. Control of Y:Ba:Cu stoichiometry is one key element that needs to be closely controlled. Other goals include development of thicker single layer (~1 μm) and multilayer (1-3 μm) approaches to enable high current (100-300 A) conductors. In addition, SNL will collaborate with ORNL on improved tape coating/pyrolysis equipment (furnace design, tape handling) and process methods.

ORNL will continue in FY 2004 to study precursor conversion for a range of pressure. Rapid conversion of thicker precursors to higher performance YBCO will be emphasized. A new slot die coating system, with an in-line furnace, will be used to deposit and pyrolyze precursor solutions continuously on lengths of buffered tape. More uniform solution deposits resulting from the use of a slot die coater will facilitate process optimization.

FY 2003 Results: Key results from the FY 2003 program are summarized below.

1. Existing ORNL equipment was adapted to enable continuous dip coating of three-meter lengths of 0.25-um-thick TFA-YBCO, at a coating speed of 90 m/h. Critical current densities as high as 1 MA/cm^2 (S.F., 77 K) were achieved for short lengths of these samples converted in 1.5 atm. Furnace redesign is under way to enable dip coating of longer lengths.
2. A significant difference has been observed in reaction kinetics of thin (~0.25 μm) TFA-precursor for vacuum and atmospheric pressure conversions. The total processing time for vacuum conversion of ~0.25-μm TFA-precursor has been found to be as low as six minutes, whereas for atmospheric conversion ~60 minutes is typical for the same level of performance (~0.8 MA/cm^2, S.F., 77 K). The reason for this difference in reaction kinetics and whether this difference applies to thicker TFA precursors are presently under investigation. The consequence of this difference is that vacuum or low-

pressure conversion may enable substantially more rapid processing of high performance conductor.

3. Initial results for a 0.7-μm-thick TFA-YBCO film prepared at SNL and converted at ORNL have yielded 35 A/cm-width in self-field and at 77 K. Significantly higher performance can be expected with optimization of process.

4. Construction of a slot die coating system is under way to provide an alternative to dip coating for application of precursor solutions to buffered substrate. Better control and uniformity of the solution deposit are expected using slot die coating technology.

Research Integration: This on-going collaboration between SNL and ORNL is beneficial to both laboratories and to the entire coated conductor effort. For this, SNL has provided experience with rapidly pyrolyzed TFA precursors and ORNL has offered experience with continuous processing techniques, vacuum conversion with *in-situ* XRD diagnostics, and atmospheric conversion of thicker (>0.25 μm) precursors. Thus far, this collaboration has enabled a demonstration of long-length deposition of TFA-YBCO on RABiTS tape and a comparative investigation of conversion kinetics for precursors derived by the TFA method and the BaF_2 e-beam evaporation method. Buffered tapes, TFA precursor solutions, and pyrolyzed precursor films have been routinely exchanged between laboratories. Results and advice have been freely shared via telephone and electronically. Two visits to ORNL by SNL staff (PGC) were conducted to facilitate technical exchange. The availability of substrates, staff, and YBCO coating and conversion facilities at ORNL have enhanced SNL's ability to qualify TFA-YBCO film processes and identify process issues, such as film stoichiometry and phase development.