Project Title:	**Reel-to-Reel Characterization of Time-Based Phase Evolution in YBCO Coated Conductors: The BaF2 Precursor**
Organization(s):	**Argonne National Laboratory and Oak Ridge National Laboratory**
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Project Purpose and FY 2003 Objectives: At the FY 2002 Peer Review, several presenting organizations reported results on YBCO coated conductor (CC) in upwards of one meter lengths. Emerging reports of results for FY 2003 are indicating that performance at these lengths (and at lengths greater than 10 meters) is improving steadily. In the ex-situ approach, the fabrication of multi-meter lengths of YBCO CC is generally being accomplished by deposition of a suitable YBCO precursor mix onto buffered/textured metal tape, followed by heat treatment of the coated tape to produce a biaxially textured film of orthorhombic YBCO. However, there is still no broadly recognized understanding of the mechanisms involved in the YBCO precursor conversion, and, concomitantly, there is a rapidly developing need for on-line diagnostic procedures that can provide critical information about the progress and the quality of the CC fabrication process. The purpose of this project (inspired by considerations of research issues and emerging capabilities revealed at the FY 2002 Peer Review) is to investigate phase evolution during the reactive heat treatment of meter-length tapes coated with the "BaF_2"-type precursor to the YBCO phase. The work on this project during FY 2003 has combined expertise in long-length "BaF_2" precursor deposition and reel-to-reel (R2R) X-ray diffraction (XRD) at Oak Ridge National Laboratory (ORNL) with the R2R Raman microscopy capability at the Argonne National Laboratory (ANL).

FY 2003 Performance and FY 2004 Plans: During FY 2003, researchers at ORNL developed and tested a method for creating a graded Y-Ba-Cu-O phase assemblage on a single "BaF_2" precursor tape. This methodology involved slowly reeling a coated tape into a preheated furnace, such that the time at the prescribed treatment temperature (in the required processing atmosphere) varied in a systematic way along the length of the tape, then rapidly backing the tape out of the furnace to quench in the various states of YBCO phase evolution. The time domain expressed in these "quenched tape" experiments ranged from the very early stages of precursor crystallization to stages that involved (1) the initial formation of YBCO, (2) the time domain of optimally converted YBCO, and (3) time domains past the optimum. These quenched tapes have subsequently been analyzed by R2R XRD at ORNL and R2R Raman microscopy at ANL. The results of these examinations have produced a model for understanding the "BaF_2" precursor conversion mechanism based on processing methodologies currently used at ORNL.

The plan for future work that has emanated from the FY 2003 results includes (1) using insights from these results to further optimize the heat treatment protocol for "BaF_2" precursor conversion, (2) conducting experiments to test the proposed mechanistic model for "BaF_2" precursor conversion, (3) modifying the "BaF_2" precursor to examine the potential effects of differing precursor phase assemblage on reaction pathway, (4) applying the "quenched tape" technique and the associated R2R characterization methods to other precursors [e.g., the trifluoroacetate (TFA) precursor], and (5) testing the utility of the complementary R2R characterization methods (XRD and Raman microscopy) as on-line diagnostic tools.

FY2003 Results: In FY 2003, two one-meter-plus length tapes comprised of "BaF_2" precursor deposited on CeO_2/YSZ/Y_2O_3/Ni/Ni-3at.%W RABiTS-type/buffered substrates were given the "quenched tape" treatment at ORNL. The YBCO thicknesses on the two tapes were ca. 280 nm and ca. 1000 nm, respectively (to allow interrogation of thickness effects). Both tapes were examined in detail by R2R XRD at ORNL and by R2R Raman microscopy at ANL. The XRD results tracked selected phases, such as, YBCO, BaF_2, $BaCeO_3$, and the various epitaxial layers of the buffered substrate. The Raman results also tracked the YBCO and to a limited extent the BaF_2 and $BaCeO_3$. However, the Raman microprobe also detected and allowed us to track key intermediate phases, such as CuO, $Y_2Cu_2O_5$, and barium cuprates, and, in addition, it provided information on the phase state of the YBCO (orthorhombic versus tetragonal). Using the combined information from the XRD and Raman measurements, we were able to deduce the optimum heat treatment times for the two different tapes, which were confirmed by transport J_c measurements on similarly processed samples. In addition, we were able to determine the consequences of over-heat-treating, and develop a plausible/testable model for the YBCO formation mechanism that has as its basis a series of binary reactions.

Research Integration: Once the first vestiges of useful information began to emerge from the BaF_2 "quench tape" specimens, we prompted American Superconductor (AMSC) to perform a similar experiment with their metal organic TFA precursor. Accordingly, AMSC prepared the first in an anticipated series of such meter length tapes and that tape was subjected to detailed examination at ANL. We have also completed a R2R Raman examination of a fully-processed 12 meter tape manufactured by IGC-SuperPower using an MOCVD precursor route. Both of these studies have produced salient new information on the respective precursor conversion process, the texture of the YBCO layer, and the spatial dependence of orthorhombic YBCO phase homogeneity. Results of the latter studies will be reported in other FY 2003 Peer Review presentations.