Organization: Oak Ridge National Laboratory
Project Title: Continuous Processing of YBCO Coated Conductor
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Project Purpose and FY 2001 Objectives: The purpose of this project is to address issues associated with continuous processing of lengths of YBCO coated conductors. Our primary objectives for FY 2001 are:

1. To improve the structure, processing, and throughput of RABiTS using reel-to-reel equipment.
2. To fabricate meter-length RABiTS using textured alloys.
3. To further develop the *ex situ* process to convert lengths of YBCO on RABiTS.

FY 2001 Performance and FY 2002 Plans: A significant portion of our FY2001 effort has been focused on understanding, optimizing, and refining our reel-to-reel equipment. In order to obtain a conductor with good performance characteristics, every processing step must be carried out correctly. Since each piece of reel-to-reel equipment performs a specific step in the YBCO coated conductor fabrication process, it is possible to study and optimize these individual steps. We have successfully uncovered certain important processing conditions that have significant influence on the texture and performance of second-generation HTS conductors.

Particularly noteworthy accomplishments in the fabrication of RABiTS include a study of inter-relationships among processing conditions, surface chemistry and texture during the metal annealing/seed-layer deposition step. Also, the effects of cracks in the CeO_2 seed-layer on the quality of subsequent buffers and YBCO have been investigated. Well-textured meter-long RABiTS has been fabricated with Ni and strengthened Ni-alloys using both physical vapor and solution-based seed-layers. As reported in FY 2000, dimensional flaws in RABiTS were determined to contribute to the non-uniform conversion of *ex situ* processed YBCO. Causes of these dimensional flaws have been isolated and corrected such that smooth and straight RABiTS can now be produced routinely.

In the area of *ex situ* YBCO conversion, a systematic study of dominant processing parameters in our continuous reel-to-reel reaction chamber is underway. Statistical data on uniformity of tape performance are being collected and have shed light on the influence of gas flow and conversion time on ultimate conductor characteristics. We have devoted effort to investigate the possible advantages of using reduced pressure during *ex situ* conversion. This effort includes the design and construction of a low-pressure conversion system with *in situ* XRD and mass spectrometry, as well as, a rotating batch conversion furnace capable of processing six-meter long samples in reduced total pressure.

Our FY 2002 plan focuses on:

1. Understanding, optimizing, and modifying individual processing steps to improve further the overall quality and consistency of RABiTS.

2. Using our reel-to-reel and batch furnaces to *ex situ* process YBCO conductors with J_c consistent with the underlying RABiTS texture.
3. Utilizing our conversion furnaces to explore the influences of processing pressure and furnace geometry on the efficiency of large-area conversion.

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FY 2001 Results: Commercial development of a RABiTS conductor requires adequate supply of well-textured substrates with smooth surface and minimal density of defects. The establishment of an industrial supply chain providing each of the fabrication steps, including consolidation of Ni or Ni alloy powder or castings, homogenization of grain sizes, formation of a coil, rolling to final thickness and annealing to obtain the cube texture is essential. We have made a first attempt at putting together a supply chain consisting of industrial vendors for fabrication of kilometer lengths of substrate.

Based on results from the strategic research portion of our program, we have installed an *in situ* Auger analyzer in our metal annealing/seed-layer deposition system to probe the inter-relationships among annealing conditions, deposition conditions, surface chemistry and texture. Preliminary results indicate that annealing conditions have significant influences on the sulfur content of the annealed metal surface. The sulfur content, in turn, has a noticeable effect on the texture quality of the CeO_2 seed-layer. With this newly uncovered information, further improvement in the overall texture and consistency of RABiTS is expected.

Systematic investigations of the effects of gas flow rate and conversion time on the *ex situ* formation of YBCO have been performed in our continuous reel-to-reel furnace using 50 to 60 cm-long samples. These results have provided important statistical data on the performance and uniformity of converted YBCO coated conductors. In agreement with short samples, results from these long-length conductors reveal that an optimum conversion time exists for a particular gas flow rate. Furthermore, the flow rate has been shown to have a significant influence on the performance of the converted material. To date, samples with end-to-end J_c approaching 0.5 MA/cm^2 average J_c greater than 0.6 MA/cm^2, 1-cm sectional J_c approaching 0.8 MA/cm^2, and good sectional uniformity have been obtained. These values are only slightly lower than short sample results of 0.8 MA/cm^2, which represents the J_c limit according to the underlying RABiTS texture.

Several 20-cm-long *ex situ* YBCO tapes fabricated on RABiTS were used to study the quench behavior of second-generation HTS conductors. Quench tests of the samples were performed with both liquid nitrogen cooling and conduction cooling with a cryocooler. With liquid nitrogen cooling, full recovery of the superconductor was observed under a short initial over-current pulse followed by different operating currents. With conduction cooling, minimum quench energy, minimum propagating current, and thermal runaway current were observed. Normal zone propagating velocities of 0.1 to 0.8 cm/s have been measured so far. Comparison of quench behaviors in conductors with varying current carrying capabilities is under way.

y on an alloy substrate.

Technology Integration: Four CRADA teams, led by 3M, AMSC, MCT, and Oxford work with ORNL on implementing and scaling RABiTS technology. We collaborate with LANL on PLD of YBCO on lengths of RABiTS. ORNL has established a suite of laboratories for implementation of the Accelerated Coated Conductor Initiative. These facilities were shown to industrial partners for the first time in conjunction with a workshop for patent licensees held on April 19, 2001. Input concerning industry's needs and suggestions for facility development was sought. Our latest results on processing of lengths were discussed and individual CRADA discussions were held. Numerous additional individual CRADA meetings hosted by industry partners were held during the year.