
Project Title:	Non-Vacuum Techniques for HTS Coated Conductors
Organization(s):	National Renewable Energy Laboratory
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FY 2003 Funding:	\$500 K (NREL); \$300 K (OST); \$50 K (ORNL)

Project Purpose and FY 2003 Objectives:

Project Overview: The U. S. Department of Energy's vision is, "Low-cost, high performance YBCO coated conductors will be available in 2005 in kilometer lengths. For applications in liquid nitrogen, the wire cost will be less than \$50/KA-m, while for applications requiring cooling to temperature of 20-60 K the cost will be less than \$30/KA-m." One of the important critical needs to achieve this goal is to develop a simple low-cost technology for producing HTS and also buffer layers for low-cost metal substrates. Our project offers non-vacuum electrodeposition, dip coating and spray deposition processing technologies, which are potentially low-cost, long length and continuous processes. At present, we are working on development of HTS and buffer layers employing all these non-vacuum technologies. The bismuth-based cuprate is the primary HTS material system under investigation. NREL is working with Oxford Superconducting Technology (CRADA partner) in developing the Bi-2212 conductor for a HTS MRI system. The overall approach for HTS "wire" processing employs the non-vacuum deposition of precursor followed by high-temperature reaction in an appropriate atmosphere. The processing issues under investigation are deposition conditions, substrates, buffer layers, and post-deposition heat treatment. For the Bi-2212 coatings, textured substrates, such as NREL's electrodeposited Ni/Ni-W, Au/Ni, as well as YSZ/CeO₂ nickel substrates, are utilized, combined with appropriate buffer "cap" layers such as CeO₂. The realization of biaxially textured "thick" oxide superconductor films with high transport current is the primary objective for this part of our research project. NREL is also actively participating in the development of second-generation YBCO HTS tapes. NREL is developing electrodeposited biaxially textured buffer layers (Ni, Au on both Ni-W and Cu) for YBCO in collaboration with ORNL. NREL is also developing an electrodeposited Cu stabilizer on a YBCO-coated conductor in collaboration with LANL, BNL, and ORNL. NREL provides communications support by maintaining the DOE Web site for the Superconductivity program.

FY 2003 Objectives:

- Demonstrate current density for electrodeposited Bi-2212 film on polycrystalline Ag comparable with dip-coated films.
- Demonstrate the improved superconductor properties of biaxially textured films compared to uni-axial textured films.
- Prepare electrodeposited buffer layer for YBCO-coated conductors.

FY 2003 Performance and Results:

- Bi-2212 "coated conductor" was reacted from electrodeposited precursor on polycrystalline Ag showing current density near 106 A/cm² at 4.2 K.
 - Biaxially textured Bi-2212 was prepared on MgO, LAO and buffered Ni substrates.
 - Buffer layer processes on textured Ni, Ni-W and Cu were developed using electrodeposited Au and Ni.
 - Developed a "melt-quench-melt-growth" (MQMG) process, which facilitated an open reaction and eliminated loss of material during processing. Nearly phase pure Bi-2212 was produced with $J_c > 5 \times 10^6$ A/cm² at 4.2 K and $J_c > 10^4$ A/cm² at 77 K.
 - Transmission electron microscopy (TEM) measurements on Bi-based superconducting films prepared by electrodeposition were carried out to determine the quality of the materials.
 - Prepared 70 μ m thick Cu layer by electrodeposition process to be used as a stabilizer on YBCO coated conductors.
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FY 2004 Plans:

- Investigate non-vacuum techniques for producing biaxial texturing of Bi-2212 on textured metal substrates.
- Demonstrate a biaxially textured Bi-2212 thick film with $J_c > 106 \text{ A/cm}^2$ at 4.2 K.
- Optimize Bi-2212 oxygenation heat treatment to improve transport current in the 20-40 K temperature range.
- Explore techniques for improving Bi-2212 by nanoparticle additions.
- Work with Oxford Superconducting Technology on CRADA.
- Prepare electrodeposited biaxially textured buffer layers for YBCO HTS (collaboration with ORNL).
- Prepare electrodeposited Cu stabilizer on YBCO-coated conductor (collaboration with LANL, BNL, and ORNL).
- Maintain the DOE Web site for the Superconductivity program.

Research Integration: NREL, Boston College, and University of Colorado studied processing conditions to obtain single-phase Bi-2212 films from electrodeposited and spray deposited precursor films. TEM analysis on electrodeposited Bi-2212 was also carried out by BC. NREL and Oxford Superconducting Technology are studying the processing of electrodeposited biaxially textured Bi-2212 films as an alternative to dip coating and powder-in-tube methods for possible high-field magnet applications. NREL established new collaborative effort with ORNL, LANL, and BNL on low-cost electrodeposited buffer layer deposition for YBCO coated conductors.
