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HIGH CRITICAL CURRENT COATED CONDUCTORS

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ORNL – SuperPower CRADA to Develop IBAD/MOCVD-based 2G Wire

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Abstract

One of the important critical needs that came out of the DOE's coated conductor workshop was to develop a high throughput and economic deposition process for YBCO. Metal-organic chemical vapor deposition (MOCVD) technique, the most critical steps in high technical micro fabrications, has been widely employed in semiconductor industry for various thin film growth. SuperPower has demonstrated that (Y,Gd)BCO films can be deposited rapid with world record performance. In addition to high critical current density with increased film thickness, flux pinning properties of REBCO films needs to be improved to meet the DOE requirements for various electric-power equipments. We have shown that doping with Zr can result in BZO nano-columns, but at substantially reduced deposition rate. The primary purpose of this subtask is to develop high current density MOCVD-REBCO coated conductors based on the ion-beam assisted (IBAD)-MgO deposition process. Another purpose of this subtask is to investigate HTS conductor design optimization (maximize J_e) with emphasis on stability and protection issues, and ac loss for REBCO coated conductors.

Statement of Objectives:

Assist SuperPower to understand the fundamentals of the technology and in the fabrication and commercial scale-up of IBAD-MgO-based high-performance low-cost commercial 2G wire.

Benefits to the Funding DOE Office's Mission

To advance technology in partnership with industry, government, and the public and to meet America's need for a reliable, efficient, secure, and affordable electric power grid.
The goal of the DOE-Office of Electricity Delivery and Energy Reliability (OE) is to jointly develop with industry the technology base needed for US industry to proceed to commercial development of electric power applications of high temperature superconductivity (HTS). Benefits of this research' will be 1) transmission cables that are three to five times current capacity, retrofit in urban applications, and substitute for overhead lines when environmentally prohibited; 2) transformers that are smaller, higher efficiency, have decreased fire hazard, and with negligible environmental impact; 3) motors and generators that are 50% smaller, 50% more efficient, and quieter than conventional equipment; and 4) current limiters that enhance the stability of the U.S. electricity grid. This project will also integrate the ORNL activities with other national laboratories, government agencies, universities, and electric utilities.

Technical Discussion of Work Performed by All Parties

The main objective of this agreement is to assist SuperPower in the development of high performance IBAD-MOCVD-based 2G wires for the commercial application of HTS technology. The CRADA work has provided an improved understanding of the fundamental properties of the IBAD-MgO template including planarization of mechanically polished hastelloy substrates using solution Al_2O_3 layers, functionalized LMO buffers and MOCVD-REBCO in the process. The activity is closely coupled to SuperPower's REBCO scale-up

program and has assisted SuperPower in implementing a robust, efficient, high throughput manufacturing process.

The SuperPower/ORNL High Performance LMO-enabled, High Temperature Superconducting Tape (LMO e-HTS) is a robust, high-current second-generation superconducting wire. This superconducting wire can be fabricated at high throughput rates using reel-to-reel processes. One of the key success factors which have enabled the above is the use of an epitaxial $LaMnO_3$ (LMO) buffer layer which can be deposited at high rates homogenously in long lengths. This buffer layer also allows formation of very high performance superconducting films. SuperPower demonstrated world-record performance superconducting wires based on the ORNL-developed LMO platform. To optimize the pinning performance of HTS films on such substrates, incorporation of zirconates and double perovskite based columnar defects were also investigated.

Subject Inventions (As defined in the CRADA)

All the buffer and MOCVD technology has been successfully transferred to SuperPower, Inc.

Commercialization Possibilities

SuperPower, Inc. has commercialized second generation high temperature superconducting wires for electric power applications.

Plans for Future Collaboration

ORNL will be interested in working with SuperPower, Inc. to develop second generation high temperature superconductor wires for SMES applications if proper funding is available. In addition, there may be interest in both parties for developing flexible electronic devices on SuperPower's IBAD-MgO/LMO templates.

Conclusions

The CRADA work has provided an improved understanding of the fundamental properties of the IBAD-MgO template including planarization of mechanically polished hastelloy substrates using solution Al_2O_3 layers, functionalized LMO buffers and MOCVD-REBCO in the process. The activity was closely coupled to SuperPower's REBCO scale-up program and has assisted SuperPower in implementing a robust manufacturing process. Close collaboration and interaction between ORNL, University of Houston, and SuperPower has resulted in significant advancement in process understanding and subsequently in the development of a robust manufacturing process at SuperPower. The collaboration functioned through regular conference calls, frequent sample exchanges, joint development and joint materials evaluation and testing, and CRADA meetings. Joint publications have resulted from this work. Furthermore, this team has also collaborated with both Argonne National Laboratory and Los Alamos National Laboratory scientists to evaluate substrates and characterize films produced at ORNL.