

**2010 Advanced Cables and Conductors Peer Review
Project Summary**

Project Title:	ORNL-AMSC CRADA: Development of RABiTS-Based 2G Wires
Organization:	Oak Ridge National Laboratory/American Superconductor Corporation
Presenters:	A. Goyal, M. Paranthaman (ORNL), and Cees Thieme (AMSC)
FY 2010 Funding:	\$800 K (DOE to ORNL)

Overall Project Purpose and Objectives:

The overall goal of this project is to support AMSC in establishing a low-cost, industrial manufacturing capability for 2G HTS wire based on the wide-strip MOD-YBCO/RABiTS™ technology. This collaborative project is focused specifically at the development of a commercial HTS wire required for the DOE mission of developing transformational electric power equipment, such as cables, fault current limiters, and transformers based on HTS technology. This project focuses on both (1) near-term improvements to AMSC's current 2G wire manufacturing process benefitting yield and performance and (2) long-term development of new materials and processes impacting future 2G wire performance, throughput and manufacturing cost.

The CRADA activities over the past year have focused on three major areas: (1) characterizing epitaxial growth mechanisms during the high-rate deposition of Y_2O_3 buffer layers on wide-web NiW substrates; (2) characterizing and improving the uniformity of the RABiTS template and MOD-YBCO films; (3) evaluation of low-cost, scalable manufacturing routes for RABiTS substrate with reduced ferromagnetic loss; and (4) exploration of solution processing of buffer layers.

2010 Approach and Results:

The ORNL-AMSC CRADA combines the expertise in the RABiTS template technology and unique characterization capabilities at ORNL with the process development and manufacturing expertise at AMSC to help establish an industrial manufacturing line for 2G HTS wire based on the RABiTS/MOD-YBCO technology. The close collaboration of ORNL and AMSC scientists, combined with the availability of unique resources at ORNL, enables the project team to explore a variety of potential technologies and new materials and to rapidly transform the most promising ideas into practical solutions that can be implemented in AMSC's 2G wire manufacturing process. During the past year, AMSC focused on improving manufacturing throughput and yield of the wide-web manufacturing process. The detailed characterization and correlation with process parameters carried out by the ORNL-AMSC team were key factors in establishing the YBCO-MOD/RABiTS technology for manufacturing 500 meter lengths of 2G wire with an I_c on order of 100 A in 4 mm wire (AMSC's 344 superconductors).

Key results and accomplishments in FY2010 included:

- Characterized non-uniformities in RABiTS templates which impacted wire yield and performance in AMSC's 2G production wire
- Characterized the Y_2O_3 seed layers and correlated texture and microstructural features with deposition key parameters
- Demonstrated the growth of solution-based CeO_2 seed layers directly on textured Ni-5W substrates and established a texture compatible with sputtered YSZ barrier layers
- Explored annealing parameters compatible with composite RABiTS substrates with reduced ferromagnetic loss

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2011 Plans and Expectations:

The ORNL-AMSC CRADA, during FY2011, will focus on short term manufacturing yield and performance improvement and long term development of new materials and processes compatible with AMSC's wide-web manufacturing process. Specific goals include:

- Identification, characterization and mitigation of defects impacting yield and performance in AMSC's 2G manufacturing line;
- Integration of solution-based seed and barrier buffer layers in a wide strip deposition process;
- Development and evaluation of novel pinning microstructures compatible with AMSC's MOD-YBCO deposition process;
- Characterization of a reduced ferromagnetic loss RABiTS substrate compatible with AMSC's wide web manufacturing process. .

Technology Transfer, Collaboration, Partnerships:

ORNL scientists work closely with the AMSC R&D team to develop long-term improvements to the RABiTS technology and to assist in the scale up and optimization of AMSC's 2G manufacturing line. This on-going collaboration has been highly valuable in developing AMSC's wide-web manufacturing process and addressing technical issues encountered during the initial operation and qualification of AMSC's 2G manufacturing line. The technical contributions have been key to resolving template manufacturing issues impacting both performance and yield. In addition, the collaboration has and continues to focus on the development of new materials and processes for the RABiTS technology which will impact the long-term performance and cost of 2G HTS wire produced in AMSC's wide-web manufacturing process.

The collaboration functions through weekly conference calls, frequent sample exchanges, CRADA meetings, joint development and joint materials evaluation and testing. AMSC views ORNL as their fundamental RABiTS template research laboratory and a key partner in characterizing and optimizing reel-to-reel manufacturing processes and materials, testing of 2G wires and developing novel, low-cost technologies that will further advance the MOD/RABiTS technology. A key aspect of the CRADA interaction is the ability of the ORNL technical staff to rapidly respond to AMSC's need to diagnose critical manufacturing issues and to work with AMSC's staff to identify solutions that can be transferred into AMSC's production process.