Project Title:	**Characterization of Coated Conductors for Improved Performance**
Organization:	Argonne National Laboratory
Presenters:	Dean Miller and Victor Maroni
FY 2010 Funding:	$650 K

Overall Project Purpose and Objectives:

The purpose of this project is to provide the critical link between microstructure, processing, and properties that is needed to understand and improve the performance of coated conductors. Our research addresses both basic science and applied research issues and is carried out in close partnership with American Superconductor Corp. and SuperPower to ensure maximum impact and relevance to the improvement of performance in coated conductors produced by those partners. We provide materials science insight through comprehensive characterization of samples provided by AMSC and SP to help guide their processing. At the same time, we also address some of the more fundamental research issues, such as flux pinning behavior, to provide the materials science basis for longer-term improvement. We utilize complementary capabilities that are strengths of the ANL program, including optical imaging, electron- and ion-beam microscopy, Raman spectroscopy, and x-ray absorption spectroscopy. The coordinated application of these approaches provides insight into the underlying microstructure and materials processes relevant to the production and performance of long-length coated conductors.

2010 Approach and Results:

Our research for FY10 has focused on providing critical microstructural characterization to address manufacturing and scale-up issues with our industrial partners and establishing the microstructural basis for in-field performance by chemically-derived flux pinning defects.

Research with AMSC has largely concentrated on addressing scale-up for their MOD-based coated conductor process. AMSC is transitioning to wider tape geometries that offer improvements in efficiency and cost. However, the commissioning and optimization of new equipment requires a high level of understanding of phase and microstructural evolution through the conversion process. Our research this year focused on helping AMSC identify key processing parameters that control uniformity across the tape width. We utilized our coordinated characterization techniques including Raman spectroscopy and analytical electron microscopy to establish the microstructural basis for variations in performance as a function of position in the deposition zone. The insight gained from these studies drew heavily on our earlier work that revealed important details of the nucleation and growth process of the HTS phase. In a collaboration with Industrial Research Ltd., a partner in the AMSC-led Wire Development Group, we explored the role of cation chemistry on HTS phase nucleation and growth. Whereas we had shown previously that precursor fluorine content is a significant factor, through this work we now show that cation chemistry is not a major influence.

In research with SP, our focus was on achieving a better pinning landscape through modification of chemistry. SP explored the synergistic effect between Zr additions and (Y,Gd) content, noting changes in H//ab and H//C peaks depending on the ratio of Zr to (Y,Gd). Our characterization of these samples excluded cation disorder as a major factor and suggested an interplay between columnar defects and ab-plane aligned rare-earth oxide precipitates as the key influence.

Related to the above, a significant part of our research activity focused on alternate chemical additions for flux pinning. The goal is to identify additions that can yield improved in-field performance and are also compatible with a manufacturing-scale MOCVD process. This research relied on a strong collaboration with ORNL, with both the ANL and ORNL research activities closely linked to SP and focused on additions that are compatible with an MOCVD process. ORNL has used their capabilities to prepare and evaluate MOCVD coated conductors with candidate additions such as Ce, Ho, and Nb, while ANL helped establish the chemistry and microstructure of the pinning landscape induced by these additions. Through this work, we have developed and more enlightened understanding of how these additions influence behavior.

2011 Plans and Expectations:

The primary focus of our research will continue to be on improving the performance of long-length coated conductors produced by AMSC and SP by using our coordinated characterization to address key issues for processing and performance. We will address the most critical issues identified through our interactions with AMSC and SP that can benefit from the application of our coordinated characterization approach.

With AMSC we will explore how to improve texture and nucleation to improve Ic. We will exploit the comprehensive understanding of nucleation that we have established for the MOD process to explore the influence of buffer layer modification and seed layers. A second major activity will be to establish the limit to thickness for single MOD coat processing. This will require our coordinated characterization to establish the chemical and microstructural evolution through process in these thicker single-coat films. A third area of focus will involve improving the efficiency of chemical additions for pinning, especially for different T and H regimes. This work will address two important aspects: i) establishing the nature of the important pinning defects at lower T and higher H and ii) improving the MOD process to achieve a higher yield of smaller precipitates that are most effective pinning sites.

Our research with SP will support their activities toward high performance, high efficiency processing, and advanced wire architectures. While we have contributed toward significant progress to achieve better pinning through chemistry, we will now explore routes to develop a better pinning landscape through process. The synergistic effects between chemistry and process will require the comprehensive evaluation and understanding of microstructure that ANL provides. A second area of focus will be to improve performance by improving nucleation. This work will involve extensive interactions between SP, who will explore process and substrate/buffer modifications, and ANL, who will provide detailed microstructural characterization to evaluate effectiveness. Finally, we will continue our work on alternative flux pinning additions with an emphasis on evaluating their efficacy in SP's commercial-scale process.

Technology Transfer, Collaboration, Partnerships:

This ANL research program is first and foremost committed to supporting our two industrial research partners, AMSC and SP. Research is carried out in direct collaboration and partnership with scientists and engineers at both of these institutions, and ANL researchers work closely with them to develop work plans, design experiments, and evaluate results. Research with AMSC is also carried out under the auspices of the AMSC-led WDG, ensuring that research topics address AMSC's highest priority concerns. Active collaborations with WDG partners (AMSC, ORNL, LANL, FSU, and IRL) provide critical interactions, enhancing the value of new discoveries that can impact other areas of research. Similarly, research with SP is also highly interactive with other research partners, notably ORNL and LANL. These collaborations are forged to help address key issues and expand the impact of each partner's research capabilities. We also provide important characterization to a number of other research partners, including BNL and SNL, to help strengthen the overall OE HTS research portfolio.