Project Title:	**Electromechanical Studies for Coated Conductor Development**
Organization:	National Institute of Standards and Technology, Boulder, CO
Presenters:	Danko van der Laan and Fraser Douglas
FY 2010 Funding:	$350 K

Overall Project Purpose and Objectives:

This project provides the electromechanical research needed to develop YBCO coated conductors for electric power grid applications. On one hand, the project performs the measurements needed to ensure that the conductor can withstand the stresses and strains that develop during operation. On the other hand, the project uses its expertise in electromechanical research to help industry, universities and National Laboratories to enhance the performance of YBCO coated conductors and to help resolve key issues related to their application.

2010 Approach and Results: Key results from the FY 2010 program are summarized below:

1) **Stress-strain measurements of facetted sapphire fibers:**
Facetted sapphire fibers are a promising new substrate material for YBCO coated conductors for low ac-loss applications. We performed stress-strain measurements at room temperature and at 76 K on fibers that were prepared by Amit Goyal at ORNL. At room temperature, the stress at failure was relatively high, namely about 1.5 GPa at 0.8 % strain.

2) **Electro-mechanical testing of YBCO coated conductor splices:**
Electro-mechanical tests of YBCO coated conductor splices to determine their mechanical integrity have been performed on lap joints that were prepared by Robert Duckworth at ORNL. One-inch long lap joints were prepared with different solders using conductors from SuperPower Inc. The joints proved to be mechanically sound under axial loading. No significant change in joint resistance was measured below the critical stress at which the superconductor degrades.

3) **Development of a new concept for YBCO cabling:**
The YBCO coated conductor cabling concept for low ac-loss and high-field magnet applications, which was developed by NIST last year, has been further studied. In this concept, the coated conductors were wound with their YBCO layer under compression around a round former. The conductor was twisted around the former to allow a full transposition of the YBCO layer, which in the future may be patterned into filaments. In collaboration with ORNL and SuperPower, several cables were prepared and the performance of the coated conductors in these cables was studied as a function of former diameter, conductor twist pitch, and cable bending radius.

4) **Effect of strain on I_c and flux pinning in YBCO coated conductors at 65 K and 76 K:**
The strain dependence of the critical current of a number of YBCO coated conductors made by SuperPower, American Superconductor and Bruker has been measured as a function of magnetic field and field angle at 65 K and 76 K. These measurements provide our collaborators with important performance feedback needed for their application designs. A large difference in strain dependence of I_c was measured when the magnetic field was applied along the *c*-axis of the coated conductor, compared to the case where the magnetic field was applied within the *ab*-plane. In most cases, strain reduced the critical current density and flux pinning strength in YBCO coated conductors. This has important

consequences for their application. The reduction in performance needs to be further characterized and its origin needs to be understood.
DOE has selected two of its control milestones for FY'10 from this task.

5) **Studies of the fundamental origin of the strain effect in YBCO:**
Understanding the fundamental origin of the reversible strain effect in YBCO will help improve the performance of coated conductors and may lead to more effective pinning defects. One of the reasons why the origin is not yet fully known is that the strain effect is influenced by the complex microstructure of the YBCO, where grain boundaries and twinning planes within the grains affect the conductor behavior under strain. The interplay between strain and microstructure is better understood in $Bi_2Sr_2Ca_2Cu_3O_x$ tapes. We will provide evidence that the reversible strain effect on critical current density and magnetic flux pinning in this material is entirely caused by the pressure dependence of the critical temperature. We believe that this knowledge will help us create a better understanding of the origin of the reversible strain effect in YBCO coated conductors.

2011 Plans and Expectations:

The FY 2011 plans are determined in consultation with the manufacturers and a number of research collaborators within the DOE/OE community:

- Measure the effect of strain on the critical current of YBCO coated conductors in magnetic field at various field angles and temperatures to investigate the effect of strain on pinning. This will provide industry with important design data for high-field applications.
- Expand our measurement capabilities to study the effect of strain on critical current density and magnetic flux pinning at various temperatures in YBCO grains and grain boundaries.
- Continue to develop a detailed understanding of the fundamental origin of the strain effect in YBCO coated conductors.
- Continue the development of the YBCO coated conductor cabling concept for low ac-loss and high-field magnet applications. Collaborate with ORNL to perform ac-loss measurements on the various cabling geometries.
- Measure the mechanical properties of sapphire fibers to support the development of alternate coated conductor substrates.
- Continue with the investigation of the mechanical integrity of YBCO splices, with an emphasis on different splice geometries.
- We will perform various electromechanical measurements upon request, such as measurements of delamination strength, in-plane bending performance, stress-strain, irreversible strain limit, etc.

Technology Transfer, Collaboration, Partnerships:

NIST collaborates closely with researchers and managers from AMSC, SuperPower, ORNL, LANL, AFRL and universities such as FSU to implement a research program that utilizes the specialized electromechanical test facilities and expertise at NIST. The resulting data provide performance feedback of YBCO coated conductors, which is incorporated into the application design. In support of the strategic research performed under the DOE program, NIST provides its collaborators with new concepts to address key issues related to the application of YBCO coated conductors. A growing number of collaborative papers with these organizations have been published or are currently being prepared.