Project Title:	**Wire Development Group: Improving the Understanding and Performance of HTS Wire.**
Organization(s):	**Los Alamos, Argonne and Oak Ridge National Laboratories American Superconductor Corporation University of Wisconsin**
Presenters:	Alex Malozemoff (AMSC), Eric Hellstrom (UW) Leonardo Civale (LANL) and David Larbalestier (UW)
FY 2004 Funding:	DOE-EERE AMSC LANL $375 K ORNL $225 K UW $262 K ANL $150 K (initially authorized – only $80 K available) AMSC $535 K

Project Purpose and FY 2004 Objectives: The Wire Development Group (WDG) is a unique multi-institutional collaborative effort focused on advancing the materials science underpinning advanced HTS (BSCCO and YBCO) conductors for energy and magnet applications in the US and international marketplace. The WDG combines the expertise and resources of three DOE national laboratories (ANL, LANL and ORNL) and a leading university program in applied superconductivity (UW-Madison) with the world's leading entrepreneurial company (American Superconductor – AMSC) developing and manufacturing both first (BSCCO-1G) and second (YBCO coated conductor – 2G) generation HTS wire and wire products. Robust long-length 1G wire is commercially available today and is being used in an expanding range of applications. This project aims at extending the state-of-the art performance of the 1G conductor to improve its price/performance and to maintain the U.S. position as the world-wide leader in commercial HTS wire development and manufacturing. During the past year, this project has also undertaken the task of enhancing the performance of 2G wires, focusing specifically at the operating conditions (T,H,θ) of targeted commercial and military applications. Specific objectives of the past year were:

1) Improve the understanding of the BSCCO-2223 formation process,
2) Evaluate routes to increasing BSSCO-2223 phase purity in 1G wire and enhancing J_c,
3) Develop a low-temperature scanning laser microscopy (LTSLM) capability and combine it with transport MO studies to identify and characterize local sources of dissipation in 1G and 2G HTS conductors,
4) Evaluate over-pressure (OP) processing for 1G wire production,
5) Bring WDG experience and capabilities to bear on materials science and superconducting properties of 2G wire – specifically in enhanced pinning.

FY 2004 Performance and FY 2005 Plans: Progress was made on most FY04 objectives (see results below), resulting in significant performance improvements in both 1G multifilamentary conductors and 2G films. A major new initiative to broaden WDG activity into 2G wire was undertaken, focusing on detailed characterizations of the microstructure and field dependence of ex-situ processed YBCO films. A temporary interruption of funding limited the effort on Objective 2 above and delayed purchase of equipment, e..g. for Objective 3. Because of a major increase in performance in non-OP processed 1G wire, the focus of Objective 4 was shifted from long-length production to optimizing the OP process for additional J_c increases using the same wires. Our efforts in FY05 will remain focused on continued improvements in the processing, materials chemistry, and characterization of 1G wire, and the characterization and optimization of pinning and current limiting mechanisms (CLMs) in 2G wires prepared with ex-situ techniques. Specific areas of research include:

1) Enhance our understanding and control of BSCCO-2223 phase formation in 1G wires to further improve phase purity, eliminate CLMs and open new paths to increase I_c, including optimized OP processing,
2) Combine detailed J_c-anistropy and microstructure measurements with new processing to introduce pinning and improved grain boundary structure to optimize 2G wire performance at the operating conditions of temperature, field and field orientation for targeted applications,
3) Implement and refine new analytical techniques such as LTSLM for probing current flow and dissipation in 1G and 2G conductors, identifying CLMs and opening new paths for J_c enhancement.

FY2004 Results: Key results include:

- The role of BSCCO-2212 intergrowths as CLM's in HTS wire was studied, and a new "anticorrelation" was found between J_c and the 2212 SQUID index. These results explain increases in J_c achieved during the final stages of heat treatment.
- A critical current of 202A (480A/cm-width at 77K sf), a new record, was achieved in a 1G wire using overpressure processing (OP). Another new record I_c of 190A (450A/cm-width) was obtained in a 4.2x0.21 mm^2 wire cross-section without OP. Work to apply OP to these wires has been initiated.
- Localized dissipation was observed along YBCO grain boundaries by LTSLM, and correlations with local grain boundary orientation are studied.
- Temperature, magnetic field H, and field orientation dependent measurements of J_c were performed on PVD-BaF_2 YBCO conductors on RABiTS with the goal of establishing correlations with controlled process variations. Fast-processed films may exhibit significantly reduced anisotropy (<2 for the J_c ratio for fields parallel or perpendicular to the tape plane at H=1 T, 77 K). The angular dependence of field angle typically exhibits only a minor peak for fields parallel to the c-axis. A simple scaling of low-temperature, medium field (e.g., 2 T) J_c values and the self-field J_c at 77 K was observed, with remarkably weak dependence on high-field pinning characteristics.
- J_c anisotropy of MOD-based 2G wires was measured as a function of magnetic field orientation and temperature. Rare-earth nanodots in MOD YBCO films, detected by TEM, were shown to significantly improve the in-field performance from 26 – 77K with themagnetic field oriented in a range around the perpendicular to the tape plane. The dominating contribution of planar defects was identified for the magnetic field oriented in a range around parallel to the tape plane.

Research Integration: The WDG remains a vibrant example of effective inter-institutional, university-lab-industry collaborations, which has helped establish US scientific leadership in HTS wire development, as well as unquestioned world leadership in 1G HTS wire production by a US company. During the last year, new members have been added to the core WDG group to enhance the expertise in the 2G wire area. Trimesterly meetings, frequent individual visits, emails, phone calls, and intra-organizational sample exchanges insure rapid coordinated progress by exploiting the unique skills at the different sites. A sensible balance of proprietary technology and publishable results is maintained. An atmosphere of trust supports a positive and enthusiastic esprit de corps. The expertise and cooperation in the group allows new challenges, including 2G wire development, to be rapidly addressed. Key lab and university results are tech-transferred effectively to AMSC, enabling rapid introduction of new developments to the AMSC production of robust long-length wire.