Project Title:	Coated Conductor (2G) Manufacture Scale-up at AMSC
Organization(s):	**American Superconductor Corporation**
Presenters:	John Scudiere
FY 2003 Funding:	$400 K (from DOE contracts)

Project Purpose and FY 2003 Objectives: This effort is directed toward continuous process development for the manufacture of RE-123 Coated Conductor (2G) composite wire. The multi-year objective of this program is to demonstrate an HTS wire process and product that will be commercially viable and broadly applicable for commercial and military customers. Financial support for this effort includes DOE funding for: (a) SBIR wire development, (b) Ic improvement and (c) 2G wire purchase. Technical support has been provided many groups, particularly through CRADA programs at ORNL, LANL, ANL and SNL.

Target -Specific FY 2003 goals include:

1) Develop a reproducible, high-performance, low cost (>100A/cm-width at 77K, sf) manufacturing process for 2G wire.
2) Fabricate and characterize multiple 10 meter long wires using low-cost manufacture process.
3) Demonstrate commercial wire geometries applicable as form-fit-function replacements for commercial BSCCO 1G wire (to accelerate acceptance).
4) Develop a realistic cost model for 2G manufacturing process compatible with a $10-20/kAm price in production volume (competitive with copper).

Note: goals established in the 2002 Peer Review ORNL CRADA presentation and 2003 AMSC WDW presentation.

FY 2003 Performance and FY 2004 Objectives: Significant progress was demonstrated against all FY 2003 goals. The AMSC R&D reel-to-reel processing capability was extended from a one-meter to a ten-meter process length. Characterization of the 10 meter tapes showed no Ic reduction with increasing tape length. Wire Ic was dramatically increased over the past year for both long (10 meter) and short (<10 cm) samples (providing a clear path for higher performance during FY 2004). Two commercial 2G HTS wire geometries incorporating electrical, mechanical and thermal stabilization were designed and demonstrated. The first 2G wire order was delivered to Ultera and ORNL (30 x 1.6m wires) for prototype cable fabrication and characterization. Commercially viable fabrication rates have been demonstrated for all process steps required for YBCO wire manufacture. We have confirmed customer interest in obtaining a form-fit-function replacement for 1G BSSCO wire at $10-20/kAm price. We have validated our cost model based on (a) actual measured R&D process rates for each process step and (b) proposed Pilot equipment configurations.

Proposed FY 2004 goals include:

1) Scale-up R&D process width from 1cm to 4cm wide to confirm uniform deposition and growth of buffer and HTS layers (Ic performance over width and length) on wide in-process tape. This is a critical demonstration since the low cost 2G manufacture process is predicated on slitting multiple wires from a single laminated process tape.
2) Demonstrate high-performance (300A/cm-width @ 77K, sf) commercial (form-fit-function) geometry wire at 4mm wide and 10 meters long (laminated and slit).
3) Demonstrate 10cm wide substrate fabrication meeting texture and surface quality specifications.

FY 2003 Results:

Key results from the FY 2003 program are summarized below:

1) Demonstrated uniform, stable high-performance (>100A/cm-width at 77K, sf) on 10 meter long tape using low-cost manufacture process. Produced HTS tape using continuous reel-to-reel R&D equipment. Mitigated risk by focusing internal resources primarily on one low-cost manufacture path (RABiTS/PVD buffer/MOD HTS). Utilized strategic partners to evaluate alternate process paths and characterize process/product.

   July 2002: Demonstrated 100A, 1cm wide, 1 meter long tape.
   October 2002: Demonstrated three 100A, 1cm wide, 10 meter long tapes.
   May 2003: Demonstrated 180A, 1cm wide, 10 meter long tape.

2) Demonstrate commercial wire geometries. Utilized strategic partners to characterize wires.

   February 2003: Demonstrated "neutral plane" wire geometry.
   May 2003: Delivered 30 x (1cm x 1.6 meter) neutral plane wires, min. Ic >155A (end-to-end, 77K, self-field).
   July 2003: Demonstrated "face-to-face" wire geometry.

3) Detailed cost model validated $10-20/kAm price in production volume. Confirmed that form-fit-function specification will accelerate initial market acceptance of 2G wire by commercial 1G customers.

Key risk areas mitigated during FY 2003:

1) Uniform high performance HTS tape was manufactured with no measurable Ic degradation in 10 meter lengths. Speculation that RABiTS based wire would show significant Ic reduction over increased length was not observed (for 3 orders of magnitude increase in length)
2) Jc for MOD based HTS films on RABiTS (and IBAD) continued to increase, reaching ~3MA/cm^2 in 0.9μm HTS film on RABiTS
3) Volumetric deposition and growth rates for buffer and HTS layers were increased to levels required for designing a low-cost, high throughput pilot manufacturing facility. Rates are compatible with the target wire price.
4) Commercial wire architectures were designed, fabricated and tested in prototype applications. Mechanical and electrical properties meet the needs for current commercial 1G customers.

Research Integration:

AMSC is privileged to work with an excellent group of partners, collaborators and sponsors, each providing important benefit toward defining, characterizing and improving the AMSC 2G wire product. We are pleased to acknowledge their tremendous efforts.

Substrate: **ORNL, WPAFB, IFW, DARPA, MDA**

Buffer: **ORNL, WPAFB, LANL, ANL, LBL, SNL, IFW, ATFI, NRL, University of Wisconsin, EPRI, Duke University, MIT**

HTS: **MIT, SNL, ANL, University of Wisconsin, BNL, NIH, NIST, NRL, LANL, University of Albany, IRL, NHMFL**

Wire: **ORNL, Pirelli, GE, WPAFB, DARPA, NIST, NRL, NIH, MIT, NHMFL, IRL**

This group of R&D partners have conducted experiments, provided characterization, provided access to equipment and tools, defined requirements, and assisted in developing fundamental understanding for the AMSC manufacturing process, commercial wire geometries and future cost reduction enhancements for

the 2G process. These collaborations have been essential to the success of the AMSC program.