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<b>Project Title:</b>	<b>Coated Conductor R&amp;D using RABiTS™ and Combustion Chemical Vapor Deposition (CCVD)</b>
<b>Organization(s):</b>	<b>Oxford Superconducting Technology, MicroCoating Technologies</b>
<b>Presenters:</b>	Ken R. Marken (OST) and Shara S. Shoup (MCT)
<b>FY 2003 Funding:</b>	\$430 K (DOE to OST/MCT)

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**Project Purpose and FY 2003 Objectives:** The purpose of this project is to develop cost-effective, high-performance YBCO coated conductors for energy applications. The project is focused on achieving this goal using the scaleable, low-cost, non-vacuum deposition technique, Combustion Chemical Vapor Deposition (CCVD), in conjunction with the Rolling Assisted Biaxially Textured Substrate (RABiTS™) process to make both buffered tape templates and complete YBCO coated conductors.

Our primary objectives for FY 2003 are:

1. Develop surface chemistry control for continuous metal anneal.
2. Continue metal secondary recrystallization studies.
3. Improve the critical current density of CCVD YBCO on RABiTS™ to  $> 1.0 \text{ MA/cm}^2$ .
4. Increase CCVD deposition rates and throughputs by  $> 5x$ .
5. Offer RABiTS™ for sale.

**FY 2003 Performance and FY 2004 Plans:** In FY2003, OST has established surface chemistry control in the continuous annealing facility. Secondary recrystallization is well controlled in NiW substrates but still occurs in particular batches of high purity Ni. In FY2003, using nitrate precursors and no vacuum, MCT has grown high critical current density films ( $> 2 \text{ MA/cm}^2$ ) of CCVD YBCO on NiW RABiTS™ substrates. Higher deposition rates were achieved using a highly robust, automated 8 Nanomiser® device system built this year and investigating an alternative CCVD process proven and used by a MCT licensee in another field of use. Short lengths of RABiTS™ (up to 1.25 m continuous sections) were sold to 3 domestic and foreign companies.

Current DOE allocated funding has ended, but both Oxford and MicroCoating are interested in continued pursuit of commercialization of RABiTS™ and HTS tape made entirely by the CCVD process. If funding is available, FY2004 plans would include:

1. Correlation of metal texture with starting grain size and impurities, using both vacuum cast and powder metallurgy material.
2. Improved metal surface smoothness control through continuous monitoring.
3. Correlation of metal surface smoothness with YBCO properties, particularly  $J_c$ .
4. Design and construct prototype production “high efficiency” deposition system for buffer and superconductor layers.
5. Improve process parameters thru “high efficiency” system to affect a 10x increase in throughput, reduce gas usage by over 80%, and yield deposition efficiencies of  $> 60\%$ .
6. Fabricate minimum 10 m lengths with critical currents of at least 50 A/cm and desirably  $> 100 \text{ A/cm}$  width at 77 K, self field.

**FY 2003 Results:** In FY2003, OST has put an upgraded continuous annealing process in use and has demonstrated good epitaxial buffer coatings along with excellent texture and surface smoothness. Secondary recrystallization studies, done in collaboration with ORNL, showed good success in suppressing secondary grains in NiW.

The flame-based CCVD process was developed in 1994 as an alternative to expensive, vacuum-based technologies and targets next-generation applications such as high-temperature superconductors. MCT’s research into high temperature superconductors began in the fall of 1997 with SBIR grants from DOE. Thru several Phase I awards, one Phase II award along with one DOE subcontract, substantial progress

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towards developing MCT's low-cost method to produce buffered tape and coated conductors has been made. MCT has provided outstanding R&D value and can be the lowest cost tape provider with proper funding.

In FY2003, MCT optimized YBCO produced by CCVD to yield critical current density films over 2 MA/cm<sup>2</sup> on NiW RABiTS™. This translates into a critical current of ~60 A/cm width from a less than 0.5 micron thick film. An 8 Nanomiser® device system was designed and constructed to increase deposition rates and incorporate design changes over the previously used systems to continue to optimize buffer and superconductor layers to improve their performance. An alternative CCVD deposition system was investigated to increase deposition rates and efficiencies based on its successful implementation in another MCT application area. This system differs from the previously used direct impingement systems by increasing the tape area to gas volume ratio. With little optimization, buffer deposition rates were found to be 3-5 times higher than when a direct impingement system was used. RABiTS™ were sold to three customers here in the US and overseas in FY2003. Each customer has a different YBCO deposition process and purchased various buffer layer architectures and metal substrates for investigation with their process. Lengths up to 1.25 m (continuous length) have been produced for these customers, and recurring sales have been made.

**Research Integration:** Since OST and MCT began working in coated conductors, involvement with the Oak Ridge National Laboratory has been strong resulting in both OST and MCT obtaining licenses to ORNL's RABiTS™ technology. In FY2003, OST has provided textured metal substrates to several national laboratories including Oak Ridge, Sandia, and Brookhaven. In FY2003, MCT and ORNL entered into a new 2 year CRADA agreement to optimize and scale the CCVD RABiTS™ process. ORNL has provided MCT with metal substrates, YBCO deposition on CCVD RABiTS™, RABiTS™ substrates for CCVD YBCO depositions along with continued technical advice and sample testing. MCT has visited the ORNL's Accelerated Coated Conductor Initiative user facility to take advantage of the reel-to-reel XRD system and laser scatterometry system to further evaluate meter lengths of CCVD RABiTS™. MCT has established other collaborations with Brookhaven to investigate the compatibility of the CCVD RABiTS™ with the BaF<sub>2</sub> process and with Sandia to mutually share expertise regarding the SrTiO<sub>3</sub> buffer layer. Work has been done with three other companies both domestic and foreign to investigate the compatibility of CCVD RABiTS™ with their respective YBCO deposition processes.

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