Project Title:	Solution-Deposition of YBCO Coated Conductors
Organization(s):	**Sandia National Laboratories**
Presenters:	P. Clem, M. Siegal, J. Voigt
FY 2003 Funding:	$500 K

Project Purpose and FY 2003 Objectives: The purpose of this project is to develop economical, scaleable, non-vacuum film deposition techniques for continuous processing of 2nd generation coated conductor tapes. Sandia has a long history in sol-gel chemistry, scale-up of sol-gel-derived materials, and BaF_2- and trifluoroacetic acid-based (TFA) YBCO processing, and is applying this background to integration of high quality buffer layer and YBCO conductor process methods. We have substantially achieved all four of our FY2003 project milestones:

1) Develop high-rate solution deposition methods capable of producing YBCO films on RABiTS carrying (a) 1 MA/cm^2 at 0.25μm and (b) 0.5 MA/cm^2 at 1.0 μm film thickness.
2) Begin technology transfer and formal industrial collaboration related to solution-derived YBCO and buffer layer methods.
3) Optimize conversion and conversion rates of YBCO on single crystals and buffers to enable 1 MA/cm^2, 1 μm thickness films with rapid pyrolysis and crystallization times (< 30 min).
4) Develop a high throughput (> 30 m/h) continuous YBCO production method, and demonstrate meter lengths of MA/cm^2-quality films.

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FY 2003 Performance and FY 2004 Plans:
We have pursued two methods toward integration of solution-derived YBCO: (i) collaboration with other national laboratories and industry on use of textured, vapor-deposited buffer substrates (RABiTS, IBAD, ISD), and (ii) continued research on our internal, solution-deposited $SrTiO_3$ single buffer layer structure. Highlights of our progress include:

1) Development of a new, solution-derived TFA-YBCO coating process in FY2003 for production of 0.25-0.75 μm single-coat thickness YBCO films, at 90 meter/hour coating speeds. MA/cm^2-quality films have been produced with ORNL on RABiTS substrates. This YBCO deposition method, based on diethanolamine (DEA) enables *instantaneous* pyrolysis, enabling continuous YBCO deposition at 2.5-10 cm/s (90 – 360 m/h) coating speeds. We believe the proprietary SanDEA YBCO process will ultimately enable low cost, high throughput (10^6 meters/year) production of coated conductors. We are pursuing integration of this YBCO process on both our solution derived $SrTiO_3$ buffer on Ni//Ni-W substrates and on externally supplied, vapor-deposited CeO_2//YSZ//Y_2O_3//Ni//Ni-W.

2) Investigation of vacuum conversion of TFA-YBCO with Fred List at ORNL. In contrast to traditional BaF_2 YBCO conversion rates of 1-2 Å/s, we have found conversion rates up to 40 Å/s in TFA-YBCO films, with conversion rates of 25 Å/s yielding good quality YBCO. This would enable micron-thickness film conversion in 400 s, less than 7 minutes. YBCO vacuum conversion has also been performed at Sandia on RABiTS and single crystals.

3) Collaboration with M. Paranthaman, D. Lee, and F. List at ORNL on scale-up of the SanDEA YBCO process to meter lengths. Deposited 3 meters of SanDEA YBCO on RABiTS by continuous dip-coating, producing 1 MA/cm^2 J_c in short converted lengths.

4) Use of the SanDEA YBCO process to produce 0.25 μm, 1.2 MA/cm^2 films (30 A/cm I_c), and 0.75μm, 0.5 MA/cm^2 YBCO (37.5 A/cm I_c) films on CeO_2//YSZ//Y_2O_3//Ni//Ni-W.

5) Signed a CRADA with AMSC on joint coated conductor research.

With appropriate external guidance to maximize our programmatic impact, we propose the following future research and development for FY 2004:

- Continue to improve YBCO deposition schemes for faster processing and preparation of thick (1-3 μm), c-axis films YBCO on RABiTS and IBAD substrates. We will collaborate with ORNL, LANL, and AMSC to enable continuous, multimeter lengths.

- Scale-up to dip coating longer lengths of solution-derived buffer layers for use in YBCO deposition studies at Sandia and elsewhere, toward industrial buffer layer technology transfer.

- Study the integration science of YBCO and sol-gel buffer layers on RABiTS and IBAD substrates via electron microscopy (FESEM, HRTEM, compositional mapping) and surface techniques (SIMS, XPS). Nucleation origin, interdiffusion, and oxygen diffusion are of particular importance.
- Continue ORNL, LANL, AMSC and recent collaborations with DOE and university programs, including Argonne ISD and NREL electrodeposition. Pursue further commercial integration.

Research Integration: Toward scale-up, we have three new collaborations with ORNL, LANL, and AMSC that have improved our program capabilities.

- ORNL: We have collaborated closely in FY03 with ORNL's ACCI facility to enable continuous (3 meter) high rate dip coating of our proprietary SanDEA TFA-YBCO deposition method, achieve 1.2 MA/cm^2 J_c values on RABiTS, convert 0.75 μm YBCO films (0.5 MA/cm^2), and investigate vacuum conversion of TFA-YBCO precursors. This has enabled continuous, meter length YBCO deposition on RABiTS, with short lengths J_c > 1 MA/cm^2. Our plans in FY 2004 are to continue this collaboration, aiming for single-coat or double-coated, > 1 μm YBCO films with > 1 MA/cm^2.

- LANL: We are working with LANL in two areas: (1) deposition of YBCO and buffer layers on their ACCI-produced IBAD $LaMnO_3$ and MgO buffer layers, and (2) development of Cu-doped $SrTiO_3$ buffer layers on IBAD substrates. We have successfully demonstrated solution-derived epitaxial growth on LANL ACCI IBAD substrates. We are collaborating with LANL on low temperature processing of dense Cu-doped $SrTiO_3$ buffer layers on IBAD substrates.

- AMSC: We have signed a CRADA and agreement to license with American Superconductor Corporation to explore areas of mutual interest. The Materials and Process Sciences Center at Sandia National Laboratories will work in conjunction with AMSC toward development of high current superconductor wires. The collaboration will help facilitate rapid commercialization.