Project Title:	All Solution Deposited YBCO Coated Conductors
Organization(s):	**Sandia National Laboratories**
Presenters:	P. Clem, J. Voigt
FY 2004 Funding:	$200 K Solution Buffers and YBCO Development $200 K YBCO Vacuum Conversion and Industrial CRADA

Project Purpose and FY 2004 Objectives: The purpose of this project is development of economical, scaleable, solution film deposition techniques for continuous processing of 2nd generation coated conductor tapes. Sandia has a long history in sol-gel chemistry, scale-up of solution-deposited 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 on commercial substrates. The solution deposition processes developed are inherently capable of continuous, 90-360 m/h deposition rates, and have promise to be the lowest cost method of producing 2nd generation coated conductors, if vacuum crystallographic quality can be attained. Towards this goal, we have substantially achieved all four of our FY2004 project milestones:

1) Develop high-rate solution deposition methods capable of producing YBCO films on RABiTS carrying (a) 1 MA/cm^2 at 0.5 μm and (b) 1 MA/cm^2 at 0.75-1.0 μm film thickness, deposited in a single coating.
2) Begin CRADA 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 buffered substrates to enable 1 MA/cm^2, 1 μm thickness films with rapid pyrolysis and crystallization times (< 30 min).
4) Develop thin solution buffers on NiW capable of supporting MA/cm^2-quality films.

FY 2004 Performance and FY 2005 Plans: Summary of FY 2004 performance**:**

1) Collaboration with commercial and inter-laboratory partners to enable development and scale-up of solution-derived 2nd generation coated conductors: (i) a CRADA with American Superconductor Corporation (AMSC) for evaluation of Sandia solution buffers, and application of Sandia methods for optimization of AMSC processes, (ii) collaboration with Oak Ridge National Laboratory (ORNL) on solution deposition scale-up and vacuum conversion of solution-deposited YBCO, and (iii) collaboration with Los Alamos National Laboratory (LANL) on IBAD substrates of MgO and $LaMnO_3$/MgO, solution development of Cu-doped $SrTiO_3$ at LANL, and TEM of SNL YBCO/$SrTiO_3$/NiW. We have continued research on solution-deposited $SrTiO_3$ single buffer layer structures on NiW, followed by solution-deposited 0.25-0.75 μm YBCO.
2) Use of the SanDEA YBCO process to produce 0.5 μm, 1.2 MA/cm^2 films (60 A/cm I_c), and 0.75 μm, YBCO films on CeO_2//YSZ//Y_2O_3//Ni//Ni-W.
3) Finished the first year of a CRADA with AMSC on joint solution-deposited coated conductor research. Demonstrated high quality YBCO atop $SrTiO_3$/NiW buffer stacks.

We propose the following future research and development for FY 2005:

1) Increase thickness of 1 MA/cm2 YBCO to 2μm using fast deposition and process methods on RABiTS and IBAD substrates. Continue collaborations with ORNL, LANL, and AMSC to enable continuous, multimeter lengths of 200-400A/cm conductors.
2) Continue optimization of solution-derived buffer layers (FWHM, roughness) to replace vacuum deposited buffer layers. Work to attain vacuum-quality FWHM values.
3) Develop continuous, 0.3μm solution buffers toward industrial buffer layer technology transfer (CRADA). Apply industrial metrics and methods to enable process spin-off.

FY 2004 Results: Highlights of our progress include:

a. Development of new, solution-derived TFA-YBCO coating processes in FY2004 for production of 0.5-0.75 μm single-coat thickness YBCO films, at 90-144 meter/hour coating speeds, with 20 second organic burnout time. MA/cm^2-quality films have been produced in collaboration with ORNL on RABiTS substrates.

b. Investigation of vacuum conversion of TFA-YBCO with Fred List at ORNL and at Sandia. 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 high quality YBCO, which would enable 1 micron film conversion in 400 s, less than 7 minutes. Vacuum conversion has been performed on RABiTS and single crystals.

c. Demonstrated well-aligned $SrTiO_3$ buffer layers on AMSC NiW substrates, and deposited YBCO atop these with MA/cm^2 critical current densities. Collaborated with AMSC on solution YBCO, solution buffer layers, and vacuum buffer layer development.

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

- AMSC: We have completed the first year of a CRADA and agreement to license with American Superconductor Corporation to explore areas of mutual interest, including solution deposition of YBCO and buffer layers on NiW. Sandia methods including ^{18}O in-diffusion experiments, focused ion beam sample sectioning, *in-situ* stress analysis, and $SrTiO_3$ buffers have been used to aid optimization of AMSC technologies. AMSC has provided substrates, precursors, and processing expertise for development of Sandia solution-derived YBCO/$SrTiO_3$/NiW conductors.
- ORNL: We have collaborated closely in FY04 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.
- LANL: We are working with LANL in three areas: (1) deposition of YBCO and buffer layers on their IBAD $LaMnO_3$ and MgO buffer layers, and (2) development of Cu-doped $SrTiO_3$ buffer layers on IBAD substrates, and (3) TEM analysis of YBCO/$SrTiO_3$/NiW conductor interfaces. Solution-derived epitaxial growth has been demoinstrated on LANL ACCI IBAD substrates.