
Project Title:	Microstructure and Mechanics of Superconductor Epitaxy via the Chemical Solution Deposition Method
Organization(s):	University of California, Santa Barbara
Presenters:	F.F. Lange
FY 2004 Funding:	\$150 K

Project Purpose and FY 2004 Objectives: The purpose of this project is to study chemical solution deposition methods for single buffer-layers in YBCO/RABiTS superconductor wires. The study focuses on the development of microstructure during epitaxy and the mechanical phenomena that produce cracks during dip coating, pyrolysis, crystallization and epitaxy. The primary objectives for FY 2004 are:

- 1) Investigate and develop the precursor chemistry for LaMnO₃ and MgO buffer-layer systems for deposition onto the RABiTS Ni substrates.
- 2) Utilize spin coating for the chemical solution deposition of LaMnO₃ and MgO buffer-layers onto RABiTS Ni substrates.
- 3) Investigate the effect of deposition and processing conditions of LaMnO₃ and MgO on buffer-layer critical thickness.

FY 2004 Performance and FY 2005 Plans: Two buffer-layer compositions, LaMnO₃ and MgO, are currently being developed for use with RABiTS Ni-alloy substrates. MgO has been selected as a buffer-layer for its low oxygen diffusion coefficient and good lattice match to RABiTS Ni-W alloys exhibiting no S superstructure. LaMnO₃ has been selected due to a low oxygen diffusion coefficient, apparent deposition ability, based on PLD methods, on RABiTS Ni substrates and a good lattice match to YBCO.

Solution precursors for LaMnO₃ and MgO have been investigated and characterized using powder X-ray diffraction. Solutions of La acetate/Mn acetate dissolved in acetic acid and either water or methanol have been chosen as the preferred candidates for LaMnO₃. Powder X-ray diffraction of LaMnO₃ precursors heated under Ar-5%H₂ (required to prevent Ni from oxidizing) with differing levels of p_{H2O} (required to produce the LaMnO₃) allow the orthorhombic LaMnO₃ phase to be synthesized. Two precursor solutions are currently under investigation for MgO. One is a Mg ethoxide in a mixture of ethanol and acetic acid, and the other is a Mg 2-ethylhexanoate in toluene. Heat treatment under Ar-5%H₂ resulted in the synthesis of MgO phase as determined by powder x-ray diffraction.

The solution deposition of LaMnO₃ and MgO precursors has produced epitaxial films on various substrate materials when heat treated above 800°C. Epitaxial films of (101) LaMnO₃ has been achieved on (100) SrTiO₃, however, for the same atmospheric conditions, deposition of LaMnO₃ on Ni-alloy substrates have produced different results. Namely, LaMn₂O₅ has been identified besides the orthorhombic phase, LaMnO₃; LaMn₂O₅ is first observed at 800 °C. In addition, the lattice constants for the 'LaMnO₃' phase produced on the Ni substrate suggest that it might incorporate NiO. Continued work into variations of heat treatment conditions, and atmosphere is under study to achieve a single phase epitaxial regime.

MgO has been successfully deposited on MgO and (100) SrTiO₃ substrates. Deposition of MgO precursors onto RABiTS Ni-alloy substrates has produced weak XRD peaks for epitaxy for current conditions.

Variations in precursor solution chemistry and thin film heat treatment have been investigated to increase the critical film thickness of LaMnO₃ films. Studies using LaMnO₃ deposited on Si substrates have resulted in critical film thickness increases when using high boiling point solvents such as polyvinylpyrrolidone or glycerol as well as slow heating rates. Film thicknesses of 230 nm have been achieved with LaMnO₃ on Si substrates.

FY 2005 Plans

- ◆ Continue research into epitaxy through chemical solution deposition of LaMnO₃ and MgO single buffer-layers on RABiTS Ni substrates.
- ◆ Research and develop other possible candidate materials for single buffer-layer superconducting wires, that limit the oxidation of the Ni substrate during YBCO epitaxy, and limit the diffusion of Ni to the superconductor.
- ◆ Continue research into improving thin film mechanical properties including the critical film thickness of chemical solution deposited oxide films.
- ◆ Develop a high rate solution process for the candidate buffer-layer materials.

Research Integration: The University of California, Santa Barbara has two research collaborations with ORNL and Sandia NL:

- ◆ ORNL: We have collaborated closely with ORNL, through Amit Goyal, in investigating the viability of LaMnO₃ and MgO buffer-layers via face-to-face conversations at two Society meetings, phone calls, and email correspondence. Current collaboration activities center around the use of RABiTS Ni-alloy substrates for deposition of LaMnO₃ and MgO thin films. Future work and collaboration will revolve around modifying the spin-on precursor system to a slot dip-coating system for the deposition of LaMnO₃ and MgO thin films as well as the deposition of YBCO layers on top of the LaMnO₃ and MgO architectures.
- ◆ Sandia NL: Paul Clem has helped us to initiate an investigation of a new MgO precursor, namely, magnesium ethoxide in trifluoroacetic acid and methanol. Initial experiments show that this precursor solution wets SrTiO₃ single crystal substrates, but does not wet Ni substrates.