
Project Title:	Epitaxial Electrodeposition of Metal and Metal Oxide Capping Layers for RABiTS-Based Second Generation Coated Conductors
Organization(s):	University of Missouri-Rolla
Presenters:	Jay A. Switzer
FY 2004 Funding:	\$150 K

Project Purpose and FY 2004 Objectives: The goal of the proposed project is to apply recent advances in epitaxial electrodeposition of metals and metal oxides to develop a new epitaxial substrate coating process and high rate manufacturing technology for commercial lengths of YBCO. A high throughput, non-vacuum technology is proposed that would extend the operating temperature of commercial high field superconductors up to 77 Kelvin, and enable broad new markets. This approach, if successful, would address three of four key research areas: improved wire fabrication, production of high engineering current density tapes, and lower cost of wire fabrication. Epitaxial electrodeposition has been developed in the past three years to deposit films and epitaxial nanostructures of both metals and metal oxides. This research will be performed in partnership with Sandia National Laboratories (SNL), Microcoating Technologies (MCT), and Oxford Superconducting Technology (OST). We have substantially achieved all of our FY2004 project milestones, in addition to beginning work on a FY2005 milestone on the electrodeposition of epitaxial CuO. The FY2004 milestones are listed below:

- 1) Electrodeposit Ni and Cu₂O on Cu(001) single crystals and Cu(001) RABiTS.
- 2) Characterize films by XRD pole figures, STM/AFM and EBSD.
- 3) Determine effects of additives on roughness.

FY 2004 Performance and FY 2005 Plans: Films of Cu₂O, Ni, and CuO were deposited onto Cu(001) single crystals and Cu RABiTS. The Cu₂O films were deposited from a solution of 0.4M CuSO₄, 3M lactate ion, with the pH adjusted to 9.0 with 5M NaOH. The films were deposited at room temperature, at a current density of 10 μA/cm², to a total thickness of about 1 μm. The orientation of the film was primarily [001]. The [111] pole figure showed four sharp spots at a tilt angle of 54.7 degrees, consistent with cube-on-cube epitaxy. There was little or no evidence of a fiber texture. The SEM of the film showed that it was highly faceted. Preliminary work showed that by switching the deposition bath to one based on tartrate ion at pH 13-14, the film was very much smoother.

Films of Ni were deposited onto Cu RABiTS from a Watts bath consisting of 60 g/L NiSO₄, 10 g/L NiCl₂, and 10 g/L H₃BO₃. The deposition was performed at room temperature, at an applied potential of -0.7 V vs. AgCl, to a total thickness of 1 μm. The film orientation was [001]. The pole figure showed four sharp spots at a tilt angle of 54.7 degrees. The surface roughness was measured by AFM to be about 15 nm rms.

Films of CuO were deposited onto Cu RABiTS from a solution of 0.2M CuSO₄, 0.2M L-tartaric acid, and 2.5M NaOH. The deposition was performed at a temperature of 30 degrees, at an applied potential of +0.4V vs. SCE, to a total thickness of about 1 μm. X-ray diffraction θ -2 θ scans show that the CuO film grows in the [010] direction on Cu(001). X-ray pole figure analysis indicates that the CuO film has two equivalent epitaxial domains with orientation relationships of CuO(010)[001]||Cu(001)[110] and

CuO(010)[001]||Cu(001)[1 $\bar{1}$ 0]. Scanning electron microscopy reveals that crosshatch patterns of CuO with 25 nm wide and 150 nm long orthogonal features are formed on top of the substrate. Preliminary results showed that the crystallographic orientation and chirality of the film can be controlled through the use of chiral complexing agents. The resistivity of the electrodeposited CuO film is 21 Ω-cm at 300K and the activation energy for the resistivity is 0.12 eV.

For FY2005 we would like to extend our work on the use of additives to control the crystallographic orientation and roughness of the electrodeposited Cu₂O, Ni, and CuO. For example we have found that

using tartrate ion to complex the Cu(II) produces much smoother Cu₂O films, and that the hand of chiral CuO films can be controlled by changing the enantiomer of tartrate ion used in the deposition bath. We would like to develop new deposition waveforms that will allow us to electropolish the films during deposition. We would also like to extend our portfolio of electrodeposited oxides to include highly-conducting PbO₂ and Tl₂O₃, and superconducting KBaBiO₃.

FY 2004 Research Results: most of the research results were summarized above. X-ray pole figures are shown in Fig. 1 for an epitaxial film of Cu₂O on a Cu RABiTS. Fig. 2 shows an SEM micrograph of a CuO film deposited onto a Cu RABiTS. The orthogonal microstructure of the CuO film may lead to a reduction of critical currents if the 90 degree grain boundaries are transferred to the superconductor overlayer. The smoothest Cu₂O films with a cube-on-cube epitaxial relationship were deposited at pH 13 using tartrate ion to control the morphology.

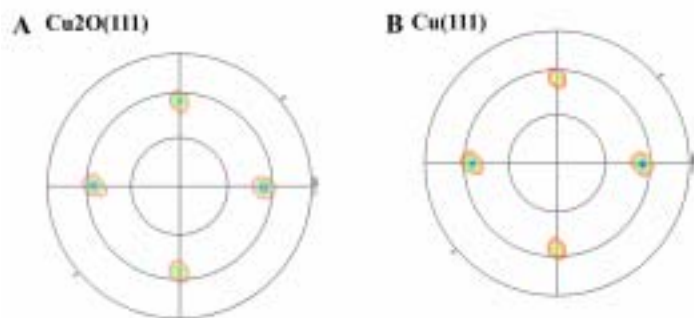


Fig. 1. (111) Pole Figures of Electrodeposited Cu₂O and Cu(001) RABiTS

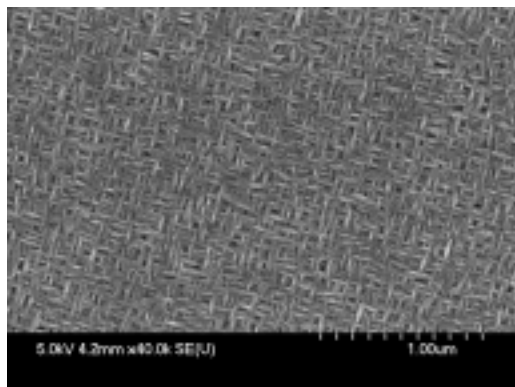


Fig. 2. SEM Micrograph of Electrodeposited CuO on a Cu(001) RABiTS

Research Integration: Our main interaction has been with Dr. Amit Goyal of Oak Ridge, who has provided us Cu RABiTS for our deposition studies. We have deposited epitaxial Ni, Cu₂O, and Cu onto these substrates. He and Dr. Paul Clem of Sandia have also provided input on the desired microstructures and orientations. Our Cu₂O/Cu RABiTS samples will be sent this year to Paul Clem for sol-gel coating of YBCO superconductors.