

**Electrodeposition Division Research Award  
Address: Epitaxial Electrodeposition of Metal  
Oxide Nanostructures**

Jay A. Switzer  
University of Missouri-Rolla  
Department of Chemistry  
103 Materials Research Center  
Rolla, Missouri 65409-1170 USA  
Email: jswitzer@umr.edu

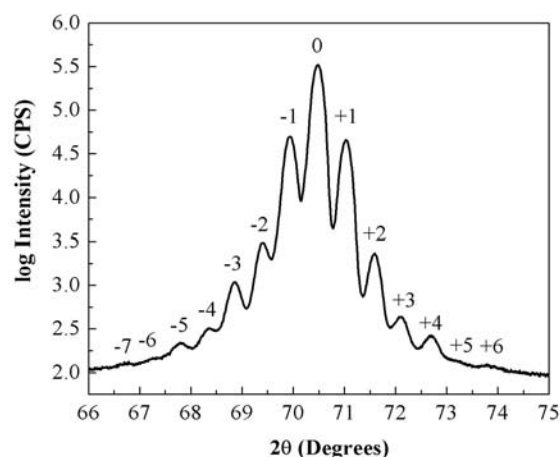
Electrodeposition is a splendid method to fabricate nanostructures. The materials are produced from solution precursors at low processing temperatures. Our emphasis has been on the epitaxial electrodeposition of ordered nanostructures of metal oxide semiconductors and magnetic materials. Electrodeposited materials have included  $\text{Bi}_2\text{O}_3$  (1),  $\text{Cu}_2\text{O}$ ,  $\text{ZnO}$ ,  $\text{Fe}_3\text{O}_4$  (2),  $\text{PbO}_2$ ,  $\text{Ti}_2\text{O}_3$ ,  $\text{CeO}_2$ ,  $\text{AgO}$ , and  $\text{CuO}$ . Examples of electrodeposited nanostructures include superlattices (3-6), layered  $\text{Cu}_2\text{O}/\text{Cu}$  nanostructures (7,8), ordered cross-hatch patterns (9), and epitaxial nanocubes. An XRD pattern of an electrodeposited Pb-Tl-O superlattice on Au(001) with a modulation wavelength of 18.9 nm is shown in Fig. 1. Layered nanostructures based on  $\text{Cu}_2\text{O}$  and Cu were produced in a self-oscillating system (7). The  $\text{Cu}_2\text{O}/\text{Cu}$  layered materials exhibited NDR in perpendicular transport measurements, with evidence that quantum confinement of holes occurred in the valence band of  $\text{Cu}_2\text{O}$  (8).

Work in our lab has focused on the use of the deposition solution (pH, complexing agents, etc.) and overpotential to control the shape and orientation of epitaxial metal oxides. The goal is not to imitate vapor deposition, but to exploit the “wet” aspects of electrodeposition to produce architectures which may not be accessible to UHV methods. For example, by controlling the growth rates along specific directions we have deposited nanometer-scale cross-hatch patterns of  $\text{Cu}_2\text{O}$  on Au(001) (see Fig. 2), and nanocubes of  $\text{Cu}_2\text{O}$  on InP(001) (see Fig. 3).

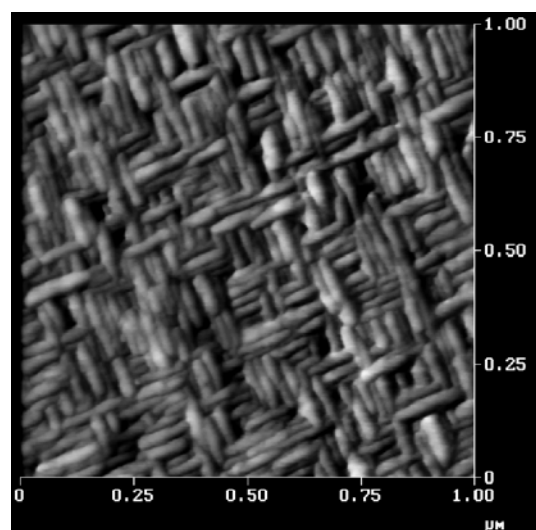
Recent results on the electrodeposition of chiral metal oxide surfaces will also be presented. The goal is to produce chiral surfaces for enantiospecific synthesis and detection.

#### References

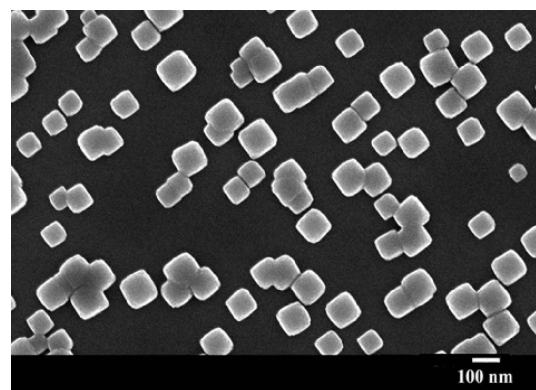
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**Fig. 1.** X-ray  $2\theta$  scan of a Pb-Tl-O superlattice with a 18.9 nm modulation wavelength.



**Fig. 2.** AFM image of  $\text{Cu}_2\text{O}(110)$  on Au(001) after a transition from thermodynamic to kinetic control of orientation. The kinetically-controlled orientation is dictated by the solution pH. The film has a 20 by 100 nm cross-hatch morphology.



**Fig. 3.** SEM of  $\text{Cu}_2\text{O}$  nanocubes on InP(001). Nanocubes are deposited at pH 12, and nanopyramids are deposited at pH 9. The cubes have a size of  $100 \pm 15$  nm and an areal density of about  $10^9 \text{ cm}^{-2}$ .

**Acknowledgments.** Support by the National Science Foundation (CHE-9816484, DMR-0071365, DMR-0076338, and CHE-0243424) and the Foundation for Chemical Research is gratefully acknowledged.