

In-Situ SCANNING TUNNELING MICROSCOPY STUDIES OF ELECTROCHEMICAL ATOMIC LAYER EPITAXY: FLOW CELL STM OF THE FORMATION OF CdS AND CdSe

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A new flow cell STM has been built in this group and is being used for studies of CdS and CdSe growth by electrochemical atomic layer epitaxy. Studies of the atomic layers formed on Au(111) single crystal surfaces will be described, as well as the alternated deposition of atomic layers of elements to form compound semiconductors. The impetus for these studies was to determine the ideal conditions for growing II-VI compound semiconductor thin films (1). In each EC-ALE cycle, aqueous precursors for a compound's elements are alternately flowed in to the cell at specific potentials, and atomic layers are deposited (UPD). Thin film growth is just the reapplication of the cycle the desired number of times.

The first few EC-ALE cycles are the most important as they become the interface between the deposit and substrate. For instance, the lattice match with the Au surface and CdSe is less than a %, 0.2%, while that for CdS is more like 3.6 %. The lattice match can have a large effect on a deposit's structure. In addition, the coverages of the elements in the first few cycles can determine surface morphology. Consequently, the real space, instantaneous atomic scale information yielded by *in-situ* electrochemical scanning tunneling microscopy (EC-STM) is invaluable.

Various solutions that can produce UPD sulfur layers have been studied. Presented in figure 1, is an EC-STM micrograph obtained as S deposited at step edges on a Au(111) surface. This behavior is similar to that described by Vericat et al (2). The adsorption of S at step edges occurs prior to the formation of the Au(111)($\sqrt{3}\times\sqrt{3}$)-S UPD structure.

Cadmium electrodeposition is markedly affected by the anions present. To attain a better understanding of Cd electrodeposition, this process has been studied in the presence of various anions. Results of sulfate studies, figure 3, and chloride, figure 4, are presented here. The effect of Cd deposition on the Au(111) Herringbone reconstruction has been investigated as well.

An *in-situ* STM flow cell has been constructed for monitoring the atomic structure and coverage during the alternated deposition of various compound semiconductors. Using this flow cell, it will be possible to study deposits of more than one monolayer. The STM flow cell will also allow the study of compounds in which Cd is deposited first. These have not been examined as yet due to impediments cause by Cd oxidation upon exposure to air. Preliminary data from this flow cell shall be presented as time allows.

REFERENCES

1. D.W. Suggs, I. Villegas, B.W. Gregory, J.L. Stickney, *J. Vac. Sci. Technol. A.*, **10**, 886, (1992)
2. C.Vericat, G.E. Andreasen, M. Vela, R.C. Salvarezza, *J. Phys. Chem.*, **104**, 302 (2000), 302.

FIGURES

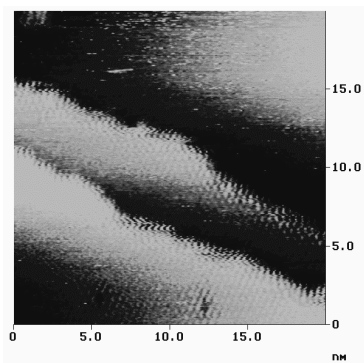


Figure 1. S adsorbing on the atomic steps of a Au(111) surface at a potential prior to the formation of the Au(111)($\sqrt{3}\times\sqrt{3}$)-S.

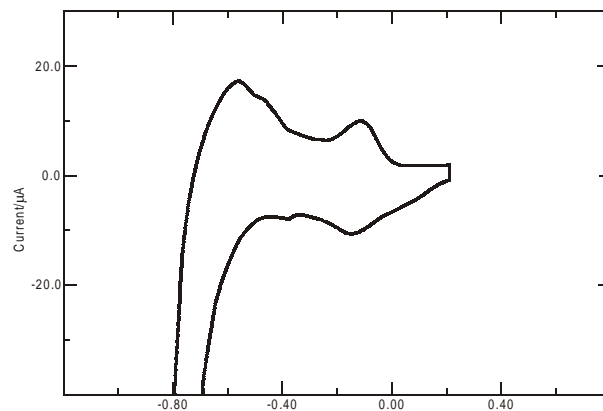


Figure 2. Cyclic voltammogram of Au(111) single crystal immersed in 0.20 mM CdSO₄ in 1 mM H₂SO₄.

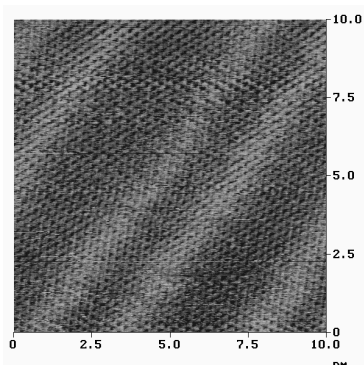


Figure 3. Atomically resolved image of the Au(111) herringbone reconstruction in prior to Cd deposition in 0.2 mM CdSO₄, 1 mM H₂SO₄.

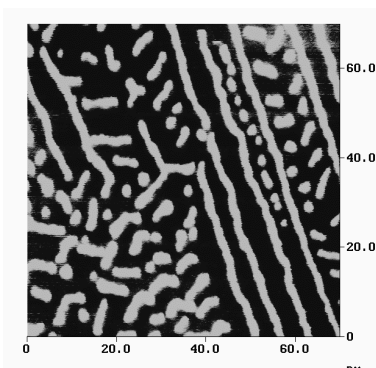


Figure 4. Au(111)- Cd alloy formed in the presence of Cl.