

DEPOSITION OF CDSE USING AN AUTOMATED FLOW DEPOSITION SYSTEM.

M.Ken. Mathe, Billy H. Flowers Jr., Raman Vaidyanathan, Nattapong Srisook, John L. Stickney, and Uwe Happek*.

Department of Chemistry, University of Georgia, Athens, GA 30602-2556 USA

*Department of Astronomy and Physics, University of Georgia, Athens, GA, 30602 – 2556 USA

Electrochemical atomic layer epitaxy (EC-ALE) was used to prepare CdSe thin films, by alternating electrodeposition of Cd and Se, in a cycle, on flame annealed Au on glass substrates. CdSe is important as possible photovoltaic material, and is well lattice matched with the Au on glass substrates used, <1%. EC-ALE is the electrochemical analog of atomic layer epitaxy (ALE), and makes use of underpotential deposition (UPD) to electrodeposit single atomic monolayers of the elements making up a compound semiconductor. UPD is a well-documented phenomenon in which one-element deposits onto another element at a potential prior to (under) that necessary to deposit the element onto itself. UPD generally results in an atomic layer of the element, due to the favorable free energy of formation of the surface compound. The formation of CdSe thin films via EC-ALE is described through the presentation of stoichiometric data (EPMA, or electron microprobe analysis), crystallographic data (XRD, or X-ray diffraction), morphology data (AFM, or atomic force microscopy) and band gap data. Also included is ellipsometric data showing that the EC-ALE process deposits only one monolayer of CdSe per cycle.

EC-ALE is an alternative method for compound semiconductor fabrication. The main advantage EC-ALE has over MBE and MOCVD is its ability to operate under ambient temperature and pressure conditions. This avoids problems with heat-induced interdiffusion of species. Also, EC-ALE is orthogonal to conventional methods, such as MBE (Molecular Beam Epitaxy) and MOCVD (Metallo-Organic Chemical Vapor Deposition), possibly allowing formation of materials or structures not accessible using conventional techniques. In addition, the thickness of deposits is easily controlled, a simple matter of programming the number of EC-ALE cycles to be run. Many researchers have explored the electrodeposition of CdSe by various methods [1,2, 3,4,5,6]. As well, several papers concerning CdSe electrodeposited on various single crystalline substrates have been published [7,8,9,10].

Solutions were prepared using 18 M Ω , UV sterilized water (Nanopure) fed from an in house deionized water system. Concentrations of Cadmium and Selenium were 5.0 mM and 0.5 mM, respectively, prepared from Cadmium sulfate and Selenium oxide precursors of high purity (99.999%, supplied by Aldrich Chemicals). The supporting electrolyte was vacuum-filtered 0.5M sodium sulfate (Fischer Chemicals). Cadmium solutions were buffered to a pH of 5.7 with 50mM sodium acetate, while the selenium solutions were buffered to a pH of 5.5 with 50mM sodium acetate (Fischer Chemicals). A linear step program for potential increases was used for both cadmium and selenium deposition. The potentials for both were stepped incrementally over the first 30 cycles to a steady state point. Cadmium starting potentials ranged from -0.300V

to -0.550V, while selenium potentials ranged from -0.300V to -0.580V (all potentials were referenced to Ag/AgCl). Microprobe data shows stoichiometric CdSe thin films, with values ranging from 0.93 to 1.06 (ratio Cd/Se). Figure 1 is a plot of deposit thickness (as measured by ellipsometry) vs. Se steady state deposition potentials. The plateau in the plot is indicative of a surface limited process. XRD (Figure 2) shows strong (111) reflections for both CdSe and Au, but indicates no elemental Cd or Se. CdSe thin films were grown with an automated flow cell system [11].

References:

1. M. Cocivera, A. Darkowski, and B. Love, J. Electrochem. Soc., **131**, 2514 (1984).
2. B.H. Flowers Jr., M.K. Mathe, R. Vaidyanathan, N. Srisook, U. Happek, and J.L. Stickney. (In prep) 2001.
3. R.K. Pandey, and A.J.N. Rooz, J. Phys. D: Appl. Phys., **19**, 917 (1986).
4. D. Ham, K.K. Mishra, and K. Rajeshwar, J. Electrochem. Soc., **138**, 100 (1991).
5. Y. Golan, L. Margulis, I. Rubinstein, and G. Hodes, Langmuir, **8**, 749 (1992).
6. L.P. Colletti, B.H. Flowers Jr., and J.L. Stickney, J. Electrochem. Soc., **145(5)**, 1442 (1998).
7. Y. Golan, Y.L. Margulis, I. Rubinstein, G. Hodes, and J.L. Hutchison, Surf. Sci., **311**, L633 (1994).
8. H. Cachet, R. Cortes, M. Forment, G. Maurin and N. Shramchenko, J. Electrochem. Soc., **144(10)**, 3583 (1997).
9. T.E. Lister, and J.L. Stickney, Appl. Surf. Sci., **107**, 153 (1996).
10. T.E. Lister, L.P. Colletti, and J.L. Stickney, Isr. J. Chem., **37(2-3)**, 287 (1997)
11. B.H. Flowers Jr., T.L. Wade, M. Lay, J.W. Garvey, U. Happek, and J.L. Stickney, J. Electrochem. Soc., in press.

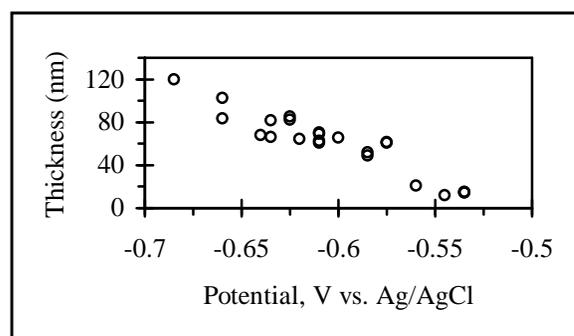


Figure 1. Thickness vs. Se Deposition Potential

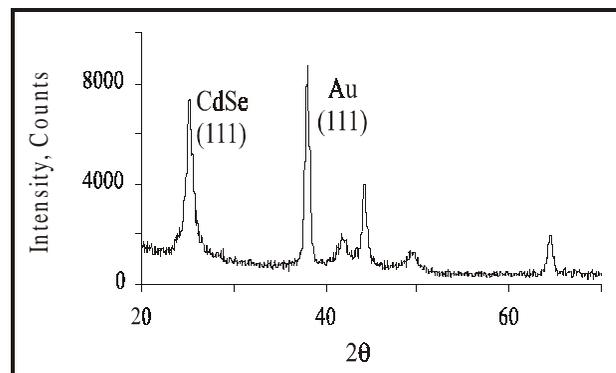


Figure 2. XRD spectrum of EC-ALE CdSe