E1-17: Electrical and optical properties of electrodeposited thin films of CdS_xSe_{1-x}

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Eventhough binary chalcoenides CdX (X = S,Se,Te) have been examined extensively for solar energy conversion purpose, relatively little work has been done on composite materials such as $Cd_xSe_yTe_z$. The possibility of modification of bandgap of these materials through the introduction of predetermined proportions of chalcogenide elements is advantageous because solar energy conversion efficiency could be improved through the use of arrays of such materials with varying bandgaps. The main objectives of this study are to investigate the variation of the bandgap of CdS_xSe_{1-x} with x and, to study its photoelectrochemical properties under different experimental conditions of preparation.

Thin films of CdS_xSe_{1-x} were electrodeposited on heavily doped indium-tin oxide (ITO) conducting glass under galvanostatic conditions and at carefully selected pH values. In the preparation of CdS (x = 1) films, an ethylene glycol solution containing 6.7 g l^{-1} $CdCl_2$ and 3.3 g l^{-1} sulphur was used. In the case of CdS_xSe_{1-x} ($0<x<1$), varying amounts of SeO_2 was also added to the above solution. The deposition was carried out at 170°C with suitable current densities.

The photoelectrochemical cell used in the experiment consisted of a 0.2M KI solution as the electrolyte, a platinum counter electrode, a saturated calomel electrode as the reference and, the CdS_xSe_{1-x} film as the working electrode. The working electrode was held at -2.0V with respect to SCE during the spectral response measurements. The photoabsorption measurements were carried out using a spectrophotometer covering the visible range of wavelengths. All the above measurements were carried out on As-deposited samples and also after annealing at different temperatures ranging from 100°C to 300°C. Duration of annealing was 30 min. in each case.

The edge of the absorption spectrum of CdS_xSe_{1-x} steadily shifted towards shorter wavelengths when x was increased from 0 to 1 (x = 0, 0.25, 0.5, 0.75, 1) indicating an increase of the bandgap with x. The estimated values of the bandgap obtained from the absorption spectra ranged from 1.7 eV (CdSe) to 2.4 eV (CdS). It was observed that As-prepared CdS_xSe_{1-x} films had a relatively poor quality and their photoresponse improved by about 2 to 5 fold after annealing. The optimum annealing temperature was found to be around 300°C. The absorption edge of the spectra of the respective sample did not show any noticeable shift due to annealing.

The technique of electrodeposition can be used successfully to prepare thin films of ternary cadmium chalcogenide materials with varying compositions. The bandgap of CdS_xSe_{1-x} was found to increase steadily from 1.7 eV to 2.4 eV as x was varied from 0 to 1. The experimentally observed bandgap values are in good agreement with those reported in literature. Annealing is a very important aspect in the preparation of high quality thin films of semiconductors. The optimum annealing temperature for CdS_xSe_{1-x} was observed to be around 300°C.