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Electrodeposition and optical properties of $Zn_xCd_{1-x}S$ thin films

M Jayachandran, Mary Juliana Chockalingam, V Subramanian
Central Electrochemical Research Institute, Karaikudi - 623 006, INDIA

V Vinni and T Mahalingam
Department of Physics, Alagappa University, Karaikudi - 623 006, INDIA

Electrodeposition technique has been used to deposit CdS-ZnCdS-ZnS solid solution films. Influence of Zn content in the solution on the band gap change is studied. Bandgap tailoring has been observed from 2.41 to 3.5 eV for the entire solid solution.

Key words: Electrodeposition, ZnCdS thin films, optical properties

INTRODUCTION

Thin films of $Zn_xCd_{1-x}S$ (ZnCdS) have attracted much interest due to the possibility of using them in photovoltaic and opto-electronic thin film devices, such as heterojunction diodes, u-v photodetectors and devices incorporating ZnCdS as the photoconductor [1]. Cu_2S/ZnCdS and $CuInSe_2$/ZnCdS thin film solar cells with efficiencies exceeding 10% have been reported employing vacuum evaporation and spray pyrolysis [2,3]. The present work reports the preparation of ZnCdS films by electrodeposition. The electrodeposited films were studied for their structural, optical and electrical properties.

EXPERIMENTAL

Titanium, aluminium and SnO_2 conducting substrates were used for the electrodeposition of ZnCdS films. Analytical grade cadmium sulphate, zinc sulphate and sodium thiosulphate have been used for all depositions with molar concentrations of 10 mM, 10 mM and 200 mM respectively. The entire range of CdZnS films for x=0 to 1 were electrodeposited from mixing the desired proportion of the above solutions. The pH was kept constant at 2.5 for all depositions. The deposition potentials were changed in the range −0.9 to −1.1 V vs SCE as required by the different compositions of the bath. The observed current densities were between 2-6 $mA.cm^{-2}$. Optical studies were carried out on the electrodeposited ZnCdS films on SnO_2 substrates by using a double beam spectrophotometer. Hot probe method was used to find the nature of the films.

RESULTS AND DISCUSSION

The deposited films were adherent to the substrates and showed a color change - yellow - yellowish white - white for CdS-CdZnS-ZnS films. Optical transmission and absorption spectra of all the films were obtained and the absorption coefficient was calculated. The bandgap (Eg) of the CdZnS films were determined from extrapolation of the straight line sections of the α^2 versus $h\nu$ curves shown in Fig. 1. The observed Eg for different x values for electrodeposited films used in the present study were compared with that for spray deposited films [5] and found that the values are in good agreement. This reveals that uniform and device quality films can be prepared by electrodeposition technique.

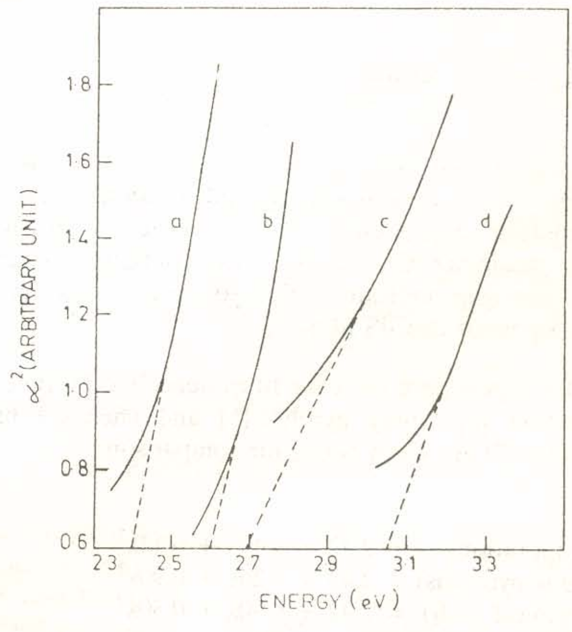

Fig. 1: α^2 vs $h\nu$ curves

Figure 2 represents the bandgap dependence on composition of zinc (y) in solution. Much deviation has been observed near the point where Cd and Zn contents are present nearly in equal amounts. This may be due to the deposition of more Zn compared to the initial stages where Cd is predominant. When Zn concentration exceeds Cd, the bandgap values take a fast recovery and approaches 3.5 eV for ZnS. The dependence of Eg on x has been represented in Fig. 3. The Eg values for CdS and ZnS were 2.41 and 3.5 eV respectively, and for ZnCdS solid solution, Eg shifted from 2.41 eV towards short wavelength side with increased Zn concentration. This variation can be described by the empirical expression given by

$$Eg(x) = 2.41 + 0.36x + 0.73x^2 \quad (1)$$

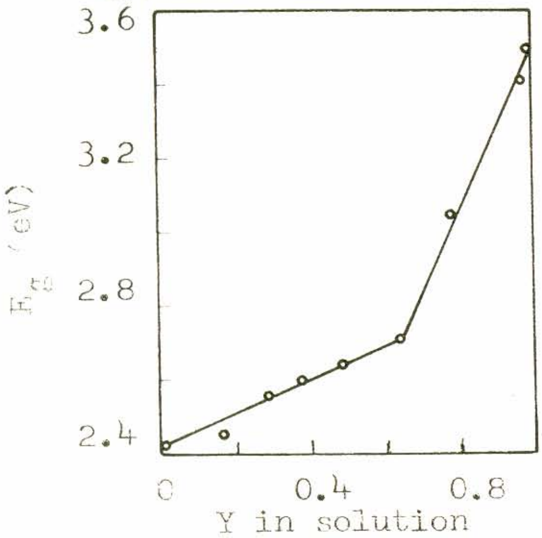

Fig. 2: E_g vs Zn in solution

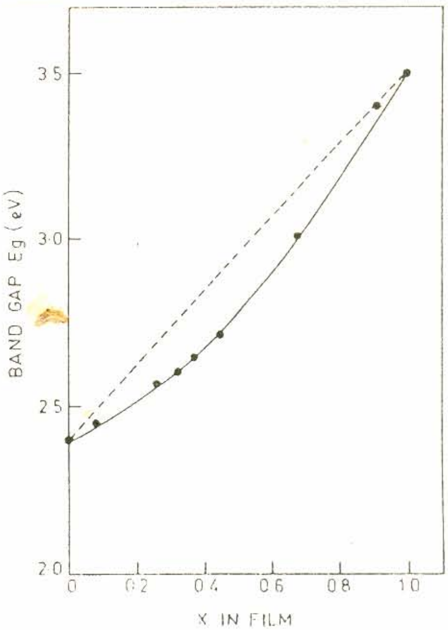

Fig. 3: E_g vs X in film

The dashed line indicates the linear variation of the bandgap which is expected for a solid solution. However, the bandgap dependence on x deviates more with bowing parameter C = 0.73. This continuous change in the bandgap indicates solid solution formation of electrodeposited ZnCdS films.

The Eg dependence on x for films deposited by vacuum evaporation [6], spray pyrolysis[5] and chemical bath deposition [7] are given below for comparison.

$$Eg\ (evaporation) = 2.42 + 0.49x + 0.43x^2$$
$$Eg\ (spray\ pyrolysis) = 2.43 + 0.20x + 0.90x^2$$
$$Eg\ (chemical\ bath) = 2.42 + 0.90x + 0.30x^2$$

The bowing parameters C of the films deposited by spray, electrodeposition, evaporation and chemical bath techniques are 0.90, 0.73, 0.43 and 0.30 respectively. It reveals that films prepared by spray pyrolysis and electrodeposition have nearly the same Eg variation.

CONCLUSION

Good quality ZnCdS thin films useful for solar cell applications are deposited by electrodeposition technique. The variation of bandgap with x predicts that a continuous series of CdS+ZnS solid solution can be formed by electrodeposition technique to suit the requirement.

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