Effect of electron irradiation on the electrodeposited cadmium sulfide thin films

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Abstract. In this paper, the effects of electron beam irradiation on the CdS thin films are studied. The CdS thin films are characterized by X-ray diffraction (XRD), scanning electron microscope (SEM) and optical absorption technique for different bath concentration. The thin film layers are subjected to irradiation of 6 MeV electrons. Finally the effect of irradiation is correlated to crystal size, grain size and band gap energy of the CdS thin films

Keywords: Thin Films, Electron beam irradiation,

INTRODUCTION

Cadmium sulfide (CdS) is the members of the family of group II and VI compounds and it is one of the best photo-conducting materials. It is widely used in solar cells as well as in opto-electric and photoconductive devices, but only in the short wavelength and visible region [1].

Several deposition techniques have been reported for the preparation of CdS films, including anodic oxidation [2-4].

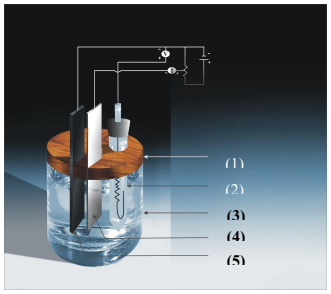
The present paper is concerned with the effect of electron irradiation on the electrodeposited cadmium sulfide thin films obtained under various bath concentrations.

EXPERIMENTAL

CdS thin films are cathodically electrodeposited from aqueous solution containing the various bath concentrations such as, (A) = 0.04 M $CdSO_4$ + 0.4 M $Na_2S_2O_3$ + 0.1 M EDTA,(B)= 0.06 M $CdSO_4$ + 0.6 M $Na_2S_2O_3$ + 0.1 M EDTA and (C)= 0.08 M $CdSO_4$ + 0.8 M $Na_2S_2O_3$ + 0.1 M EDTA.

The stainless steel and fluorine doped tin oxide (FTO) are used as substrates. The deposition is carried out for different bath concentrations, which results the yellow colored, uniform and adherent CdS thin films. The experimental set up for deposited CdS thin films is as shown in Fig. 1.

The CdS thin films obtained are subjected to irradiation of 6 MeV electrons supplied by an linear accelerator. The irradiation dose used is of l0 kGy.



(1)Bakelite holder
(2) SCE Electrode
(3)Solution Container
(4) Substrate
(5)Counter Electrode

FIGURE 1. The experimental set up for CdS thin films deposition.

RESULTS AND DISCUSSION

1. SEM STUDIES

Fig.2. (A-C) show status of the CdS films before irradiation and Fig. 2.(a-c), show status of the films after irradiation on to stainless steel substrate for

different bath concentrations. it is observed that with increase in bath concentration**,** the substantial granular growth of CdS films is commonly observed, but after electron irradiation granular growth is increased as compared to non irradiated case[5].

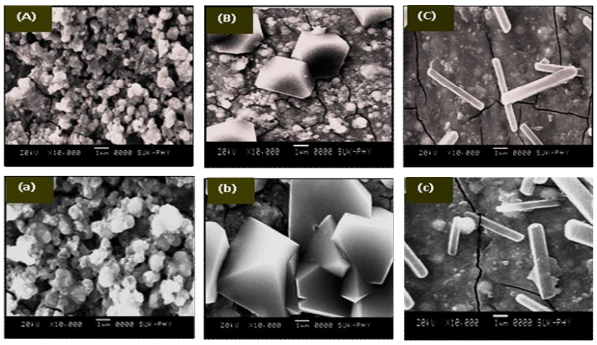


FIGURE 2. SEM images of CdS films, (A-C) before irradiation and (a-c) after irradiation.

Bath concentration,(A=a) = 0.04 M $CdSO_4$ + 0.4 M $Na_2S_2O_3$ + 0.1 M EDTA,(B=b)= 0.06 M $CdSO_4$ +0.6 M $Na_2S_2O_3$ + 0.1 M EDTA and (C=c)= 0.08 M $CdSO_4$ + 0.8 M $Na_2S_2O_3$ + 0.1 M EDTA.

2. X-RAY DIFFRACTION STUDIES

We have studied experimentally the crystalline structure of CdS thin films for different bath concentration. The films studied usually contain hexagonal crystallites or a mixture of hexagonal and cubic crystallites.

The structural properties of CdS thin films are studied by X-ray diffraction. Fig. 3 (A-C) and (a-c) shows before and after irradiated CdS films respectively. The XRD pattern of the CdS films show a mixed phase similar to those reported by other workers [6]. The d-values of XRD reflection are compared with standard d-values taken from the JCPDS data and are reported in Table 1.

The crystallite size increases after irradiation due to induced disorder in the structure and is reported in Table 2. The peak intensity increases after electron beam irradiation [7].

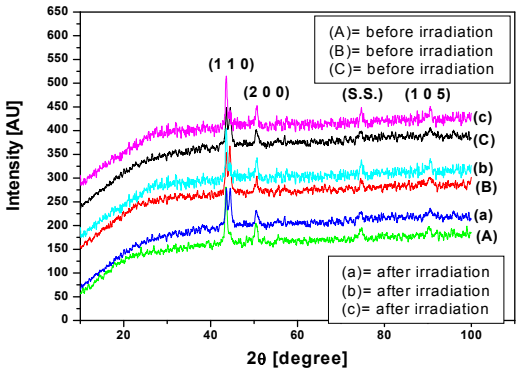


FIGURE 3. XRD Patterns of CdS films, (A-C) before irradiation and (a-c) after irradiation.

TABLE 1. Comparison of observed 'd' values with standard 'd' values of CdS thin film onto stainless steel substrate for Bath concentration,(A=a) = 0.04 M $CdSO_4$ + 0.4 M $Na_2S_2O_3$ + 0.1 M EDTA,(B=b)= 0.06 M $CdSO_4$ +0.6 M $Na_2S_2O_3$ + 0.1 M EDTA and (C=c)= 0.08 M $CdSO_4$ + 0.8 M $Na_2S_2O_3$ + 0.1 M EDTA.

Obs. No.	Standard 'd' values (A^0)	Observed 'd' values (A^0) bath concentration			Refracting plane (hkl)
		(A=a)	(B=b)	(C=c)	
1	2.070	2.074	2.076	2.075	1 1 0
2	1.793	1.804	1.807	1.805	2 0 0
3	1.258	1.271	1.269	1.270	1 0 5
4	1.075	1.083	1.085	1.083	2 0 5

TABLE 2. Crystallite size, Grain size and Band gap energy of CdS thin films, before irradiation and after irradiation for different bath concentration.

Bath concentration	(A)=before and(a)=after irradiation		(B)=before and (b)=after irradiation		(C)=before And (c)=after irradiation	
Deposition Time (Sec.)	(A=a)=130s.		(B=b)=130s.		(C=c)=130s.	
	(A)	(a)	(B)	(b)	(C)	(c)
Crystallite size (nm)	35.1	36.0	48.1	49.0	65.9	67.0
Grain size (μm)	0.43	0.45	3.1	3.2	4.3	4.7
Band gap energy (eV)	2.4	2.3	2.3	2.3	2.3	2.2

3. OPTICAL ABSORPTION STUDIES

The optical absorption studies, of CdS films deposited on FTO coated glass substrates, are carried out in the wavelength range from 350-850 nm using a UV-VIS-NIR spectrophotometer. In order to estimate the band gap energy E_g of the CdS films for different bath concentrations, Fig. 4 (A-C) before irradiation and Fig.4 (a-c) after irradiation are used. These figures show the variation of $(\alpha h\vartheta)^2$ with $(h\vartheta)$. The band gap for CdS is determined by extrapolating the straight line portion to the energy axis and it is found to be different bath concentrations. The band gap is found to be in between 2.4eV to 2.3eV before irradiation and in between 2.3eV to 2.2eV after irradiation for different bath concentrations. For given bath concentration, the decrease in band gap energy is observed after irradiation.[8].

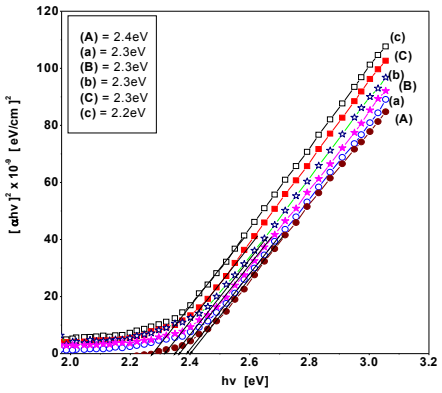


FIGURE 4. (A-C) and (a-c) band gap energy before and after irradiated of CdS films

CONCLUSION

The following conclusions can be drawn from the studies on the effect of 6 MeV electron irradiation on the properties of CdS thin films under various concentrations.

The substantial increase in both the granular growth and crystallite size is observed in CdS thin films due to irradiation for given bath concentration.

However, the decrease in the band gap energy was observed due to irradiation for a given bath concentration.

REFERENCES

1. T. L. Chu, Shirley S. Chu, N. Schalfz ,C. Wang, C. Q. Wu, *J. Electrochem. Soc.* 139 (1992) 2443.
2. J. E. Mc Cann, M. Skyllas Kazacos, *J. Electroanal Chem*. 119 (1981) 409.
3. G. Hodes, J. Manassen, S. Neagu, *Thin Solid Films* 90 (1982) 433.
4. A. S. Baranski , W. R. Fawcelt, *J. Electrochem. Soc*. 127 (1980) 766.
5. S. C. Sahu, S. N. Sahu ,*Thin Solid Films* 235 (1993) 17.
6. H. Uda, S. Ikegami, H. Sonomura, Jpn. *J. Appl. Phys*. 29 (1990) 30.
7. S. D. Chavhan, N. G. Deshpande, Y. G. Gudage, A. Ghosh, R. R. Ahire, S. V. Borse, R. S. Khairnar, K. M. Jadhav, F. Singh, Rampal Sharma, *Rad. Phys. Chem.* 77 (2008) 794.
8. Band gap shift, structural characterization and phase transformation of CdSe thin films. From nanocrystalline cubic to nanorod hexagonal on air annealing, *Semicond. Sci. Tech*nol. 20, 1, (2005).