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Effect of electron irradiation on the Electrodeposited Cadmium Telluride thin films

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ABSTRACT

Here, Cadmium Telluride thin films have been prepared by electrodeposition method using aqueous basic electrolyte. The electrodeposition of CdTe thin films is carried out by varying the concentrations. The deposition potential of the compound was studied by cyclic voltammetry. The as-deposited and irradiated CdTe thin films were characterized by X-ray diffraction (XRD), scanning electron microscope (SEM), optical absorption technique and contact angle measurements for different bath concentration respectively. The layers were subjected to irradiation with 6 MeV electrons.

Keywords: Thin Films, Electron beam irradiation, Electrodeposition, CdTe, XRD, SEM.

INTRODUCTION

Cadmium Telluride (CdTe) is recognized as a highly versatile II and VI narrow band gap binary compound semiconductor [1], from which one can expect a high solar energy conversion efficiency. This compound is the only binary II and VI material which can be in both n-and p-conductivity type [2]. Its applications range from solar cells to gamma-ray and infrared detectors [3].

Thin films of CdTe are fabricated by a variety of methods, such as vacuum evaporation [4], metal-organic chemical vapour deposition [5], anodic and cathodic deposition [6,7] etc. Among these methods electrodeposition is an

attractive method which has successfully been employed for the preparation of elemental, binary, intermetallic and termary compounds. It is an isothermal process, mainly controlled by electrical parameters, which are easily adjusted to control film thickness, morphology, composition etc [8]. The cathodic electrodeposition of CdTe from aqueous and non-aqueous solution has been developed. Extensive literature is available on preparation and characterization of CdTe thin films by various techniques.

In the present work, Cadmium Telluride (CdTe) thin films have been prepared from aqueous medium on to stainless steel and fluorine doped tin oxide (FTO) substrates using electrodeposition method. The preparative parameter such as concentration of the solution, pH of the electrolytic bath; Cadmium Sulfide and Cadmium Telluride thin films were irradiated with high energy heavy ion beam to study the irradiation induced effects in these films [9-11].

METHODOLOGY

CdTe thin films are prepared on stainless steel substrate using the Electrodeposition Technique. The Substrates were polished by polish paper, These substrates were further ultrasonically cleaned in double distilled water. The Electrodeposition bath is prepared using analytical reagent grade $CdSO_4$, Na_2TeO_3 and EDTA in double distilled water. The stainless steel and fluorine doped tin oxide (FTO) are used as substrates. Thin film deposition is carried out using a three electrode system in which a saturated calomel electrode (SCE) is used as the reference electrode. The well cleaned, mirror polished, stainless

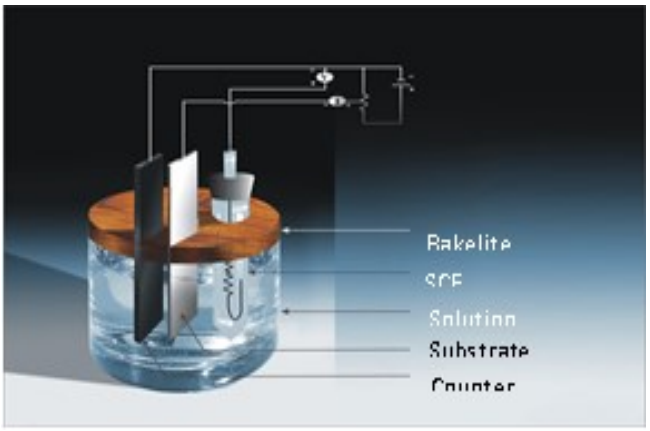

Fig.1: Experimental set up for deposited CdS thin films.

The phase formation is characterized after and before irradiation by X-ray diffraction which is performed on a PW-3710 diffractometer using Cu Kα radiation. Surface morphology of these films was studied using a JEOL-JSM 6360 Japan, scanning electron microscope. The optical band gap of the material was determined by UV-VIS-NIR spectrophotometer in the wavelength rang of 350-950 nm.

RESULTS AND DISCUSSION

Cyclic voltammetry

Cyclic voltammetry is employed to study the kinetics of the electrochemical reactions in electrolytic bath. Fig.2. (a-c) shows the cyclic voltamograms recorded on stainless steel substrate from electrolytic solutions containing 0.08M $CdSO_4$ + 0.03M Na_2TeO_3 + 0.1M EDTA, in order to find the suitable reduction potentials of $CdSO_4$, Na_2TeO_3 and CdTe respectively. The electrodeposition of CdTe thin films were carried out at the deposition potential -0.58 V/ SCE.

Table 1: Comparison of observed and standard'd' values of CdTe thin films for (A=a)= 0.04M $CdSO_4$ + 0.01M Na_2TeO_3 + 0.1M EDTA, (B=b)= 0.06M $CdSO_4$ + 0.02M Na_2TeO_3+ 0.1M EDTA, (C=c)= 0.08M $CdSO_4$ + 0.03M Na_2TeO_3 + 0.1M EDTA, before and after irradiation.

Obs. No.	Standard 'd' values (A^0)	Observed 'd' values (A^0) bath concentration			Refracting plane (hkl)
		(A)	(B)	(C)	
1	2.054	2.051	2.075	2.075	(2 2 0)
2	1.751	1.74	1.74	1.79	(3 1 1)

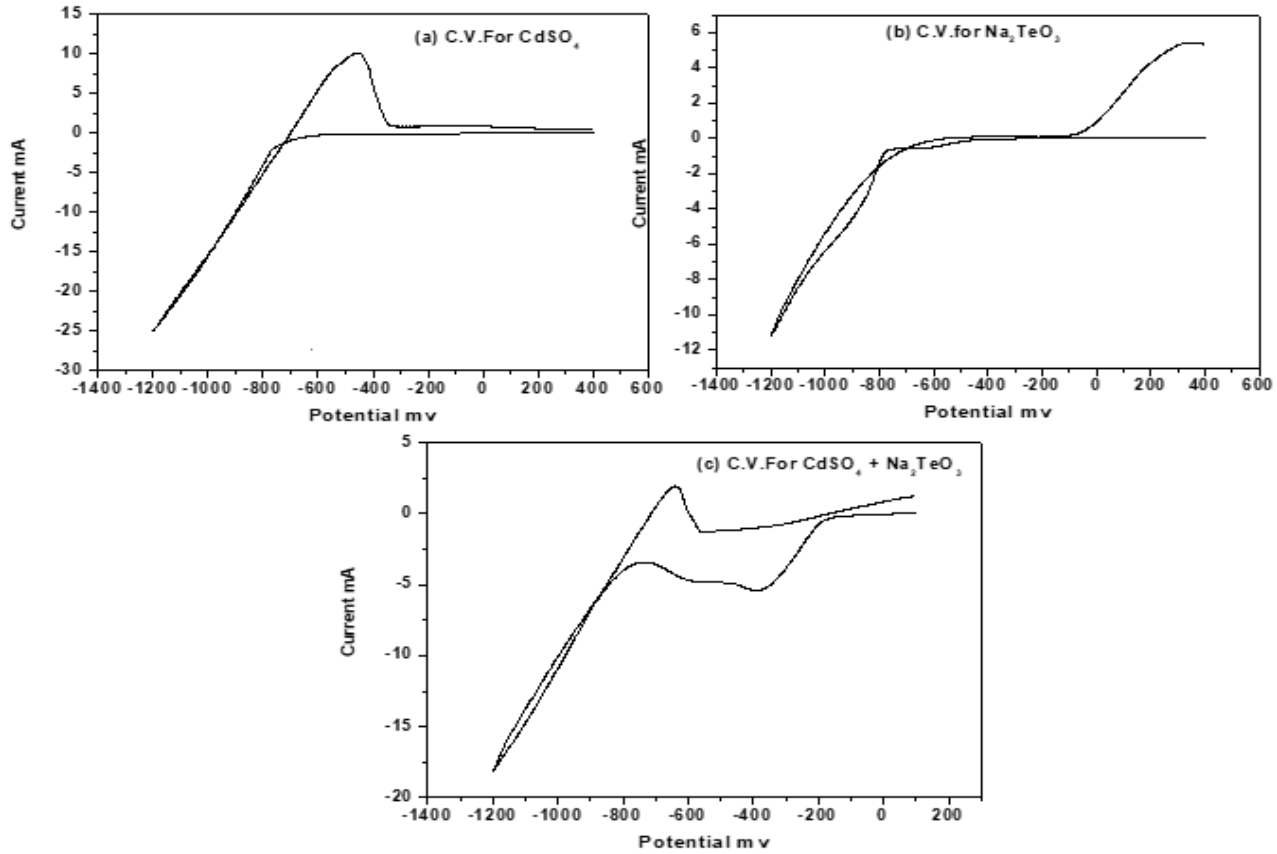

Fig.2: Cyclic voltammogram on stainless steel substrate in the solution containing.0.08M $CdSO_4$, (b) 0.03M Na_2TeO_3 and (c) 0.08M $CdSO_4$ + 0.03M Na_2TeO_3 + 0.1M EDTA.

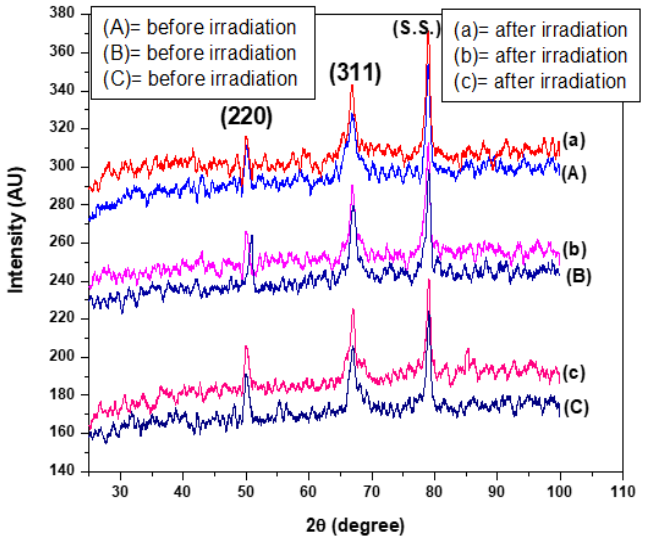

Fig.3X-ray diffraction pattern for CdTe film deposited on stainless steel substrate for different concentration (A=a)= 0.04M $CdSO_4$ + 0.01M Na_2TeO_3 + 0.1M EDTA, (B=b)= 0.06M $CdSO_4$ + 0.02M Na_2TeO_3+ 0.1M EDTA, (C=c)= 0.08M $CdSO_4$ + 0.03M Na_2TeO_3 + 0.1M EDTA. before and after irradiation.

X-Ray Diffraction Studies

The structural properties of CdTe thin films are studied by X-ray diffraction pattern. Fig.3 shows the XRD of CdTe films as-deposited and irradiated on stainless steel substrate for the different concentrations. It reveals that the CdTe films are polycrystalline with cubic crystal structure. The structural identification of CdTe film was carried out using XRD in the range of diffraction angle '2θ' between 10^0-100^0. The d-values of XRD reflection were compared with standard d-values taken from the JCPDS data and reported in Table 1.

SEM Studies

The surface morphology of as-deposited and irradiated CdTe films were analyzed using scanning electron microscope (SEM). Figs. 4 shows SEM images of CdTe thin films, the average Particle size was calculated to be as-deposited, and after irradiation. The SEM micrographs showed that the particle size increases by increasing concentration as well as irradiated.

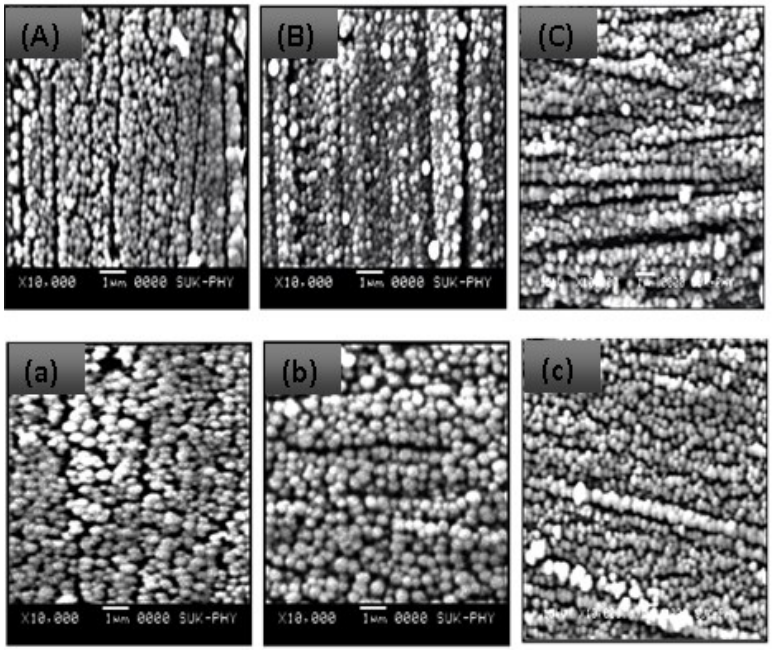

Fig.4 SEM micrograph of CdTe thin films on to glass substrate for different concentrations, (A=a)=0.04M $CdSO_4$ + 0.01M Na_2TeO_3 + 0.1M EDTA, (B=b)= 0.06M $CdSO_4$ + 0.02M Na_2TeO_3+ 0.1M EDTA, (C=c)= 0.08M $CdSO_4$ + 0.03M Na_2TeO_3 + 0.1M EDTA. before and after irradiation.

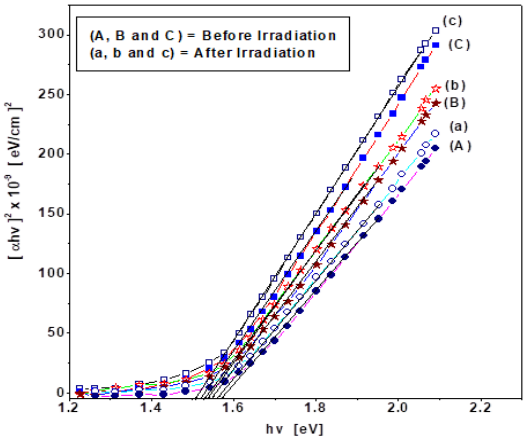

Fig.5 Plot of $(\alpha h\vartheta)^2$ versus $(h\vartheta)$ for determination of band gaps of CdTe films as for different concentrations, (A=a)= 0.04M $CdSO_4$ + 0.01M Na_2TeO_3 + 0.1M EDTA, (B=b)= 0.06M $CdSO_4$ + 0.02M Na_2TeO_3+ 0.1M EDTA, (C=c)= 0.08M $CdSO_4$ + 0.03M Na_2TeO_3 + 0.1M EDTA, before and after irradiation.

Optical Absorption Studies

The optical absorption studies of CdTe films deposited on FTO coated glass substrates was carried out in the wavelength range from 350-850 nm using a UV-VIS-NIR spectrophotometer. In order to estimate the bandgap energy E_g of the CdTe film for one concentrations. Fig. 5 shows the variation of $(\alpha h\vartheta)^2$ with $(h\vartheta)$.The bandgap for CdTe is determined by extrapolating the straight line portion to the energy axis and it is found to be 1.54eV. for concentrations, 0.08 M $CdSO_4$ + 0.03 M Na_2TeO_3 + 0.1 M EDTA .

Surface Wettability Study

An empirical diagnostic method for evaluation of thin films property is the measurement of water contact angle on its surface. Fig. 6 shows photo-images of contact angle for CdTe films for different concentrations. The films exhibits hydrophilic nature as water contact angle is less than 90^0. The obtanied contct angles for different bath concentration is as follows.

(A) before irradiation : 50^0 and (a) after irradiation: 62^0 for bath concentration, 0.04M $CdSO_4$ + 0.01M Na_2TeO_3 + 0.1M EDTA.

(B) before irradiation : 70^0 and (b) after irradiation: 84^0 for bath concentration, 0.06M $CdSO_4$ + 0.02M Na_2TeO_3+ 0.1M EDTA.

(C) before irradiation : 95^0 and (c) after irradiation: 102^0 for bath concentration, 0.08M $CdSO_4$ + 0.03M Na_2TeO_3 + 0.1M EDTA.

From this, it is clear that as the concentration of the bath increases the corresponding contact angle is also increases.

Table 2 Crystallite size, Grain size and Contact angle of CdTe thin films, for A, B and C bath concentrations before and after irradiation.

Bath concentration	(A)=before and (a)=after irradiation		(B)=before and (b)=after irradiation		(C)=before and (c)=after irradiation	
Deposition Time	120 Sec.		120 Sec.		120 Sec.	
(Sec.)	(A)	(a)	(B)	(b)	(C)	(c)
Crystallite size (nm)	24.5	26.0	29.1	31.0	31.2	32.0
Grain size (μm)	0.39	0.40	0.54	0.55	0.56	0.57
Contact angle(θ ^{0})	50^0	62^0	70^0	84^0	95^0	102^0

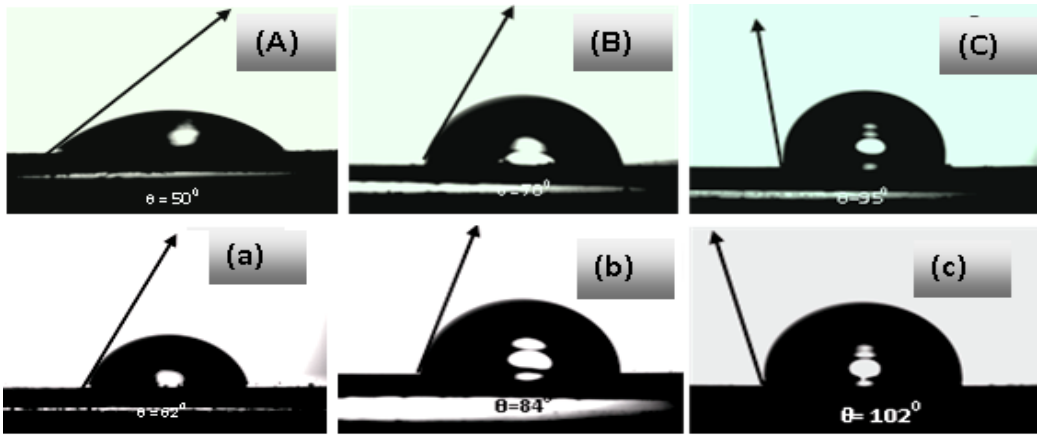

Fig.6 Contact angle measurement of CdTe thin films for different concentrations.

CONCLUSION

The effect of 6MeV electron irradiation on the properties of CdTe Thin films under electrodeposition method using aqueous basic electrolyte and the following conclusions were drawn. An increase in solution concentration the CdTe thin films parameters was observed at a dose of 10 kGy. The bandgap was found to be decreased with increase bath concentration. After irradiation at a slight decrease bandgap with bath concentrations. The surface morphological study, it is observed that the increase in deposition bath concentration shows a substantial granular growth and electron irradiation resulted in the increase in grain size. The structural property of CdTe thin films increases the crystallite size after irradiation.

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