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Characterization of Nanostructured CdS Thin Films Prepared by Chemical Route

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Abstract: The optical, structural and morphological properties of CBD deposited CdS thin films have been studied under different growth condition. The films were characterized by X-ray diffraction, FEG-SEM and UV-VIS absorption. The grain size increases with increasing the cd/s ratio and or deposition time. The films shows polycrystalline cubic structured and predominant hexagonal phase with small crystallites. The optical band gap of film estimated using optical absorption is found to be 2.5 eV.

1. Introduction

Chalcogenide Semiconductor thin films are being intensively investigated for low cost photovoltaic and optoelectronic applications [1, 2]. Cadmium sulphide is commonly used as n-type semiconductor layer for hetrojunction thin film solar cell multilayered CdS films can be employed in the manufacturer of optoelectronic devices. The deposition of CdS thin films has been explored by various techniques, such as chemical bath deposition [3], spray pyrolysis [4], molecular beam epitaxy[5], sputtering[6], thermal evaporation[7]. Chemical bath deposition is a method of growing thin film of certain material on a substrate immersed in an aqueous bath containing appropriate reagent at temperature ranging from room temperature to 80^0 C . It is suitable method for the preparation of large area thin films [8]. Chemical bath deposition is the most convenient way to deposit buffer layer which increases the efficiency of solar cell[9,10]. In this paper we report synthesis of CdS thin film on to microscope glass slide by Chemical bath deposition method. The optical, structural and morphological properties of the as –prepared films are investigated.

2. Experimental Detail

2.1 *Synthesis :*

Reagents used for the deposition include cadmium sulfate CdSO4, ammonia water NH4OH and thiourea CS(NH2)2. All reagents are of analytical grade and used without further purification. The glass substrates were soaked in 5% HCL solution, left then for 20 minutes under methanol, alcohol, washed with distilled water and finally dried in the air.

The typical procedure for the film growth is described as follows. Drop by and by 25 % NH_4OH into a 100 ml beaker containing 50 ml of 0.05 M $CdSO_4$ solution until the initially formed white precipitate is completely dissolved. The clean substrates are mounted vertically in the bath beaker in such a way rotated well inside the bath 50 ml of 0.10 M $CS(NH_2)_2$ then is poured into the mixtures.

3.2. Scanning Electron Microscopy (SEM) Imaging :

To study the homogeneity of the films and to compare one with another, the surface investigations in the SEM imaging were performed. The most homogeneous films (Fig. 2a) were obtained in the bath with 50 ml of 0.05M $CdSO_4$ solution for 20 min. In this case, the slow deposition rate led to the small uniform grain size and shape and the good adhesion to the substrate. On the films deposited in the bath containing 50 ml of 0.10M $CdSO_4$ solution for 20 min (Fig. 2b), one can see many scattered particles.

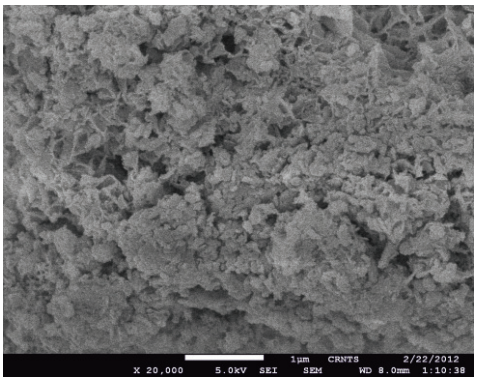

Fig. 2(a). SEM images of CdS thin film in the bath 50 ml of 0.05M $CdSO_4$

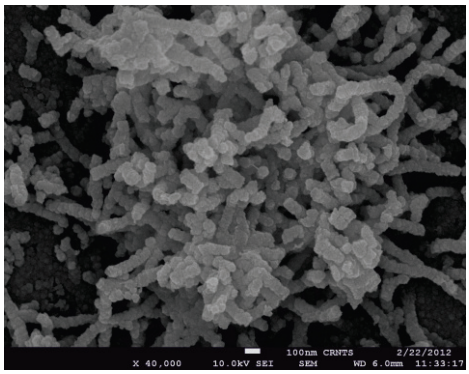

Fig. 2(b). SEM images of CdS thin film in the bath 50 ml of 0.10M $CdSo_4$

3.3 Optical Properties :

The spectra of the film were typical for those reported by many workers for polycrystalline CdS thin film. The band gap of the film were determined. The linear dependence of $\alpha h\nu^2$ verses $h\nu$ was indicative of direct band gap material. The band gap is found to be 2.5 eV as shown in Fig. 3 .

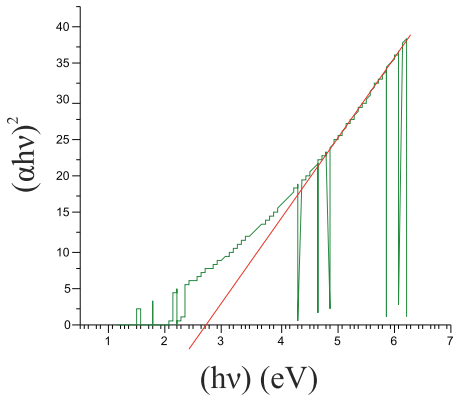

Fig. 3. Plot shows the variation of $(\alpha h\nu)^2$ verses (hv) of as deposited CdS thin film.

4. Conclusions

In this work, we show a route to the deposition of CdS thin film on glass substrates using Chemical bath deposition technique from solutions with various cadmium concentrations. The system of precursors consists of cadmium sulfate and thiourea in basic ammonia water. The as-deposited films have been characterized by XRD, SEM and UV-VIS spectroscopy. The films are of cubic (zincblende) type polycrystalline, stoichiometric. The influence of the Cd concentrations on the films morphology is also reported. The obtained results can be useful for the started point for synthesis and processing of multilayer's films solar cells applications.

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Finally, the distilled water is gradually added to make the volume up to 200 ml. The deposition is made at 80°C under magnetic stirring for all samples. To vary the composition of the films, different concentrates of the $CdSO_4$ and thiourea are used.

The CdS formation is detailed in the following series of chemical reactions:

$$CdSO_4 + NH_4OH \leftrightarrow Cd(OH)_2 + (NH_4)SO_4$$

$$Cd(OH)_2 + 4NH_4OH \leftrightarrow Cd(NH_3)_4^{2+} + 2OH^- + 4H_2O$$

$$H_2N\text{-}\underset{\underset{\|}{S}}{C}\text{-}H_2N \leftrightarrow H_2N - \underset{\underset{\|}{SH}}{C} = NH$$

$$H_2N\text{-}\underset{\underset{|}{SH}}{C}\text{=}HN + OH^- \leftrightarrow H_2N - \underset{\underset{|}{OH}}{C} = NH + SH^-$$

$$Cd(NH_3)_4^{2+} + SH^- = CdS^{-} + NH_4^{+} + 3NH_3$$

CdS thin films formed on the substrates are optically transparent, adherent, homogeneous and yellowish in color without any powdered precipitation. After deposition, the substrate were removed from the chemical bath, cleaned thoroughly in distilled water and dried in the air at room temperature. The deposition time is chosen to be 20 min. for the bath containing 50 ml of 0.5M $CdSO_4$ solution.

2.2. Characterization Techniques :

The structural characterization of the films was carried out using X-ray diffractormeter (model: Philips X'pert) with CuKα radiation (α = 1.5406 A^0) in 2θ range from 0 to 100 ^{0}. The surface morphological study of CdS film was carried out by using scanning electron microscopy (model JSM-7600F) with resolution 1 nm (15 KV). The optical absorption spectra of the films was recorded LAMBDA-25 spectrophotometer in the wavelength range 200 nm to 1100 nm.

3. Results and discussion

3.1. X-ray Diffraction (XRD) Analysis :

The typical diffractogram of the as-deposited CdS thin films is shown in Fig. 1. XRD analysis indicated that the major peaks found for these two sets indicate the presence of both cubic and hexagonal phases. The peak of maximum broadening centered at 26.7 degree is suggestive of combination of many peaks including the dominant c(1 1 1)/h(0 0 2) at 26.6 degree. Presence of CdO phase here is most likely in nano-CdS as it is very prone to oxidation when exposed to air. Also there are two characteristic peaks at 44.0 degree and 52.1degree. A sharper peak at 44.0 degree also indicates either c(2 2 0)/h(1 1 0). Another peak of relatively large broadening at 51.8 degree can be associated with c(3 1 1) or h(1 1 2). However, a small intensity peak at 70.6 degree bears the signature of c(3 3 1)which is characteristic of cubic phase [10].

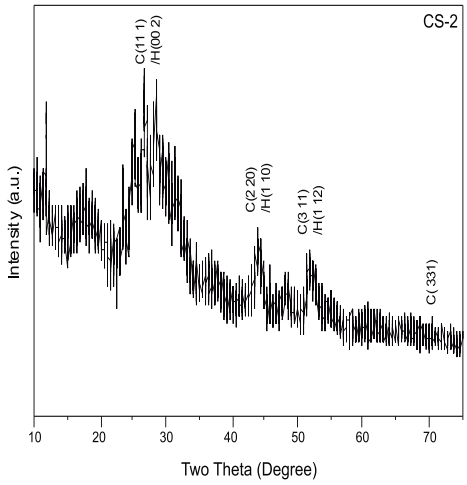

Fig. 1 : Typical X-ray diffractogram of CdS thin film as grown.

laboratory and also to IIT Bombay for carrying out characterization of samples.

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