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Growth & Characterization of Nanostructured n-type CdS/ ZnS thin films for Solar Cell Applications

V.B. Sanap

Dept. of Physics, Y. C. College, Sillod, Dist. Aurangabad (M.S.), India

Abstract: Cadmium sulfide (CdS) and Zinc sulfide (ZnS) n-type semiconductor thin films have been deposited on various substrates by Chemical Bath Deposition Technique (CBDT). All the films have been deposited at temperature 70±2ºC. The as-deposited films were characterized by X-ray diffractometer (X-PERT PRO) and scanning electron microscopy (SEM). The thicknesses of the film have been measured using weight difference method. It is observed that, the average grain size of CdS & ZnS film is in the range of 24nm to 65nm. The physical conditions were kept identical while growing all the samples. It is also observed that energy band structure and band gaps get changed because of the change in the grain size of the sample in the films. We predict that the difference in grain size of the CdS/ZnS in the thin films may be because of the binding energy of Cadmium and Zinc in the molecules of $CdSO_4$ and $Zn(CH_3COO)_2$. The investigation of the effect of the method of synthesis on the grain size and the effect of grain size on the properties of semiconductor is under consideration.

Keywords: Cadmium sulfide, zinc sulfide, thin film, chemical bath

I. INTRODUCTION

Cadmium and zinc sulfide are compound semiconductors with a wide range of potential applications. These materials have many similarities; both exist in cubic or hexagonal forms and are wide- direct-band gap semiconductors. The CdS / ZnS is an excellent material used with the semiconductor cadmium telluride to fabricate solar cells given its optimal band gap energy (2.42 eV) for optical windows, while great importance in the optoelectronic applications and a diverse range of applications for thin films of this semiconductor including as waveguides, heterojunction devices and in thin-film electroluminescent displays in which it is the most commonly used host material. The potential of ZnS layers in blue light-emitting diodes (LEDs) and laser diodes is also an area which is well documented. Applications in opt electric methods or photovoltaic devices is another area receiving attention , In CdS based solar cells, the use of wider bandgap materials such as ZnS or CdZnS could lead to decreases in window absorption losses and improvements in the short circuit current of the cells [1-6].

In this work we developed the CdS and ZnS n-type semiconductor thin films having a nanometer grain size by using Chemical Bath Deposition Technique. The (CBDT) is one of the most convenient, reliable, simplest, inexpensive method and useful for large area industrial applications as well as preparation of thin film at close to room temperatures. The technique of CBD involves the controlled precipitation from solution of a compound on a suitable substrate. The technique offers many advantages over the more established vapor phase synthetic routes to semiconductor materials, such as CVD, MBE and spray pyrolysis. Factors such as control of film thickness and deposition rate by varying the solution pH, temperature and reagent concentration are allied with the ability of CBD to coat large areas, in a reproducible and low cost process. Another advantage of CBD method with respect to other methods is that the films can be deposited on different kinds, shapes and sizes of substrates [7-9].

II. EXPERIMENTAL DETAILS

Thin films of CdS and ZnS were deposited from a solution of analytical grade $CdSO_4$ (Cadmium Sulphate) and $Zn(CH_3COO)_2$ (Zinc Acetate) as a Cd^{++} / Zn^{++} ion source and Thiourea as a S^{--} ion source in an alkaline solution of Ammonia. Commercial glass slides, used as substrates, were cleaned in acetone and methanol ultrasonically, and finally, again washed with methanol ultrasonically before use. After cleaning the glass slides were kept vertically in a closed beaker with the help of a special holder which is attached to AC Motor having a constant speed of 60 r.p.m. We have a double distilled water in a beaker and then added $CdSO_4$ / $Zn(CH_3COO)_2$ of perticular molarity as a Cd^{++} / Zn^{++} ion source slowly under Magnetic stirring. We Add liquid Ammonia slowly to the solution for adjusting the pH of solution which is measured on pH meter, Giving the temperature to the solution by means of heating coil. Add Thiourea (SC $(NH_2)_2$) of perticular molarity as a S^{--} ion source was slowly poured into the solution only when the appropriate

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temperature i.e. 60^oC was reached. Finally the temperature was kept constant with the help of a temperature controller in the range 70^oC to 72^oC. The time for the deposition was varied from 10 Min. to 60Min after achieving constant temperature. After the deposition, the CdS / ZnS films were washed with methanol ultrasonically to remove the loosely adhered CdS / ZnS particles on the film and finally dried in air. The same procedure is repeated for different time durations [10, 11].

The crystallographic structure of films was analyzed with a diffractometer (XPERT-PRO) by using Cu-Kα lines (λ= 1.54 Å). The average grain size in the deposited films was obtained from a Debye-Scherrer's formula.Also we were change the different parameters such as Time, Molarities, pH and Temperature and note the effects on deposition rate of thin films.

III.RESULTS AND DISCUSSION

A. Structural Characterization:

Figures 1 shows the XRD patterns of CdS thin films deposited on glass slides. Whereas, Figures 2 shows the XRD patterns of ZnS thin films deposited on glass slides.
The average grain size (g) was calculated using the Debye-Scherrer's formula,

$$g = 0.9\,\lambda / \beta \cos\theta$$

Where, λ= is the wavelength of x-ray source (1.54 Å)

β = the full width at half maximum (FWHM) of diffraction peak.

θ = Diffraction angle. (Bragg's angle)

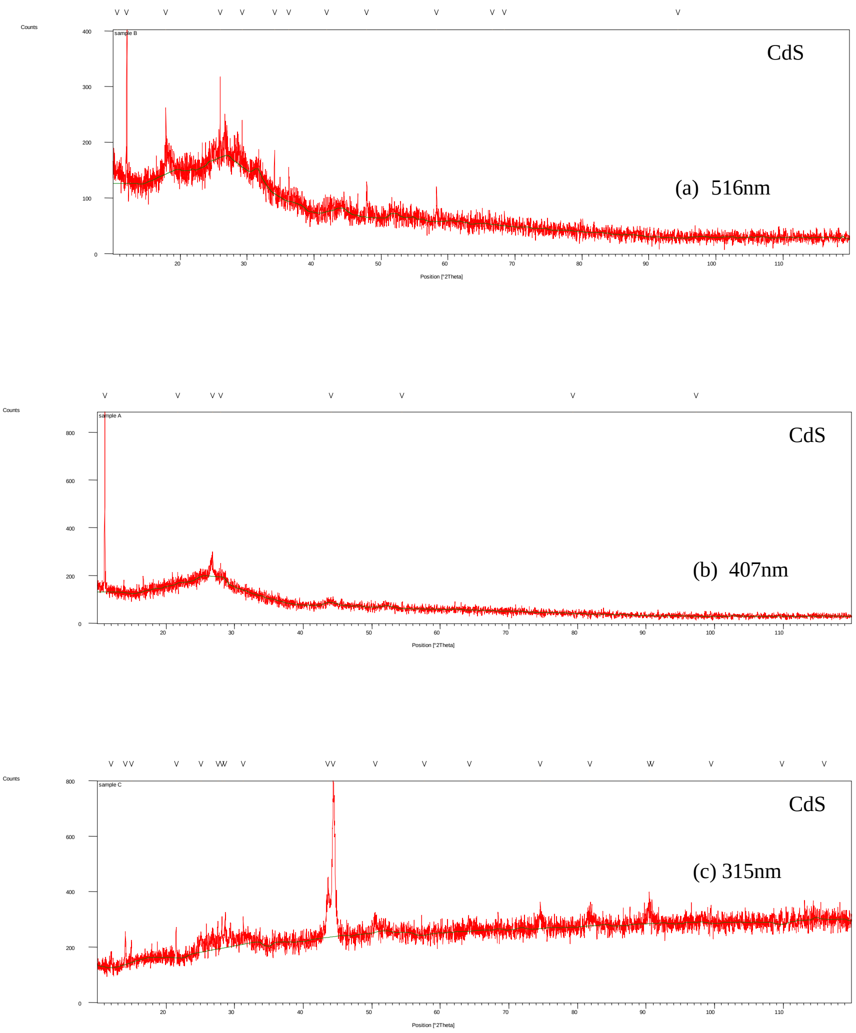

Fig.1 The XRD graphs of CdS for different thickness.

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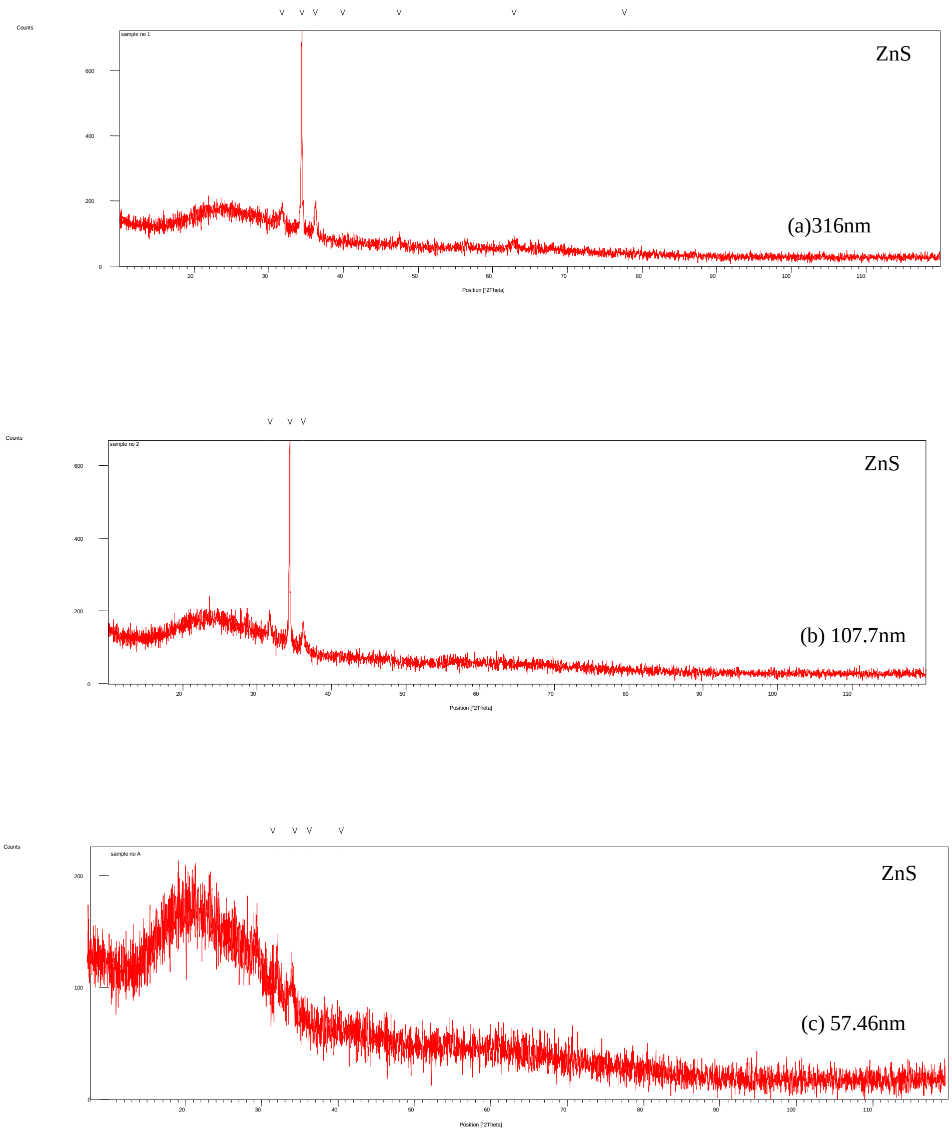

Fig.2 The XRD graphs of ZnS for different thickness.

The X-ray diffraction pattern of the as-deposited thin films show that, the average grain size of the CdS thin film is in the range of 25nm to 65nm, Whereas the average grain size of ZnS thin film is in the range of 24nm to 52nm (Table 1). The XRD graph shows the as-deposited films have polycrystalline nature with nanometer grains.

B. **Morphological study:**

Figure 3 shows the SEM images of as-deposited CdS/ ZnS thin films for different thicknesses. The morphological images clearly indicate the nanometer grains were covered uniformly over the surface of the developed samples. The developed films shows some fibrous like structure which may useful for various optoelectronic applications. The grain size obtained from XRD study matches with the grain size obtained from SEM images.
Table 1 shows the detailed Summary of average grain size of CdS/ ZnS thin films for different thicknesses.

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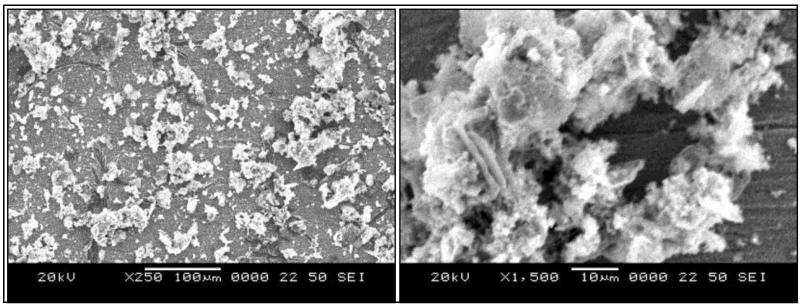

Fig.3 SEM images of CdS/ZnS thin films for different thickness.

TABLE I SUMMARY OF AVERAGE GRAIN SIZE OF CDS/ZNS THIN FILMS FOR DIFFERENT THICKNESSES.

Sample Name	CdS film		ZnS film	
	Film thickness 't' (nm)	Average Grain size 'g'(nm)	Film thickness 't' (nm)	Average Grain size 'g'(nm)
C22	315	65	57.46	24
C32	407	25	107.7	52
C42	516	36	316	47

IV.CONCLUSION

CdS/ZnS n-type nanocrystalline thin films have been grown successfully by simple and inexpensive CBD technique. The structural and morphological studies have been studied. The as-deposited thin films shows polycrystalline structure having nanometer size grains uniformly deposited over the substrate. The developed films shows some fibrous like structure which may useful as window layers in solar cells. The optical study of these films is under consideration for various optoelectronic applications.

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