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Development of n-type CdS and ZnS Nanostructured Semiconductors for Solar Cell Applications

S.P. Wagh[1] *and Vijay B. Sanap*[2,*]

[1]*Shri Shivaji College, Akot, Dist. Akola(MS), India.*
[2]*Yeshwantrao Chavan College, Sillod, Dist. Aurangabad, (MS), India.*

Email: vbsanap@rediffmail.com

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Abstract: We deposit n-type CdS & ZnS semiconductor films on different substrates by simple and inexpensive chemical bath deposition technique (CBDT). We record X-ray diffraction pattern and SEM of the developed samples. It is found that, the average grain size for CdS & ZnS film is in between 24nm and 65nm. It is observed that the energy band structure and band gaps get changed because of the change in the grain size of the sample in the films. The physical conditions were kept identical while growing all the samples. We predict that the difference in grain size of CdS and ZnS in 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 technique 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, nanostructured thin films, CBD.

1 Introduction

Zinc and cadmium 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.

In this work we developed the ZnS and CdS n-type semiconductor thin films having a nanometer grain size by using Chemical Bath Deposition (CBD) Technique. The (CBD) 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. [1, 2]

2 Experimental details

Thin films of CdS / ZnS were deposited from a solution of analytical grade $CdSO_4$ (Cadmium Sulphate) / $Zn(CH_3COO)_2$ (Zinc Acetate) 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. Well cleaned glass slides were kept vertically in a closed beaker with the help of a special holder which is attached to a motor having a constant speed of 60 r.p.m. We have 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. Ammonia solution is used for adjusting the pH which is measured on pH meter. Thiourea (SC $(NH_2)_2$) solution of particular molarity was slowly poured into the solution only when the appropriate temperature i.e. 60°C was reached. Finally the temperature was kept constant with the help of a temperature controller in the range 70°C to 72°C. The time for deposition was varied from 10 min. to 60 min. 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 similar procedure is repeated for different deposition time. [3, 4]

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 Debye-Scherrer's formula.

3 Results and discussion

3.1 Structural properties

Fig 1 shows the XRD pattern of CdS/ZnS thin films for varying film thickness. The sharp peaks show good crystalline films with nanometer size.

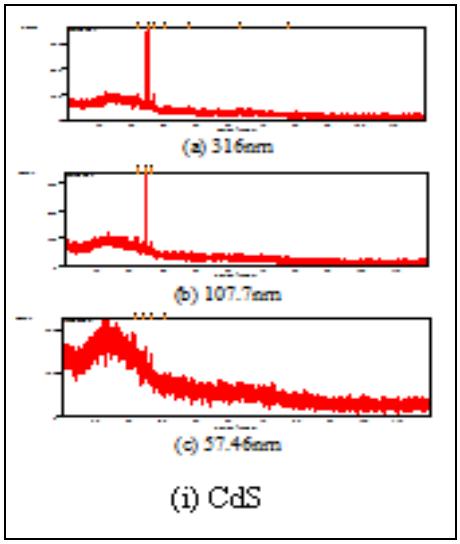

Figure 1(a): The XRD graphs for CdS at different thicknesses.

The average grain size (g) was calculated using the Debye-Scherrer's formula, [5-8]

$$g = 0.9\,\lambda / \beta \cos\theta \qquad \ldots\ldots\ldots (1)$$

Where,

λ = is the wavelength of X-ray source (1.54 Å)
β = full width at half maximum of diffraction line.
θ = diffraction angle (Bragg's angle)

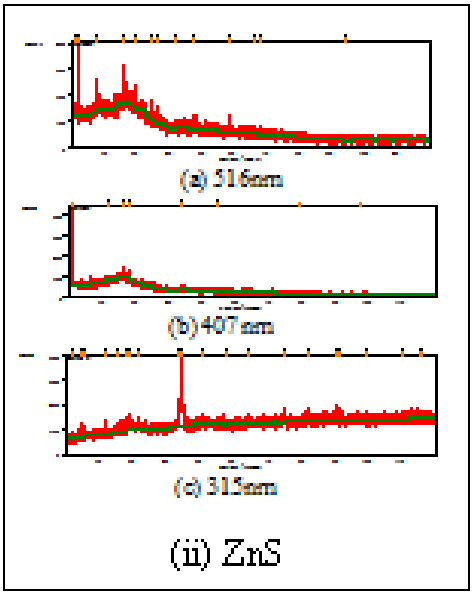

Figure 1(b): The XRD graphs for ZnS at different thicknesses,

Table 1 and 2 indicates variation of film thickness with grain size of CdS & ZnS thin films respectively. The average grain size obtained from X-ray diffraction pattern is between 25nm and 65nm for CdS and is between 24nm and 52nm for ZnS films.

Table 1: Variation of film thickness with grain size of CdS thin films.

Sample Nature	Sample Number	Thickness of film (t)(nm)	Grain size (nm)	Average Grain size g(nm)
Glass	A	407	34.91 15.26	25.085
Glass	B	516	14 57	35.5
Stainless steel	C	315	56 29 45	65

Table2. Variation of film thickness with grain size of ZnS thin films.

Sample Nature	Sample Number	Thickness of film (t)(nm)	Grain size (nm)	Average Grain size g(nm)
Glass	A	57.46	14 29 29	24
Glass	B	316	44.14 59.57 37.10	46.936
Glass	C	107.7	58.86 44.67	51.765

3.2 Morphological properties

The SEM images of thin film deposited, clearly exhibits a polycrystalline nature with nanometer grain size. The nanostructured grains densely packed in the form of nano tubes, which is helpful for various optoelectronic and sensor applications. The grain size obtained from SEM matches with the XRD data.

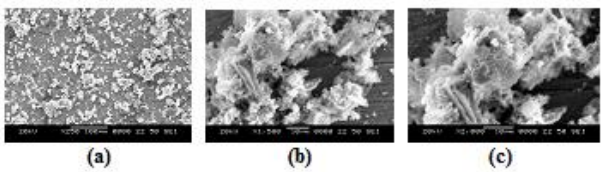

Figure 2: SEM photographs of CdS sample at different magnifications (a) X250 (b) X1500 (c) X2000.

Conclusion

Nano-structured CdS/ZnS thin films were successfully prepared by CBDT. XRD study reveals the polycrystallinity of the films. The sharp peaks shows good crystallinity, resulting in high quality films. The grain size estimated is in the range of 24 to 65nm. The nanostructured grains with nano tube like structure are suitable for various optoelectronic and sensor applications.

References

[1] Lokhande C D, Yermune V S and Pawar S H J. Electrochem.Soc. 135, 1852(1998).
[2] Isaiah O. Oladeji, Lee Chow I.O. Oladeji, L. Chow / Thin Solid Films 474, 77–83 (2005).
[3] Biswas S, Pramanik P and Basu P K, Mater. Letts 481(1986).
[4] H. Zhang, X.Y. Ma and D.R. Yang, Materials Letters, **58**, 5-9(2004).
[5] J.P. Borah and K.C. Sarma, Acta Physica Polonica A No.4, Vol. **114** (2008)
[6] V.B.Sanap, B.H.Pawar, Chalcogenide Letters Vol.**6**, 8, 415 (2009).
[7] B. S. Remadevi, R. Raveendran, A. V. Vaidyan, Prammana J. Phy., **68,** 679 (2007).
[8] Zahid Rizwan, Azmi Zakaria, M. Norizam, M. G. M. Sabri, Reza Zamiri, Monir Noroozi, Chalcogenide Letters Vol. **7**, No. 6, 423-429 (2010).