Chemical Concepts

International Journal of Chemical Concepts
ISSN:2395-4256 www.chemconsai.com
Vol.03, No.01, pp 145-149, 2017

Structural and Characterization of Zinc Sulfide Thin film depoisted by Dip and Spin Coating method

M..Balachander[1,2] , M. Saroja[2], M.Venkatalachalam[2], V. Kumar[2,3], & S. Shankar[2]

[1]Department of Electronics, CMS College of Science & Commerce, Coimbatore, Tamil Nadu, India
[2]Thin film Centre, Erode Arts and Science College, Erode, Tamil Nadu, India.
[3]Robert Bosch Engineering & Business Solutions Ltd, Tamil Nadu, Coimbatore, India

Abstract – A comparative study was carried out of Zns thin films deposited from sol – gel containing Zinc Nitrate, Thiourea and Isoproponal. Zns films prepared by Dip coating and spin coating method. Zns is an environmentally friendly material with wide band gap(Eg = 3.7 eV) compared to Cds(2.4eV), which is conventionally used as buffer layer in chalcopyrite based solar cell. The crystal structure, orientation and surface morphology were investigated by X-Ray diffractometer (XRD) and Scanning Electron Microscopy (SEM). XRD pattern reveals the hexagonal structure of ZnS thin films. Optical properties were studied using UV-visible spectroscopy. The film shows good optical properties with high absorption and energy band gap value. These prepared films can be used for solar cell applications.
Keywords : Zinc Sulfide thin films; Dip Coating Method; Spin Coating Method; structual and optical properties.

I. Introduction

In recent years, most researches in material sciences have been focusing on semiconductor materials with wide band gap. One of them is Zinc sulfide (ZnS) and it is a promising material for its uses in various application devices. In optoelectronics, it can be used as a Light emitting diode in the blue to ultraviolet spectral region owing to its wide band gap 3.6eV at room temperature [1]. Zinc Sulfide has found wide use as a thin film coating in optical and microelectronics industries. Accordingly the synthesis and characterization of zinc sulfide via different techniques have attracted considerable attention. In providing ZnS, various techniques used including Sputtering [2], evaporation [3], Chemical Bath Deposition (CBD) [4], SILAR [5], sulfur oxidation method and many others. ZnS thin films have also been proposed as potential replacement for the window layer in chalcopyrite based solar cells [6–8] currently, the preferred choice of window layer material for chalcopyrite-based solar cells is cadmium sulfide (CdS), due to its superior electrical performances and simple set-up [9]. However, cadmium is highly toxic and would present significant environmental obstacles towards large scale-integration and general public acceptance of chalcopyrite based solar cell. In contrast, ZnS is deposited using non-toxic, abundant elements that posse's higher band gap than CdS, which eliminate absorption loss and improve overall solar cell power conversion efficiency. In the present work, ZnS thin film was synthesized on glass substrate by spin coating techniques. The coated film was characterized to examine their physical properties.

II. Experimental

The sol–gel technique for preparing zinc sulfide nanoparticles has become very attractive due to its simplicity and ease of scale-up. The deposition of film was carried out by using commercially available glass slides as substrates which were initially boiled in concentrated chromic acid for 30 minutes rinsed in acetone and again in sodium hydroxide for another 30 minutes rinsed in acetone, double deionised water and finally ultrasonically cleaned. All analytical grade (A.R) reagents were used as it's without further purification for the deposition of ZnS thin films. Dpin and Spin coating method was employed to deposit ZnS thin film onto glass substrates using Zinc Nitrate as Zinc ion source and Thiourea as sulfur ion source. For the preparation of ZnS thin film samples were synthesized by mixing 0.3 m Zinc Nitrate and 0.6 m Thiourea with Isoproponal 80% and 20 % Deionsied water.The Stireed Solution was taken in a beaker and the well cleaned glass substrates were dipped in the solution for five times at regular intervals at room temperature using automatic dip coating system (Holmarc - HO-TH- 02). The prepared solution was dropped on the cleaned glass substrates and the substrates were rotated at 3000 rpm for 80s (Apex Instruments Co SCU – 2008C) and the ZnS films were prepared by repeated coating. After each coating the films were heated at 270^{o} for 10 min to evaporate the solvent and the organic residuals (Pre – heat treatment) and were allowed to cool to room temperature before applying a new coating. The spin coating and pre – heating process was repeated for five times.

III. Result and Discussion

X-ray Diffraction It has been reported that ZnS may have either cubic or hexagonal structure, depending on the synthesis conditions such as deposition temperature and precursor concentration [10]. The phase purity and crystal structure of these samples were analyzed by using CuKα radiations source in the range of 20^{0} to 60^{o} with 0.050 step size using XPERT – PRO diffractometer. Figure 1 shows the XRD Pattern of the synthesized ZnS film. The diffraction data were in agreement with the JCPDS data for ZnS (JCPDS 72-0163). Three main peaks at (004), (008) and (1011) suggest Hexagonal wurtzite structure with lattice parameter α = 3.820 A˚.[11]

From the X-ray diffraction peaks in Figure 1 the particle size are determined from at the full-width at half-maximum [FHWM] of the XRD peaks. Using the Debye – Scherrer formula:

$$D = 0.89\ \lambda /\ \beta\cos\theta \qquad (1)$$

Where D, λ, β and θ are the average particle size, wavelength of the CuKα radiation, full width at half maximum of the diffraction plane and diffraction angle respectively. The average calculated particle size of the synthesized ZnS nanopracticles is about 99nm.

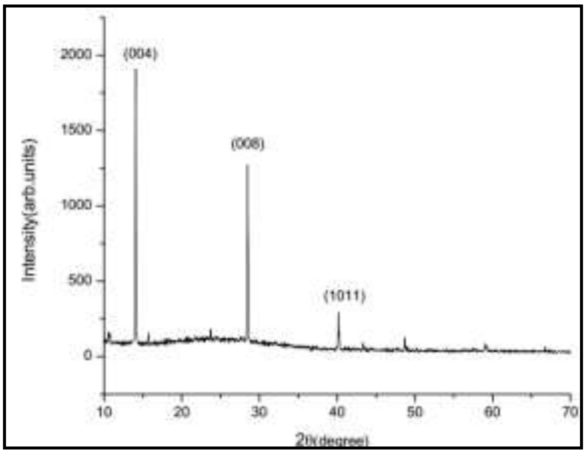

Fig 1. XRD Pattern of as prepared ZnS thin film

SEM Analysis SEM is a convenient technique to study the microstructure of thin films. Figure 2 shows the surface morphology of ZnS thin films as deposited at room temperature observed by SEM. From the micrographs, it is observed that the as-deposited films are not uniform throughout all the regions but the films are without any void, pinhole or cracks and they cover the substrates well. From the figure, it is clearly observed that the small grains engaged in a fibrous-like structure.

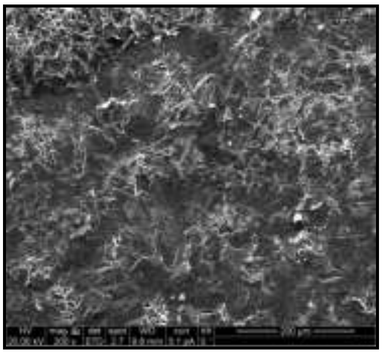

Fig 2 SEM Micrograph of as prepared ZnS thin film

Optical properties The optical properties of the film deposited on glass substrates were determined from the absorbance and transmittance measurement in the range of 300 – 800 nm. Fig 2 show the absorption and transmittance spectrum of as deposited thin film by Dip and Spin coating. Optical properties were studied by using a UV – Visible Spectrophotometer (JASCO Corp., V – 570). Figure. 3 shows the absorption and transmittance spectra ZnS thin films. It can be seen that the transmission of the film is greater than 60% for the wavelength values greater than the wavelengths that corresponds to optical band gap [12][13].

Absorbance coefficient α associated the strong absorption region of the film was calculated from absorbance (A) and the film thickness (t) using relation [14] [15]

$\alpha = 2.3026\ A/t$ (2)

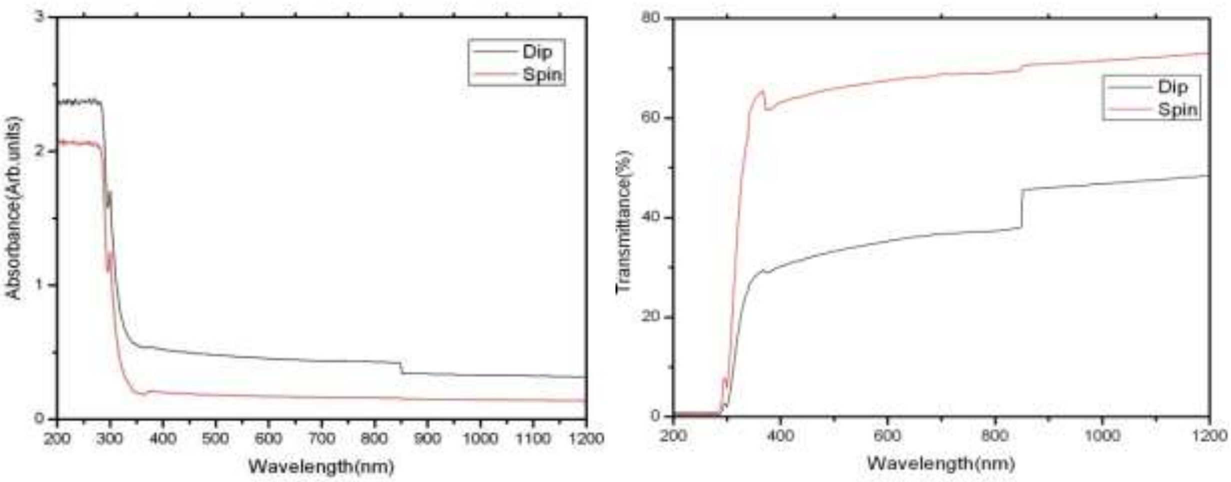

Fig 3 The Absorbance & Transmittance spectra of a as deposited ZnS thin film

The absorption coefficient α was analyzed using the following expression for optical absorption of semiconductors [16] [17]

$(\alpha h\upsilon) = K\ (h\upsilon - E_g)\ n/2$ (3)

Where k is Boltzmann's constant, E_g is separation between valence and conduction bands and n is constant that is equal to 1 for direct band gap semiconductor.

The band gap energy is obtained by extrapolating the straight line portion of the curve to zero absorption co-efficient. Fig 4 shows the band gap value of the as deposited ZnS was found to be 3.40 eV for both Dip and Spin Coating which is well matched with the band gap value (3.68 eV) for the bulk ZnS

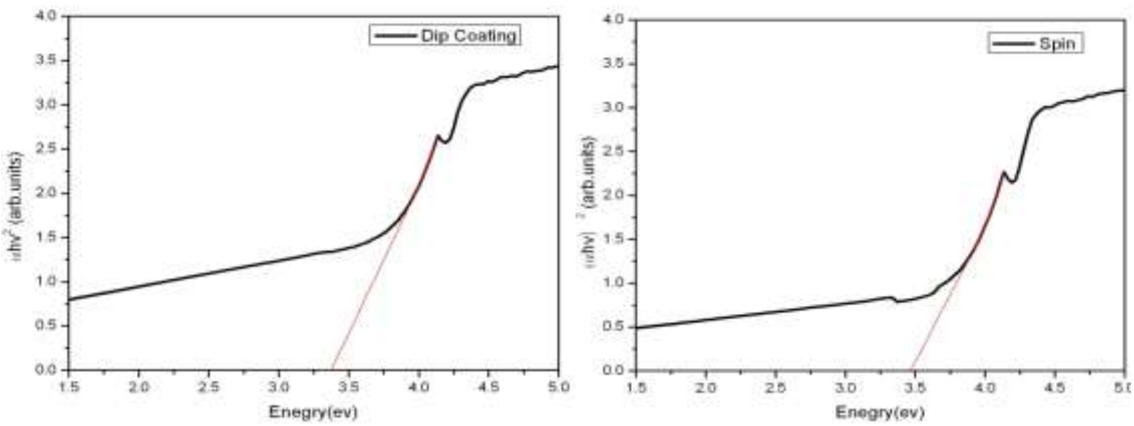

Fig. 4. Plot of (α)2 with respect to photon energy.

Conclusion

The goal of sol-gel processing is to provide nanoscale control over the structure of a material from the earliest stages of processing. Zinc Sulfide thin film can be deposited easily by a low temperature Dip and spin coating technique. Optical study shows that, films have high absorption co – efficient and band to band transition. The films are polycrystalline with hexagonal wurtzite structure. The major peak observed at 14.9^o corresponds to (004) crystallographic plane. The bandgap energy value of 3.45eV was on higher side compared to bulk value indicating quantum confinement.

Reference

1. Cattell A.F., Cullis A.G.: 'The variation in the luminescent and structural properties of sputter-deposited ZnS:Mn thin films with post-deposition annealing', Thin Solid Films, 1982,92, pp. 211–217
2. Porada Z., Osiowska E.S.: 'Surface electrical conductivity in ZnS (Cu, C1, Mn) thin films', Thin Solid Films, 1986, 145, pp. 75–79
3. Elidrissi B., Addoua M., Regragui M., Bougrine A., Kachouane A., Berne` de J.C.: 'Structure, composition and optical properties of ZnS thin films prepared by spray pyrolysis', Math. Chem. Phys., 2001, 68, pp. 175–179
4. V.Kumar, M.Saroja, M.Venkatachalam, S.Shankar.: 'Effect of growth temperature on structural and optical properties of hydrothermally grown ZnS thin films', International Journal of ChemTech Research, Vol.6, No.6, pp 3357- 3360, Aug-Sep 2014.
5. Rabah M., Abbar B., AL-Douri Y., Bouhafs B., Sahraoui B.: 'Calculation of structural, optical and electronic properties of ZnS, ZnSe, MgS, MgSe and their quaternary alloy Mg1_xZnxSySe1_y',Mat. Sci. Eng., 2003, B100, pp. 163–171
6. Monroy E., Omnes F., Calle F.: 'Wide-bandgap semiconductor ultraviolet photodetectors', Semicond. Sci.Technol., 2003, 18, pp. 33–51
7. A. Goudarzi, G.M. Aval, R. Sahraei, H. Ahmadpoor, Thin Solid Films 516 (2008) 4953.
8. Y. Fu, N.A. Allsop, S.E. Gledhill, T. K¨ ohler, M. Kr¨ uger, R. Sa´ez-Araoz, U. Block, M.C. LuxSteiner, C.H. Fischer, Adv. Energy Mater. (2011).
9. K. Catchpole, S. Pillai, J. Lumin. 121 (2006) 315.
10. I. Repins, M.A. Contreras, B. Egaas, C. DeHart, J. Scharf, C.L. Perkins, B. To, R. Noufi, Prog. Photovolt. Res. Appl. 16 (2008) 235.
11. J.A. Ruffiner, M.D. Hilmel, V. Mizrahi, G.I. Stegeman, V. Gibson, Appl. Opt. 28 (1989) 5209.
12. T. E. Manjulavalli, A. G. Kannan.: 'Structural and optical properties of ZnS thin films prepared by chemical bath deposition method', International Journal of ChemTech Research, Vol.8, No.11 pp 396-402, 2015.

13. Busarin Noikaew., Panita Chinvetkitvanich., Intira Sripichai., Chanwit Chityuttakan., 'The Influence of Growth Conditions on the Chemical Bath Deposited ZnS Thin Films' Journal of Metals, Materials and Minerals, Vol.18 No.2 pp.49-52, 2008
14. P. Vinotha Boorana Lakshmi., K. Sakthi Raj., K. Ramachandran.: 'Synthesis and characterization of nano ZnS doped with Mn ' Cryst. Res. Technol. 44, No. 2, 2009, pp 153 – 158.
15. A.Cottrell, Intorduction to Mettallurgy ,Arnold, Londan, 1975,P.173
16. R.S.Longhurst, Geometrical & physical optics ,Longmans green,Londan 1957.
17. Vipin Kumar , K.L.A. Khan ,G. Singh and T.P. Sharma , Appl .Surf. Sci., 2007, 7, 253
18. Raghad Zein, Ibrahim Alghoraibi.: ' Effect of Deposition Time on Structural and Optical Properties of ZnS Nanoparticles Thin Films Prepared by CBD Method', International Journal of ChemTech Research, Vol.6, No.5, pp 3220-3227, Aug-Sept 2014.

*****