Journal of Physical Sciences, Vol. 16, 2012, 171-175
ISSN: 0972-8791, www.vidyasagar.ac.in/journal
Published on 31 December 2012

Preparation of Zinc Sulphide thin Film by Spin Coating and their Characterization

***A. Mukherjee*[1] *and P. Mitra*[2]**

[1]Department of Physics, The University of Burdwan, Golapbag, Burdwan – 713104, West Bengal, India. e-mail: bu_pm@yahoo.co.in

[2]Department of Physics, The University of Burdwan, Golapbag, Burdwan – 713104, West Bengal, India. e-mail: mitrapartha1@rediffmail.com

Received October 19, 2012; accepted December 18, 2012

ABSTRACT

Polycrystalline zinc sulphide thin film was synthesized on quartz substrate by spin coating technique. Phase pure ZnS with hexagonal wurtzite structure was revealed from XRD. SEM micrograph shows formation of polycrystalline grains on the surface. The measured bandgap energy was ~3.70 eV and it was on higher side of the bulk value indicating quantum confinement due to lowering of particle size.

Keywords: Zinc sulphide, polycrystalline thin film, Spin coating

1. Introduction

Recent investigations have evoked considerable interest in ZnS thin films due to their vast potential for use in thin film devices such as photoluminescent and electroluminescent devices and more recently as *n*-type window layer heterojunction solar cells [1]. Zinc sulfide has found wide use as a thin film coating in the optical and microelectronic industries. The II-VI group of sulphides has distinctive features of high ionicity (compared to Si, Ge and III-V compounds), large band gap, and transparency in the visible region. Among the II-VI group of sulphides, zinc sulphide (ZnS) deserves a special mention because of its large optical band gap, in fact, the highest (~3.65 eV bulk band gap) among all II-VI compound semiconductors. Accordingly the synthesis and characterization of zinc sulphide via different techniques have attracted considerable attention. In producing ZnS, various techniques used includes sputtering [2], evaporation [3], chemical bath deposition (CBD) [1, 4], SILAR [5], sulfidation of oxide layer [6] and many others. In the present work, ZnS thin film was synthesized on quartz substrate by spin coating technique. The coated film was characterized to examine their physical properties.

2. Experimental

ZnS thin film was deposited precleaned quartz substrate. Zinc nitrate and thiourea were diluted with propanol and distilled water. The starting materials were of analytical grade. The mixed solution was stirred until a homogenous colorless solution was obtained. The ZnS thin film was prepared by spin coating and then transferred to programmable furnace and annealed at 400°C. Spin coating was performed in a programmable spin coater (Model No. SCU-2008C) at a spin speed of 4000 $r \cdot min^{-1}$ (rpm) for 60 seconds. The process was repeated several times to get a thin layer of the film.

X-ray diffraction (XRD) with CuK_α radiation ($\lambda = 1.5418$ Å) was used for structural characterization and phase identification of the deposited copper oxide films. Scanning electron microscopy (SEM) was used to illustrate the formation of crystallites on the film surface. EDX measurement was done to study the composition of the film. The optical absorbance at normal incidence was measured in a UV-VIS spectrophotometer (Shimadzu, UV-1800) at room temperature. The spectra were recorded by using similar quartz as a reference and hence the absorption due to the film only was obtained.

3. Results and Discussions

3.1 Structural characterization

Figure 1 shows the XRD patterns of ZnS film. The material was scanned in the range 20-60^o. Figure shows the presence of peak at 26.9^o. A faint peak appears at 46.55^o. The experimental peak positions were compared with the standard JCPDS files [7] and the Miller indices were indexed to the peaks. The major peak at 26.9^o corresponds to (100) crystallographic plane. The diffraction patterns reveal the films are genuinely polycrystalline with a hexagonal wurtzite structure. The observed broad hump in the XRD spectrum at 26.9^o indicates large FWHM (Full width at half maximum intensity) which in turn indicates the synthesized film contains particles with very small size.

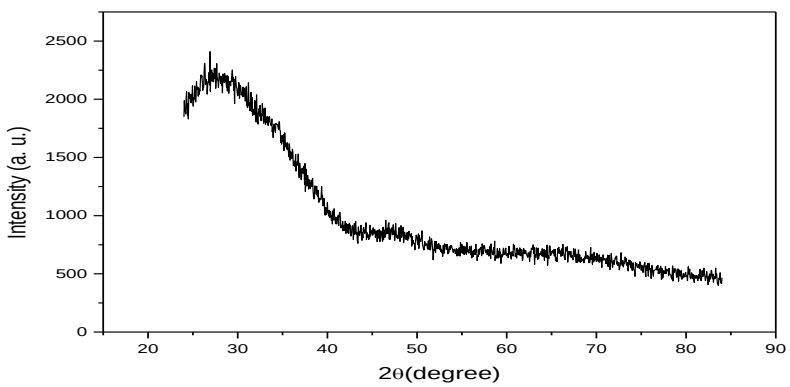

Figure 1: XRD pattern of ZnS film

The surface morphology of ZnS film was confirmed from scanning electron microscopy (SEM) image. Figure 2 shows the SEM micrograph of ZnS film. Prior to imaging, the films were sputtered with thin gold film to avoid charging. The formation of sub-micrometer crystallites distributed more or less uniformly over the surface is evident from the figure. Some holes indicating porosity and agglomeration of small crystallites also seem to be present in certain regions on the film surface.

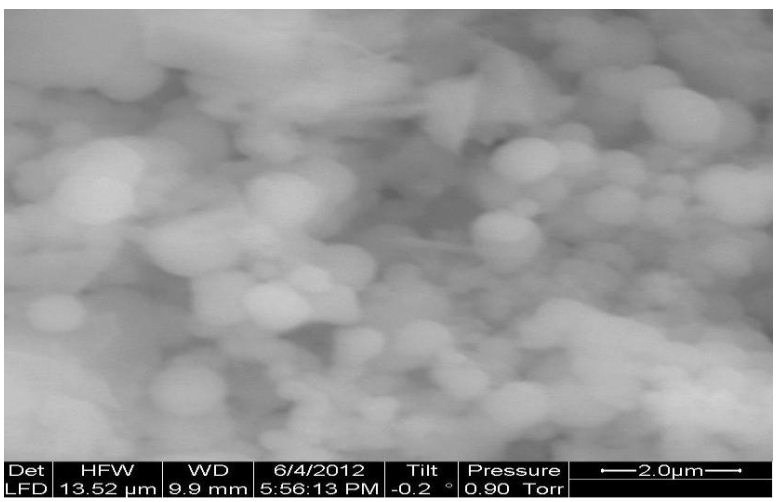

Figure 2: Scanning electron micrograph of ZnS film deposited on quartz substrate

Figure 3 shows the energy dispersive X-ray (EDX) spectrum of ZnS film. The spectrum reveals the presence of Zn and S elements in the deposited films. The silicon and oxygen signal appears from the substrate. Contamination of carbon impurity element was detected in the films.

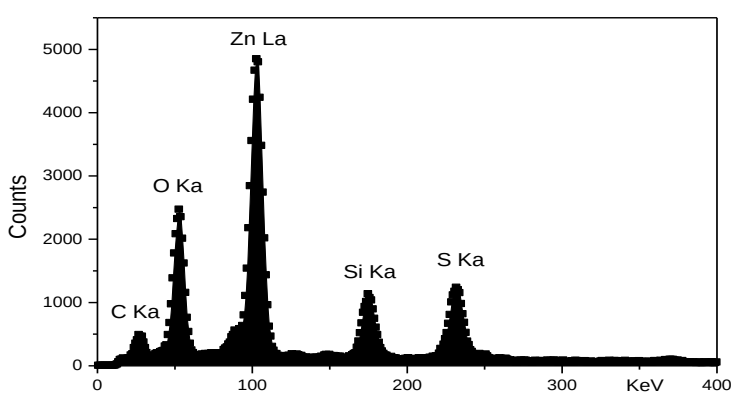

Figure 3: EDX spectrum of ZnS

3.3 Optical studies

The optical absorbance spectrum was measured in the wavelength range of 500–800 nm using a Shimadzu spectrophotometer (Model -1800). Theory of optical absorption gives the relationship between the absorption coefficients α and the photon energy $h\nu$ for direct allowed transition as

$$(\alpha h\nu)^2 = A(h\nu - E_g)$$

where A is a function of index of refraction and hole/electron effective masses**.** The direct band gap is determined using this equation when linear portion of the $(\alpha h\nu)^2$ against $h\nu$ plot is extrapolated to intersect the energy axis at α =0. Plot of $(\alpha h\nu)^2$ against $h\nu$ for ZnS film is shown in figure 4.

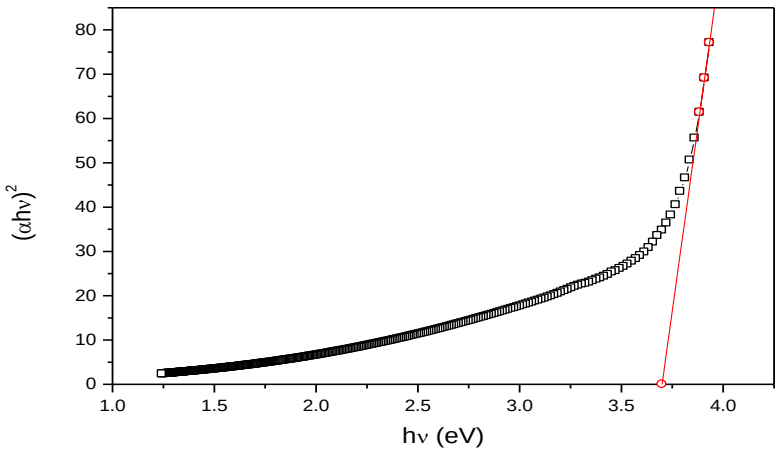

Figure 4: Plot of $(\alpha h\nu)^2$ versus $h\nu$ for ZnS

The value of optical band gap evaluated was 3.70 eV. This is on the higher side of that reported for bulk ZnS value of ~3.65 eV [8] indicating a shift in bandgap energy. Such shift might be due quantum confinement arising from lowering of particle size. This is supported from the broad hump observed in the x-ray spectrum.

4. Conclusions

We successfully prepared ZnS thin film through spin coating technique. The films are polycrystalline with hexagonal wurtzite structure. The major peak observed at 26.9^o corresponds to (100) crystallographic plane. The bandgap energy value of 3.70 eV was on higher side compared to bulk value indicating quantum confinement arising from lowering of particle size.

Acknowledgement. One of the authors (PM) would like to acknowledge CSIR (Council of Scientific and Industrial research, New Delhi, India) for supporting the work in the form of a research project [No. 03 (1195)/11/EMR-II].

REFERENCES

1. A. U. Ubale and D. K. Kulkarni, Preparation and study of thickness dependent electrical characteristics of zinc sulfide thin films, Bull. Mater. Sci., 28 (2005) 43-47.
2. T. G. R. Rawlins and R. J. Woodward, Sputtered zinc sulphide films on silicon, J. Mat. Sc., 7 (2012) 257-264.
3. A K Arora and A. Mansingh, The influence of manganese doping on I the optical properties of zinc sulphide films, J. Phys. D: Appl. Phys., 24 (1991) 1462-1465.
4. A Bayer, D. S. Boyle and P. O'Brien, In situ kinetic studies of the chemical bath deposition of zinc sulfide from acidic solutions, J. Mater. Chem., 12 (2002) 2940–2944.
5. B. Guzeldir, M. Saglam and A. Ates, Deposition and Characterization of CdS, CuS and ZnS Thin Films Deposited by SILAR Method, Acta Physica Polonica A, 121 (2012) 33-35.
6. Y. Kavanagh, Zinc sulfide thin films produced by sulfidation of sol–gel deposited zinc oxide, Thin Solid Films 398-399 (2001) 24-28.
7. Joint Committee of Powder Diffraction Standards, International Centre for Diffraction Data, Swartmore, PA (1995), Card No. 36-1450.
8. T. B. Nasr, N. Kamoun, M. Kanzari and R. Bennaceur, Effect of pH on the properties of ZnS thin films grown by chemical bath deposition, Thin Solid Films, 500 (2006) 4-8.