Volume : 5 | Issue : 10 | October 2016 • ISSN No 2277 - 8179 | IF : 3.508 | IC Value : 69.48

Original Research Paper

Physics

KEYWORDS : Spray pyrolysis, ZnS thin films, optical study

Temperature Dependence of Optical Band Gap and Thickness of ZnS Thin Films by Spray Pyrolysis

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ABSTRACT

The ZnS thin films were prepared by spray pyrolysis method. The spray pyrolysis is one of the most convenient, inexpensive and simple method for depositing semiconducting thin film. The thin film was deposited on plane Biological glass plate varying substrate temperature from 2500C to 3250C at the interval of 250C. The optimized deposition temperature is around 3000C. Thicknesses of the sample were calculated by Michelson interferometer. The optical absorption study reveals that ZnS is direct allowed transition of band gap energy is 3.02 eV matching with single crystal. Band energy decreases as temperature increases upto 300oC. Further increase temperature band gap energy increased. Reverse effect was observed in thickness as temperature increases.

Introduction

Zinc sulphide is II-VI group of semiconductor with a large direct band gap in the near UV-region. The wide band gap material used to prepare hetero-junction solar cell due to their greater open-circuit voltage and short circuit current [1]. ZnS is an important semiconductor material with large band gap (3.50 eV), high refractive index 2.35 at 630 nm, high effective dielectric constant. Its optical properties make it useful as a filter, reflector and plane wave guide [2]. Foreign atoms are generally contaminated in the lattice during the film preparation which can cause a considerable change in electrical and optical properties of semiconductor films, without causing a major change in crystal structures. However, heat treatment or annealing can reduce those types of defects considerably [3].

There are many techniques that have been used to prepare thin films. Among the various thin film deposition techniques, chemical spray pyrolysis technique is one of the principle methods to produce large area and uniform coating [4, 5, 6].

Preparation of Sample

Aqueous solution of 0.1 M Zinc sulphide and thiourea were used for spraying the films. Chemical were used as analytical reagent grade. The proportion of each solution was adjusting 1:2.2 by volume in the spraying mixture so as to obtain CdS thin films. Excess sulphur was necessary to obtain CdS thin films. The deposited films showed the sulphur difficiency when the ratio of solutions was taken 1:1 by volume. Excess sulphur in the form of thiourea were used to remove this deficiency [7, 8]. Thickness of the films was measured by Michelson-interfferometer. Transmission was taken on Shimadzu UV-1800 spectrophotometer.

Measurement of thickness

The films deposited at various temperatures were measured by Michelson-interferometer. The variation of thickness with substrate temperature is shown in figure 1. The thickness increases with increase in temperature and attain a maximum thickness at 3000C and then decreases further increase in substrate temperature. At lower temperature thickness estimated low [9]. At substrate temperature to increases further (>3000C) the film thickness decreases due to the higher evaporation [10].

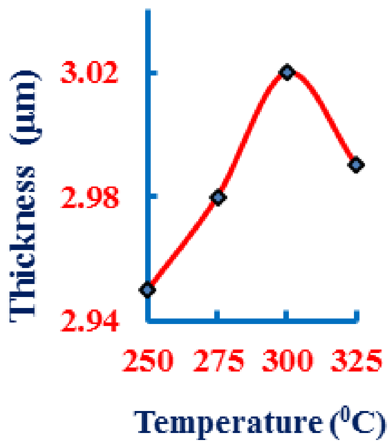

Fig.1 Temperature v/s thickness

Transmission study

The transmission T of the film was measured at room temperature on Shimadzu UV-1800 spectrophotometer. The variation in transmission with wavelength of incident beam was recorded for the wavelength range 350 nm – 900 nm for the different temperature. Figure .2 shows transmission 'T' vs wavelength 'λ' variation for the temperature (a) 2500C (b) 275 0C (c) 3000C and (d) 3250C.

The absorption coefficient α at various wavelengths for the sample of thickness't' is given by

$\alpha = 1/t \log (I0/I)$ (1)

where, I0 and I are intensities of the incident and the transmitted radiation respectively.

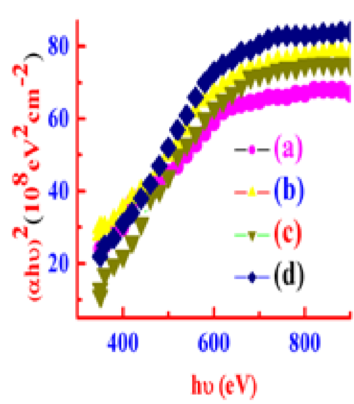

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Fig.2 Transmittance vs wavelength for variation of temperature a) 2500C, b) 275 0C,c) 3000C and d) 3250C of ZnS thin films

It was observed that onset of decrease of transmission toward the higher temperature sides. This indicates that decrease of optical band gap as temperature increases and at higher temperature > 3000C the optical band gap energy increases. The value of 'α' at various wavelengths was calculated from the each transmission curve. To calculate the band gap energy plotting (αhν)2 against hν. The curve is a linear. This linear relation indicates that direct allowed transition described by the relation,

$\alpha = 1/h\nu\ (h\nu - Eg)1/2$ (2)

is probably responsible for the absorption process.

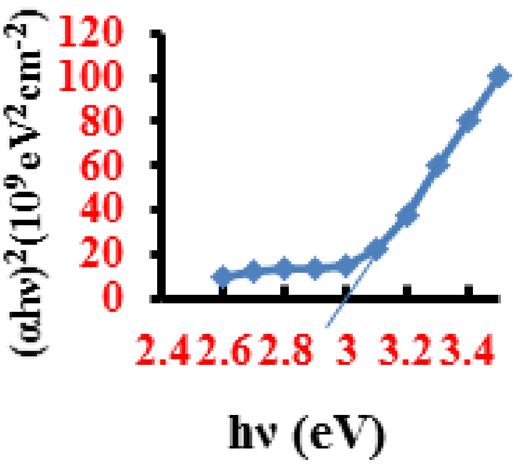

Fig 3. Plot graph between (αhν)2 v/s incident photon energy (hν)

The typical plot of (αhν)2 vs hν for the films of ZnS prepared at 3000C. From the graph band gap energy determined from extrapolated intercept on hν axis was 3.02 eV. Table 1 shows calculated band gap value and thickness for different temperature. This result agreed with the result obtained by other workers [11, 12]. Our calculated value of optical band gap are small with the reported by Pawan Kumar [13] by vacuum evaporated ZnS thin film who have reported the value of band gap 3.50 eV. Sawant et al [9] reported the similar for sprayed film of CdZn2S4. This shows that spray pyrolysis is a successful method for deposiying ZnS thin films.

Table.1 Calculated band gap energy and thickness for various temperature of ZnS thin films

Temperature (^{0}C)	Thickness (t) µm	Band gap (Eg) eV
250	0.1240	2.95
275	0.1390	2.98
300	0.1500	3.02
325	0.1290	2.99

Conclusion

The ZnS thin films prepared on glass substrates by spray pyrolysis method show a direct allowed transition. Optical gap decreases as temperature of the films increases. This shows the spray pyrolysis is a successful method for depositing ZnS thin films on glass substrates.

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