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Study of Optical Band Gap Energy of II-VI Solid Solution Thin Films of $CdZnS_2$ Prepared by Spray Pyrolysis

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Abstract: ***$CdZnS_2$ thin films were obtained by using aqueous solution of cadmium chloride, zinc chloride and thiourea each of 0.02 M on preheated glass substrate at 300^0C. The optical band gap were calculated from the plot of $(\alpha h\nu)^2$ verses hν was of 3.12 eV. The plot is a linear which shows the $CuInS_2$ thin films direct allowed transition.***

Keywords: ***Spray pyrolysis, $CdZnS_2$ thin films, optical study.***

1. Introduction

In recent years, much more attention has been shown in II-VI semiconducting compounds because of their opto-electronic properties and their possible applications in switching and memory devices, photo-diodes and solar cells. The reliability factor which is most important for device applications, can only the assured through a systematic study of the structural, electrical and optical properties of the deposited films. $CdZnS_2$ is the II-VI series of semiconducting compounds as it shows both n and p-type conductivity. These compounds is used to develop heterojunction solar cells. The development of low cost solar cells depends on the exploitation of the films and thusCdS, ZnS, CdSe, ZnSe, ZnTe, CdTe films prepared under various experimental condition.

There are number of method to prepare thin films such as, chemical bath deposition, flash evaporation, r.f. sputtering, vacuum evaporation, chemical vapour transport and chemical spray pyrolysis. We have chosen spray pyrolysis because it is cheap, inexpensive, easy to handle. The films produce on large substrate area. The preparation of thin films suitable for scientific studies and for many technological and industrial application.

In the present papers we have studied the optical properties and calculate the band gap energy from the optical transmission spectra. The evaluation of refractive indictes of optical material is of considerable importance for application in integrated optical devices such as, switches, filters and modulators,where the refractive index of a material is the key parameter in the design of a device.

There is no literature available for the data of optical parameter of $CdZnS_2$ thin films. Thus the aim of this study is to investigate the optical properties of $CdZnS_2$ thin films to calculate optical band gap energy of the films.

2. Experimental Details

Aqueous solution of cadmium chloride, zinc chloride and thiourea were prepared of 0.02 M of each in double distilled water. These solution are mixed in the proportion of 1:1:3.2 by volume and insert in the sprayer. The sprayer was mechanically move to and fro to avoid the formation of droplets on the pre-heated glass substrate and insure the instant evaporation from the substrate. The films shows the sulphur deficiency if the solution proportion were taken as 1:1:2 by volume. The temperature of the substrate was maintained at 300^0C and was measured by pre-calibrated copper constant thermocouple. Biological glass plate 1.33 mm thick was used as a substrate. The spray rate was maintained 3.5 ml/min at the pressure 12kg/cm^2. Optical transmission were taken on UV-1800 Shimadzu spectrophotometer. Thickness of the films were measured by weight difference method on unipan microbalance and Michelson interferometer. Thickness measured on both these method are same, only difference 0.003 μm was observed.

3. Optical Measurement

The optical transmission spectra of $CdZnS_2$ thin films were recorded on UV-1800 Shimadzu spectrophotometer at room temperature in the wavelength range 350 nm to 900 nm. Fig.1 shows transmission verses wavelength of as deposited thin films of $CdZnS_2$.

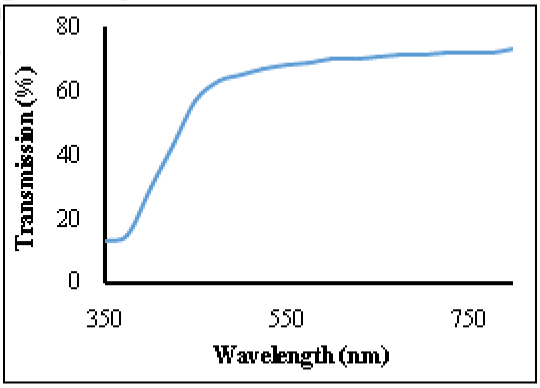

Figure 1: Transmission verses wavelength of as deposited thin films of $CdZnS_2$.

From the transmission spectra it was observed that the onset of decrease of transmittance gives the value of optical band gap.

The absorption coefficient 'α'at each wavelength calculated by using the relation,

$$\alpha = 1/t \ln (I_0/I) \quad (1)$$

Where t-thickness of the films, I_0 and I be the incidence and transmitted radiation respectively.

Figure 2 represent the reflectance verses wavelength of as deposited $CdZnS_2$ thin films.

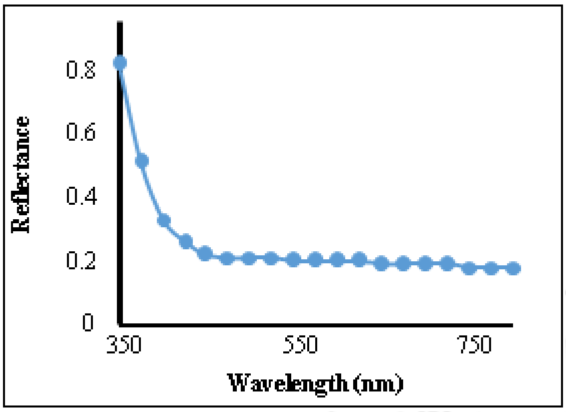

Figure 2: Reflectance (R) verses wavelength of as deposited $CdZnS_2$thin film

The absorption coefficient (α) is related to the optical transmission T and reflectanceR are each other by the relation (4)

$$T = (1-R)^2 \exp(-\alpha t)/1-R^2 \exp(-2\alpha t) \quad (2)$$

Equation (2) is valid in the vicinity of fundamental absorption edge, when $R^2 \exp(-2\alpha t) \ll 1$.The equation (2) is used to calculate the absorption coefficient (α).From the figure 2 it was observed that as the wavelength increases there is a sharp decrease in the reflectance. The onset of the decrease of reflectance gives the approximate value of band gap (5). Knowing the approximate region of band gap from reflectance curve, α is calculated by using equation (2), from the knowledge of T,R and t.

The relationship between absorption coefficient (α) and optical band gap is expressed to calculate the band gap of the semiconductors compounds by the relation (6),

$$\alpha = A/h\upsilon (h\upsilon - Eg)^n \quad (3)$$

Where A-the energy independent constant, Eg-the optical band gap, n-the constant which determined the type of optical transition.

To calculate the exact value of band gap energy, plotting the graph between $(\alpha h\nu)^2$ verses hvas shown in fig.3.

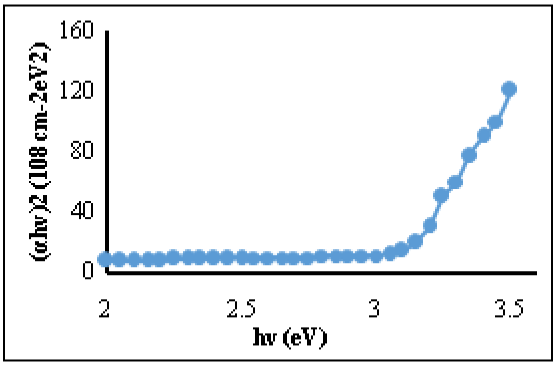

Figure 3: The graph between $(\alpha h\nu)^2$ verses hν of as deposited $CdZnS_2$ thin film

The straightline portion when extraplotted gives the value of band gap (Eg) was of 3.12 eV. The band gap energy thus obtained tally with the results obtained by salihailicanet al (7). They have reported the value of optical band gap was of 3.04 eV. Our calculated value gap also match with the value reported by Feng et al (8). $CdZnS_2$ thin films shows direct allowed transition. This shows that $CdZnS_2$ thin films shows a good stoichiometric in semiconducting nature.

4. Conclusion

Spray pyrolysis is a simple and inexpensive method to deposite thin films on large substrate area. From the study of reflectance and transmittance, the absorption coefficient were calculate which is of the order of 10^4 cm^2. The thin films of $CdZnS_2$ shows a direct allowed transition.

5. Acknowledgement

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