Original Research Paper

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Study of optical constants of II-VI solid solution thin films of $CdZnS_2$ prepared by spray pyrolysis

Physics

KEYWORDS: CdZnS2 thin films, spray pyrolysis, optical constant (n,k)

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ABSTRACT

CdZnS2 thin films deposited by spray pyrolysis by using aqueous solution of cadmium chloride, zinc chloride and thiourea of 0.02 M of each. The temperature of the substrate was maintained 3000C throughout the deposition. Optical band gap energy calculated from the plot of $(\alpha h\upsilon)2$ verses $h\upsilon$ was of 3.12 eV. It shows the direct allowed transition. The value of refractive index (n) and extinction coefficient (k) decreases with the increase of wavelength. It indicates that the value of n and k obtained by this method are suitable for many scientific studies and technological applications such as, gas sensors, heat mirrors, transparent electrodes, solar cells and piezoelectric devices.

Introduction: - II-VI ternary compound is a most important due to their use to fabrication uptoelectronic devices such as solar cells. Zinc and cadmium is the chacogenides are proming for improving II-VI semiconductor based device performance. CdS is attracting a lot of attention due to their potential application in producing photovoltaic devices and wide use in IR devices. CdS is a semiconductor that has been considered attractive for use of developing/fabricating the heterojunction photovoltaic solar cells. Whereas ZnS is a very important material for luminescent and light-emitting devices (1). Both CdS and ZnS have the band gap energy lies between 2.47 eV to 3.04-3.12 eV (2,3). The development of low –cost solar cells depends on the exploitation of films and thus CdS, CdSe, ZnS, ZnSe, CdTe films obtained under various experimental condition require comprehensive electrical characterization (4).

In the literature available we have not found data for optical parameters of $CdZnS_2$ thin films. Thus the aim of this study is to investigate the optical properties of $CdZnS_2$ thin films and calculate the optical constants such as, refractive index, extinction coefficient. In the optical study, it is possible to determine the direct and indirect allowed transition which occurring in the band gap of the material from the transmission spectra. The transmittance data help to determine the optical constants. The refractive index of a material is the key parameter in the design of a device.

There are different method to produce a thin films such as, vacuum evaporation, chemical vapour transport, r.f. sputtering, flash evaporation, epitaxial method and chemical spray pyrolysis. We have chosen spray pyrolysis method. It is a attractive method because of its simplicity, inexpensive and cheap to produce a thin films on large substrate area.

Experimental Details: - Thin films of $CdZnS_2$ were prepared by using aqueous solution of cadmium chloride, zinc chloride and thio-urea. The molarity of each solution was of 0.02 M. Chemical were used as AR-grade. The solution prepared in double distilled water. Biological glass slides of 1.33 mm thick were used as a substrate. The temperature of the substrate was maintained at 300^0C which was measured by pre-calibrated copper constantan thermocouple. These three solutions were mixed in one in the proportion 1:1:3.2 by volume. The films shows a sulphur deficiency [2, 3] if the solution of proportion were taken as 1:1:2 by volume. The sprayer was mechanically move to and fro to avoid the formation of droplets on the glass substrate and insure the instant evaporation of the substrate. A continuous films is formed on pre-heated glass substrate by thermal decomposition of the material of the droplets [5]. The Spray rate was maintained 3.5 ml/min and kept constant throughout the experiments at pressure 12 kg/cm^2. The thickness of the deposited films was measured by Michelson interferometer and weight difference method using unipan sensitive microbalance. Transmission spectra were recorded on UV-1800 Shimandzu Spectrophotometer. Details experimental set-up were described elsewhere [3].

Results and Discussion: - The transmission spectra of as deposited $CdZnS_2$ thin films were taken at room temperature in the wavelength range 350-900 nm. Fig.1 shows the transmission verses wavelength of as deposited $CdZnS_2$ thin films prepared at 300^0C.

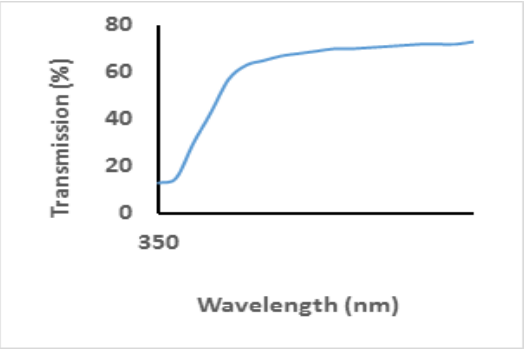

Fig.1 transmission verses wavelength of as deposited thin films of $CdZnS_2$

From the transmission spectra the absorption coefficient were calculated by the relation,

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

Where t-the thickness of the films, I_0 and I be the intensity of incidence and transmitted radiation respectively.Figure.2 represent the reflectance spectra verses wavelength of as deposited $CdZnS_2$ thin films.

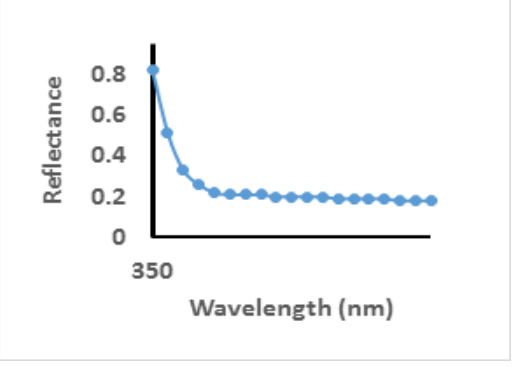

Fig.2 Reflectance (R) verses wavelength of as deposited $CdZnS_2$. thin film

To calculate the optical band gap energy, plotting the graph between $(\alpha h\upsilon)^2$ verses $h\upsilon$. The plot shows the linear portion which extrapolated on energy axis gives the value of band gap energy was of 3.12 eV. Our results are well agree with saliha Ilican et al (7) who have reported the value of band gap 3.04 eV. The refractive index was obtained from the relation [7],

$n = 1+R/1-R + [4R/(1-R)^2 - k^2]^{1/2}$ (2)

Where k-is the extinction coefficients which is related to the absorption coefficients and the wavelength as,

$k=\alpha\lambda/4\pi$ (3)

The value of refractive index and extinction coefficients (k) were calculated using above relation (2) and (3). Then plotting the graph between refractive index verses wavelength (fig.3) and graph between extinction coefficients (k) verses wavelength (fig 4).

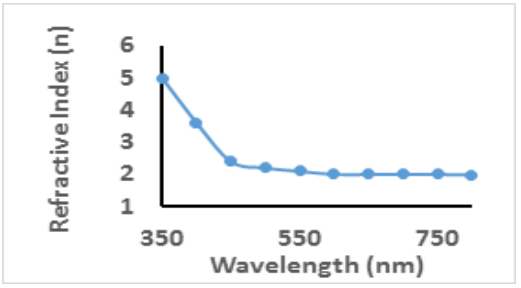

Fig. 3 The refractive index verses wavelength of as deposited $CdZnS_2$ thin film

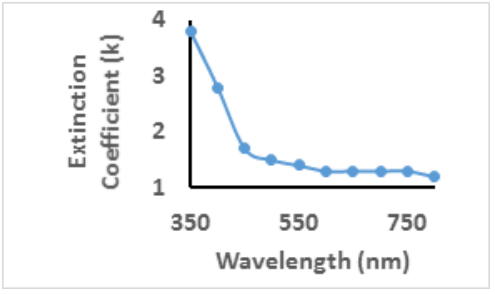

Fig.4 The extinction coefficients (k) verses wavelength of as deposited $CdZnS_2$ thin film

It was observed that refractive index (n) and extinction coefficients (k) both decreases as wavelength increases. Our calculated value of n and k are well agree with the results reported by Soliha Ilican et al (7) for spray pyrolytically deposited CdZn $(S_{1-x}Se_x)_2$ thin films. They stated that the values of optical constants obtained which are suitable for many scientific studies and technological applications such as, sensors, heat mirrors, transparent electrodes, solar cells and piezoelectric devices.

Conclusion: - $CdZnS_2$ thin films have been deposited by spray pyrolysis method at 300^0C substrate temperature. Optical band gap energy value was of 3.12 eV which shows the $CdZnS_2$ thin films has a direct allowed transition. The value of refractive index (n) and extinction coefficients (k) decreases with wavelength increases. This shows that the it was use in many scientific studies and technological application.

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