THE EFFECT OF ZN COMPOSITION ON OPTICAL AND STRUCTURAL PROPERTIES OF CDZNS THIN FILMS PREPARED BY SPRAY PYROLYSIS TECHNIQUE

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ABSTRACT

In this paper we report the study of CdZnS thin films deposited on glass substrate by spray pyrolysis technique at 350^0C temperature. The effect of Zinc content on structural, morphological and optical properties have been studied. CdZnS thin films of different thickness were characterized by X-ray diffraction, Scanning electron microscopy and UV-VIS spectrophotometer in the wavelength range 380-1000 nm. From X-ray diffraction patterns the hexagonal structure of these films was confirmed. From reflectance and transmittance studies the band gap was calculated. Optical absorption measurements indicated that the band gaps of CdZnS thin films increased from 2.42 to 2.89 eV with increasing Zn content. Transmission spectra show the blue shifting of absorption edge as the Zn content increased. The $(\alpha h\upsilon)^2$ versus photon energy $(h\upsilon)$ curves shows tuning of band gap with Zn content. The effect of Zinc content on refractive index and other optical properties were also investigated. The sulphides of cadmium and Zinc are widely used materials due to their suitable energy band gaps. Optical band gap estimation that materials prepared are nano-materials

Keywords: Thin Film, Spray Pyrolysis Technique, Optical band gap, XRD, SEM

1. Introduction

There is a great interest to study the optical and structural properties of nanometer sized semiconductor particle[1], which show a significant difference from bulk materials. The synthesis and characterization of nanoparticles of cadmium and zinc chalcogenides have become an area of intense research activity over the last few years[2-5]. II-IV semiconducting compounds, especially CdS, CdSe, CdZnS etc., are of great interest because they are potential candidates in many practical applications such as optical detectors[6], field effect transistors[7], optoelectronic devices[8-9], and solar cells[10-12].The band gap of CdZnS varies in the range of 2-42-to 3-6 eV as Zinc contest increases [13] . CdZnS provides a wider band gap and higher optical transmittance as compared to CdS; both of these properties are essential in solar cell applications. The higher transmittance and wider optical band gap reduces the window absorption losses. Therefore CdZnS thin films may be used as an ideal alternative material to CdS and ZnS[14].In the present work CdZnS thin films were prepared by spray pyrolysis technique with different Zn concentrations and the effect of Zn doping on the structural, morphological, & optical of CdS thin films was investigated[15].Cadmium Zinc Sulphides have properties in between CdS and ZnS. Addition of Zn to the most widely used CdS buffer layer material enhances the optical properties of optoelectronic devices. The CdZnS thin film has a larger energy gap than CdS. This makes the material much more attractive for the fabrication of solar cells. CdZnS thin films are prepared for comprehensive optical studies and their various applications[16]. CdZnS is the best material for the window layer in the fabrication of p-n junction solar cells without lattice mismatch in the devices based on quaternary materials like CuInx Ga $_{1-X}$ Se2 [17].

Interest in the CdZnS thin films has developed because it gives the better photovoltaic solar cell performance rather than currently used cadmium sulphide. There are various similar chemical properties in ZnS and CdS. The CdS is replaced with the ternary alloy CdZnS of high energy band gap. The Aim of this work is to stury effect of Zn an optical and structural properties of CdZnS thin films for solar cell application[18]. Wide band gap and high absorption coefficients make these materials potential candidates for solar cell and optoelectronic applications [19-20].

2. Experimental

In this study CdS thin films doped by Zn on glans substrate have been deposited with using the Chemical Spray Pyrolysis technique. Chemical spray pyrolysis is an easy and cheap that is based on spraying the solution to the surface under a certain substrate temperature and that can be obtained good crystal structures. In this study, substrates have been cleaned with acetone. Prepared solutions have been sprayed on the substrate at 350^0C as 1-2 ml per minute[21]. The glass substrates are washed in soap solution by scrubbing the surfaces with the cotton swab dipped in liquid soap till they pass the breathe figure test to remove oil, grease etc. The glass slides are then rinsed thoroughly in deionized water to remove any traces of the soap solution left on the surface.Then the substrates are soaked in chromic acid and heated to about one hour to dissolve the fine silica layer formed on the surface and to make a new surface for deposition of the film.Finally the substrates are rinsed thoroughly in deionized water and dried with acetone. Now the glass substrates are ready for the deposition of the films.

3. Results and Discussion

The X-ray diffraction patterns of Zn- doped CdS thin films deposited are shown in Fig. 1. From the pattern it is clear that the film is polycrystalline in nature. Fig. 2 shows the SEM image of CdZnS thin films coated with Zn concentration [15]. The average grain size (g) has been obtained from the XRD pattern using Debye-Scherrer's formula [16, 22-24].

$$g = \frac{K\lambda}{\beta \cos\theta}$$

Where K = constant taken to be 0.94

λ = wavelength of X-ray used ($1.542A^0$)

β = FWHM of the peak and

θ = Bragg's Angle ,The average grain size of CdZnS thin films was found in the range of 27 nm-81 nm.

UV-Visible Spectroscopy :

The spectrophotometer was used to record transmittance and absorbance as a wavelength function of the sample [25]. To calculate the optical band gap energy, first of all we convert the wavelength into meter from nm. Then the absorbance (A) was calculated from the percentage transmittance (T%) by using the relation given in equation (1)

$$A = \log(100/\%T) \text{ ---------- } (1)$$

The band gap energy of the films was calculated by using Tauc's relation [26].

$$\alpha h\upsilon = A(Eg - h\upsilon)^m \text{ ----------- } (2)$$

Where A is a constant and m is ½ for direct band gap materials, Eg is a band gap energy, h is a plank's constant and υ is the incident radiation frequency.The absorption coefficient (α) measured from the absorbance (A) and thin film thickness (t) is given in the equation (3). The thin film thickness was measured by weight difference method.

$$\alpha = (1/t)\ln[100/\%T] \text{ ------ } (3)$$

Then the factor $(\alpha h\upsilon)^2$ was calculated. Finally, the graph was drawn between E (eV) on X-axis and $(\alpha h\upsilon)^2$ on Y-axis to measure the band gap energy. The band gap increases as we increase the Zn concentration. The linear portion of the graphs show that the CdZnS is a direct band gap semiconductor material [18]. The band gap Eg was calculated from absorbance data by plotting $(\alpha h\upsilon)^2$versus $h\upsilon$ and then extrapolating the straight line portion to the energy axis at α=0. The band gap energy Eg obtained for each Zn content at different. For higher Zn content, the band gap is 2.89 eV and the lower Zn content, it is 2.42 eV. The band gap of other film is intermediate [16]. Fig (3b) shows the optical transmission spectra versus wavelength of nanocrystalline CdZnS thin films for various values of X- different concentration of Zn content. It can be seen that; the CdZnS films show transparency above 75% in the visible region of light and the transmission increases with the increasing of X content, this transmittance makes this material useful as buffer layer for solar cells[27]. The blue shifting of absorption edge indicates that the prepared films exhibit low absorption in the blue region. The lower absorption in the blue portion leads to the conclusion that the absorption of short wavelength photon may be reduced and absorption losses in CdZnS thin films prevented[14].Fig. (3b) is the plot of transmittance versus wavelength. The transmission curves show the blue shifting of absorption edge(approximately from 450-350 nm).[28] From Fig.(3b) it is clear that, the optical transmittance is maximum in the visible region(450-800 nm).Moreover, a CdZnS thin films which has the most transmittance and highest band gap is thought to be the suitable structure to others for solar cells [21].

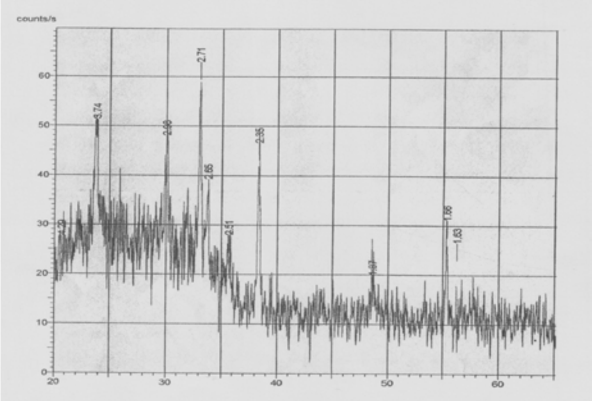

Fig .1. X Ray Diffraction of CdZnS Thin film

Fig .2a. SEM of CdZnS Thin film

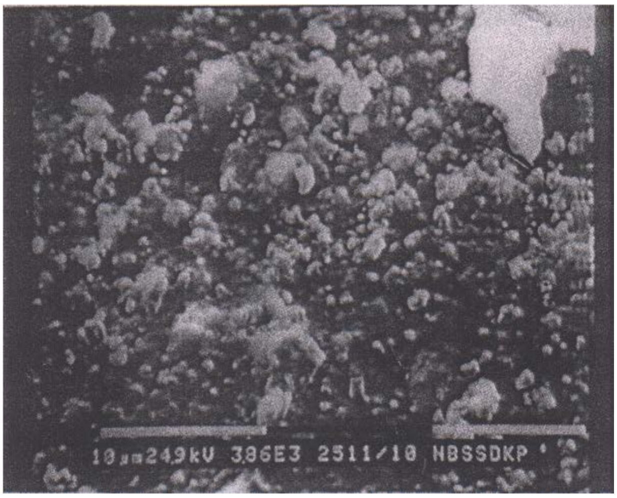

Fig .2b. SEM of CdZnS Thin film

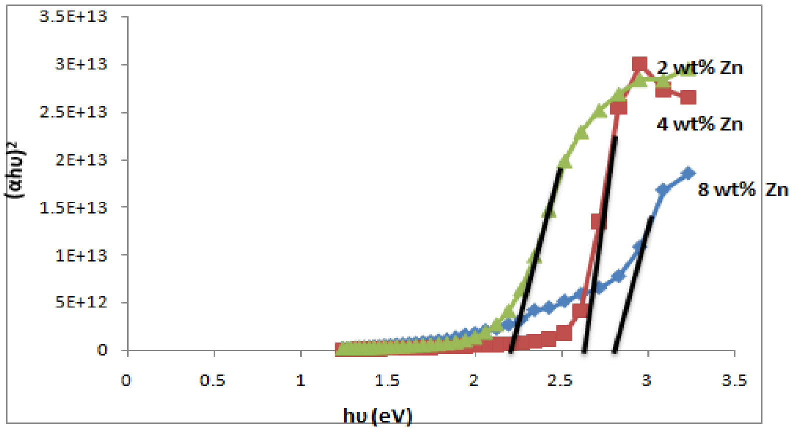

Fig. 3(a) Photon energy hυ vs (αhυ)²

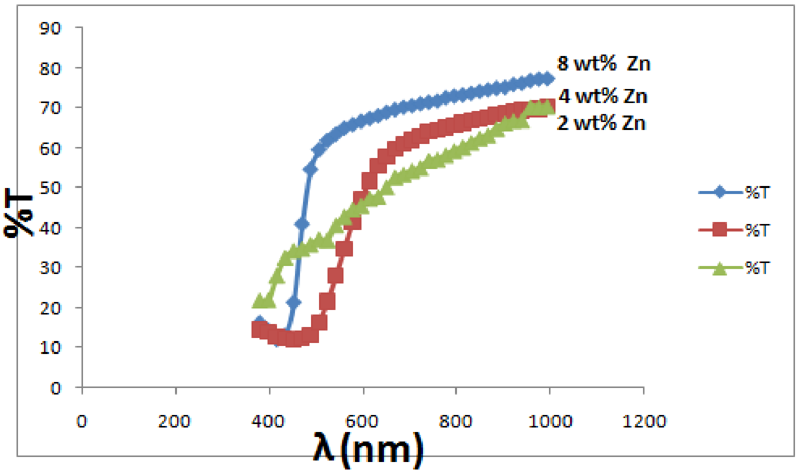

Fig. 3(b) Transmission spectra of CdZnS Thin Films

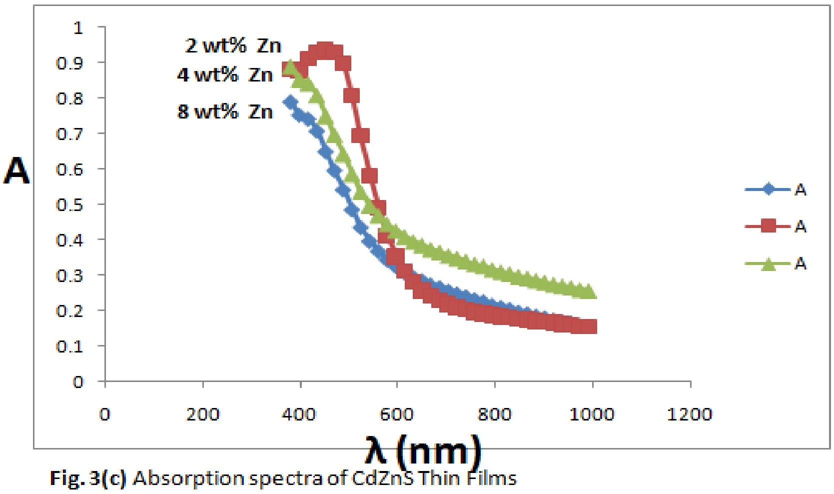

Fig. 3(c) Absorption spectra of CdZnS Thin Films

4. Conclusions:

CdZnS thin films with different Zn concentration were deposited on glass substrate by spray pyrolysis technique at 350 ^{0} c temperature. Film showed hexagonal crystal structure . The band gap values of CdZnS thin films lie in the range of 2.42-2.89 eV. CdZnS structures are thought to have the highest band gap and transmittance and it is more suitable for solar cell application.It was concluded that ,Zn content changes the optical properties of the CdZnS thin films.The films of composition X=0.8 gives maximum 78% transmittance. The maximum transmittance indicate that the prepared thin films are antireflective.The film composition X=0.8 shown maximum 2.89 eV band gap. The SEM study confiems that even though Zn content was low, it effectively changes the microstructures CdZnS thin films.

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