Influence of Se doping on Optical Properties of CdS Thin Films Grown by Closed Space Sublimation Technique

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ABSTRACT

In present work the thin films of $CdS_{1-x}Se_x$ have been deposited on glass substrates by thermal evaporation technique. The crystal parameters, surface topology, optical band gap and photo sensing coefficient of grown films were studied with the help of XRD, AFM, UV-VIS and Photo sensing experiment respectively. The XRD investigation indentified the grown films are polycrystalline. The crystal structure is orthorhombic in shape having preferential orientation along (040) plan. The surface roughness of the grown samples was determined by AFM study. The optical band gap of the films has been studied by using by using UV-VIS spectrophotometer and it is found to be 2.3-2 eV. The photo sensing coefficient was determined by photo sensing experiment.

Keywords: *XRD, AFM, UV-VIS, Photo Sensing.*

1 INTRODUCTION

The chalcogenide materials from II–VI group especially CdS:Se are very important because of wide range of applications in opto-electronics devices and PV modules. It has optical band gap of 2.2 eV [1]. The structural, optical and electrical properties of the material can be altered by changing the chemical concentrations. The optical band gap of CdS can be very within the range of 1.7 – 2.4 eV with respect to Se concentrations [2]. The CdS:Se alloy has wide range of industrial applications because of its optical and mechanical properties. Commercially, it can be used for solar cells and PV modules [3], infrared photo-detectors [4], holography, optical waveguides and temperature sensor [5-7]. $CdS_{1-x}Se_x$ thin films can be obtained by different techniques such as chemical bath deposition (CBD) technique [8, 9], laser ablation technique [10] and vacuum evaporation [11].

In present work the influence of Se on CdS thin films is studied. The films were deposited by close space sublimation technique. The deposited samples were characterized for crystal parameters, surface topology, optical band gap and photo sensing coefficient by XRD, AFM, UV-VIS and Photo Sensing experiment.

2. EXPERIMENTAL

The alloy of CdS, $CdS_{0.8}Se_{0.2}$, $CdS_{0.6}Se_{0.4}$ were obtained by melt quench method by taking appropriate amount of pure CdS and Se in an evacuated quartz ampoule with their appropriate atomic proportions. The ampoule was heated about 1000 °C for 12 hrs and then quenched in an ice bath. The $CdS_{1-x}Se_x$ ingot was taken out from the ampoule and made into fine powder and used for thin film preparation.

The thin films of CdS, $CdS_{0.8}Se_{0.2}$, $CdS_{0.6}Se_{0.4}$ were grown by close space sublimation technique under similar conditions. The distance between source and substrate was kept about 14 cm. The thickness of the growing samples was monitored on Digital Thickness Monitor (DTM-101) provided by Hind-Hi Vac. The deposition rate was maintained 8-10 Å/sec throughout sample preparation. Before evaporation, the glass substrates were cleaned throughout using detergent, chromic acid and acetone.

3. RESULTS AND DISCUSSION

The X-ray diffraction patterns of CdS, $CdS_{0.8}Se_{0.2}$, $CdS_{0.6}Se_{0.4}$ thin films with same thickness are shown in Fig 1. The XRD patterns confirm that plan of reflection are appears at 25.3° and 27.8°. The XRD pattern of the sample reveals that all the peaks are well matches with standard JCPDS data. The corresponding reflecting planes are (040) and (420). The dominant peak (040) is at 25.3° 2-Theta. From the XRD pattern the crystal structure is found orthorhombic in shape. The presence of multiple peaks shows the polycrystalline nature [12-17]. The average crystalline size (D) was calculated by using the Scherrer formula:

$$D = \frac{0.94\,\lambda}{\beta\cos\theta}$$

Where, λ is the wavelength of X-ray, β is Full Width Half Maxima, θ is the detraction angle. The crystal size was found 335 nm, 251 nm and 278 nm for CdS, $CdS_{0.8}Se_{0.2}$, $CdS_{0.6}Se_{0.4}$ thin films respectively. The unit cell parameters a, b and c are found to be 14.31, 14.07 and 14.56 respectively.

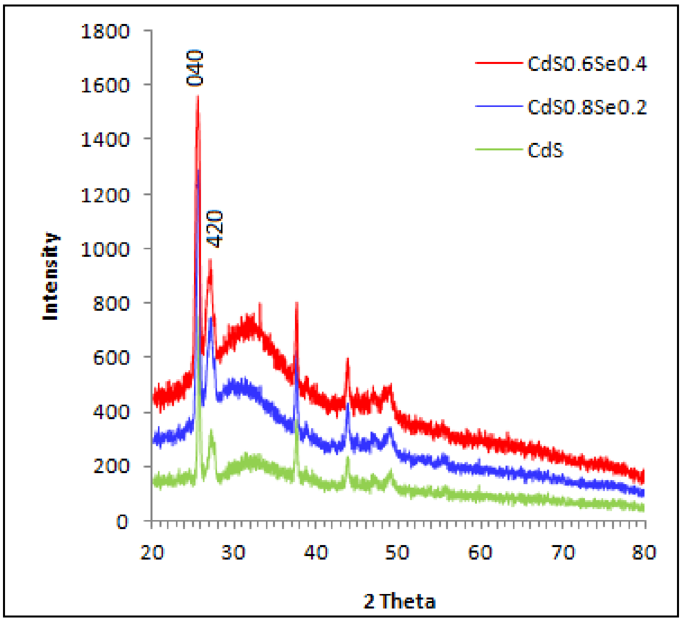


Fig 1: XRD Pattern of CdS:Se Thin Films

The surface topology of grown CdS:Se thin film was studied through AFM images. Fig 2, 3, 4 shows 3-D AFM images for CdS, $CdS_{0.8}Se_{0.2}$, $CdS_{0.6}Se_{0.4}$ thin films respectively. The micrograph reveals the film covers the substrate very well and is free from any type macroscopic defects like cracks and peeling. The grains almost uniformly distributed. The grains are closely bound together, thus obtaining a homogeneous surface. The image shows grains have elongated morphology of various sizes. The average roughness are found 6.08, 0.79, 41.64 nm for CdS, $CdS_{0.8}Se_{0.2}$, $CdS_{0.6}Se_{0.4}$ thin films respectively.

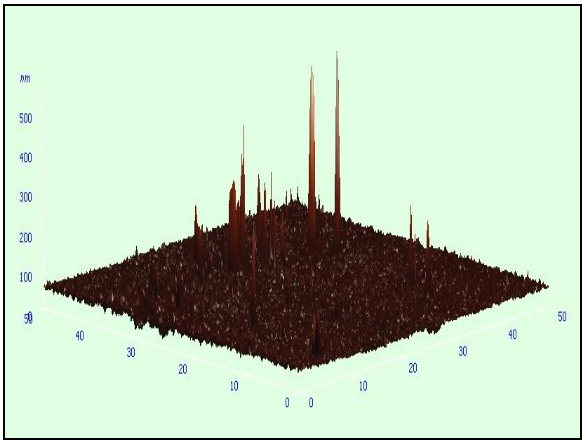


Fig 2: AFM Pattern of CdS Thin Films

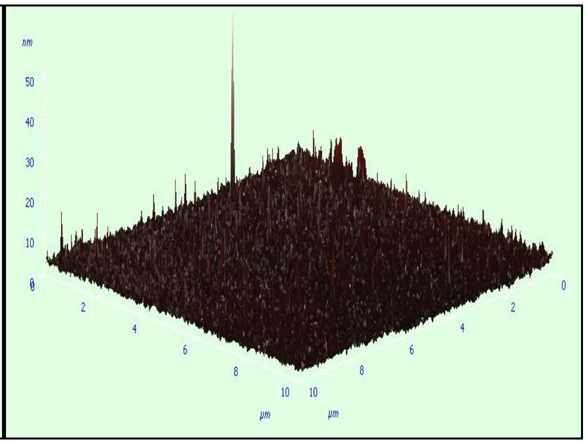


Fig 3: AFM Pattern of $CdS_{0.8}Se_{0.2}$ Thin Films

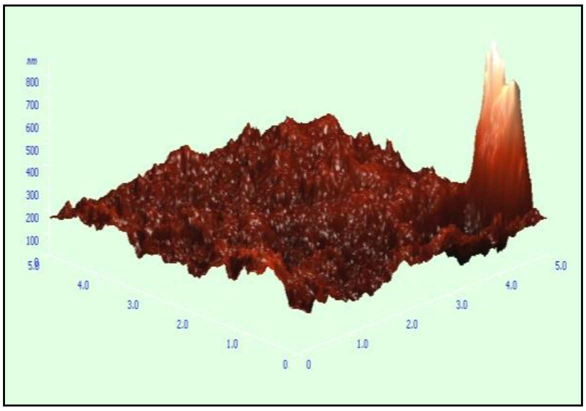


Fig 4: AFM Pattern of $CdS_{0.6}Se_{0.4}$ Thin Films

The optical band gap was studied by using UV-VIS spectro-photometer. The absorbance and transmittance pattern for CdS:Se were recorded within 300-900 nm wavelength range. The fig 5 and 6 shows optical absorbance and transmittance spectrum for $CdS_{1-x}Se_x$ thin films (where x = 0, 0.2, 0.4) respectively.

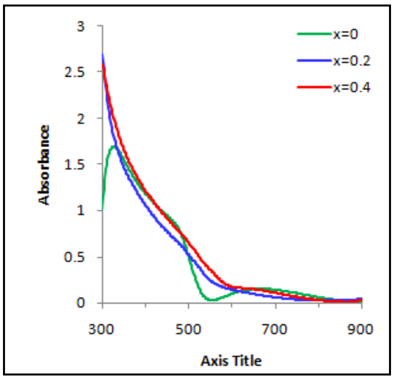


Fig 5: Absorbance Pattern

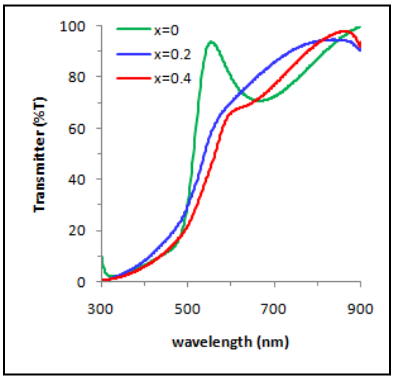


Fig6. Transmittance Pattern

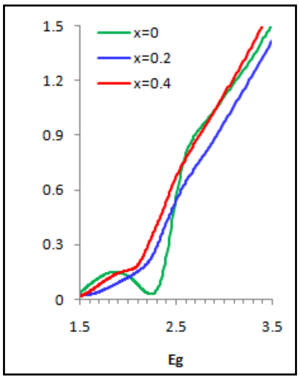


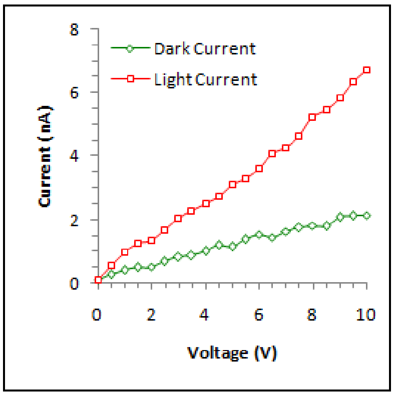
Fig. 7 Band Gap Patten

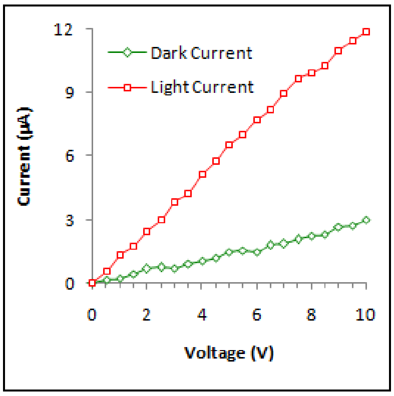
The absorbance coefficient is influenced with Se concentration. The higher absorbance is noticed within the 300 – 350 nm wavelength regions. As absorbance increases then transmittance decreases. The transmittance is found above 60% to about 90%. Hence CdS:Se can be used as a window material in development PV modules and solar cell. The optical band gap of the grown thin films were calculated 2.3, 2.1 and 2 eV for $CdS_{1-x}Se_x$ thin films (where x = 0, 0.2, 0.4) respectively [13, 14].

Photo sensing coefficient is useful for fabrication of optical devices and PV modules. Fig. 8, 9 and 10 shows the I-V plots of CdS, $CdS_{0.8}Se_{0.2}$, $CdS_{0.6}Se_{0.4}$ thin films respectively. I-V plot was obtained at room temperature under the dark condition and under the light condition. The figures shows the improvement in current with respect to the voltage for both dank and luminance conditions. From the I-V plots it is observed that the recorded current in the presence light was relatively higher than the current measured in dark condition. It is know that the incident light excites the valence electrons, which in turn move across the energy band gap. This process creates electron – hole pairs and the observed current depends upon the number of charge carriers [18]. Usually, photosensitive materials show increase in photocurrent on exposure to light. Photo sensitivity of grown thin films calculated by [19]:

$$S = \frac{I_l - I_d}{I_d}$$

Where I_l is the light current and I_d is dark current. The photo sensitivity of grown CdS thin films is calculated 1.25 , 3.36, 0.78 for of CdS, $CdS_{0.8}Se_{0.2}$, $CdS_{0.6}Se_{0.4}$ thin films respectively.





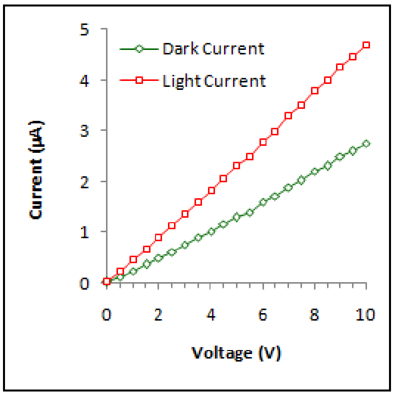


Fig 8: CdS Thin Film Fig 9: $CdS_{0.8}Se_{0.2}$ Thin Films Fig 10: $CdS_{0.6}Se_{0.4}$ Thin Films

4. CONCLUSION

The thin films of $CdS_{1-x}Se_x$ have been deposited by closed space sublimation technique. The XRD investigation reveals that grown films are polycrystalline. The crystal structure is orthorhombic in shape having preferential orientation along (040) plan. The surface roughness of the grown samples was determined by AFM study. The optical band gap of the grown films has been calculated within range of 2.3 to 2 eV by using UV-VIS spectrophotometer. The photo sensing coefficient was determined by photo sensing experiment.

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