

ENERGY BAND GAP AND CONDUCTIVITY MEASUREMENT OF CdSe THIN FILMS

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Thin film of CdSe has been deposited onto clean glass substrate by using vacuum evaporation technique. This thin film is characterized through the XRD, which indicates that film is polycrystalline in nature and having preferred orientation along (002) plane in c-direction. Absorption spectra of this thin film has been recorded using spectrophotometer. The energy band gap has been determined using these spectra. It is found that energy band gap of CdSe film is 1.67 eV. The conductivity of this thin film has been determined by I-V measurement using the electrometer. It is observed that the conductivity increases with the increase of temperature. This is due to the increase of grain size and removal of defects, which are present in the film. Activation energy of this film is also determined.

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1. Introduction

Among chalcogenide semiconductors, II-VI compound chalcogenide semiconductors have drawn interest of many researchers because they find applications in the solid-state physics. II-VI compound semiconductors have the band gap between 1-3 eV in the visible region and these semiconducting materials are used worldwide in optoelectronic devices. CdSe is one of such compound in this group and its physical properties have been constantly investigated during recent years for both fundamental and practical aims. Its interesting properties make the material suitable for many potential applications in a variety of solid state devices such as solar cells, high-efficiency thin film transistors, light-emitting diodes, electron-beam pumped lasers and electroluminescent devices, etc [1].

In recent years, major attention has been given to the investigation of electrical and optical properties of CdSe thin films in order to improve the performance of the device and also for finding new applications [2-6]. These properties of CdSe are very sensitive to deposition conditions and to the technique used. Therefore, the study of the properties of CdSe with respect to different growths as well as ambient conditions is a matter of high importance. CdSe thin film has been prepared using a variety of methods including sputtering, spray pyrolysis, electrodeposition [7-10]. Thermal evaporation under high vacuum is very convenient method for obtaining uniform film under different deposition parameters. In view of this, an effort has been made to study the optical and electrical properties of CdSe thin films prepared by vacuum evaporation.

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2. Material preparation

In the vacuum of 2×10^{-5} Torr, the thin film of CdSe has been deposited on clean glass substrate to keep the substrate at room temperature. The obtained films were heated in the same vacuum chamber at 75 °C temperature for ten minutes for reduction of lattice defects and better adhesion.

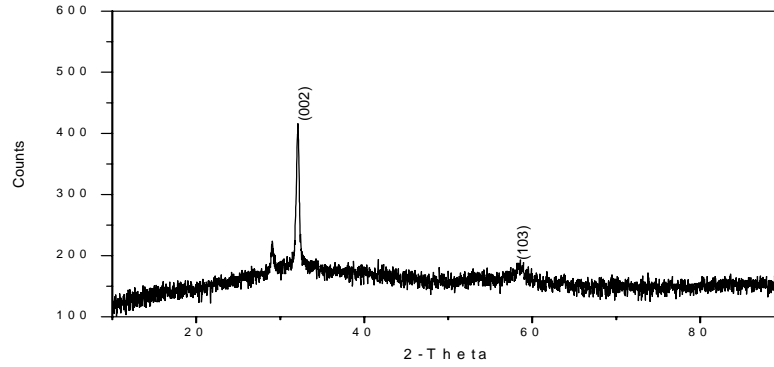


Fig.1. X-ray diffraction pattern of CdSe.

Fig.1 shows the X-ray diffraction pattern of CdSe. The presence of sharp peaks in this XRD pattern confirmed the polycrystalline nature of this thin film. Other sharp peaks observed in the vicinity of the main peak is the K_{β} peak. The experimental d- value for CdSe is determined using the Bragg's relation [11] by taking the θ value from the peak of XRD pattern. This d-value is compared with the standard ASTM data to confirm the structure of CdSe. The experimental d-values are (3.504 Å) and ASTM d* value (3.51 Å) is in good agreement and evidence of formation of hexagonal (wurtzite) structure. The preferential orientation of CdSe is found to be predominantly along (002) plane and direction of orientation is in c-direction.

3. Results and Discussion

3.1 Optical properties

The absorption spectra of CdSe thin film have been recorded over wavelength range 400 to 850 nm using a USB 2000 spectrophotometer at the room temperature. In this spectrophotometer, absorption and transmission spectra are obtained directly through the Computer using OOIBase32 software.

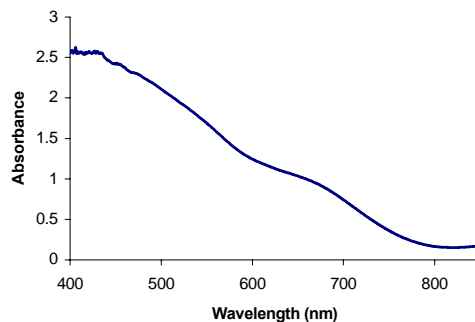


Fig 2. The absorption spectra of CdSe thin film.

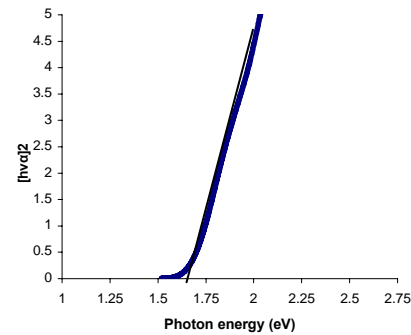


Fig.3. Energy band gap determination of CdSe thin film.

Fig. 2 shows the absorption spectra of CdSe thin film. It is observed that the absorption coefficient is high at lower wavelength and decreases sharply below a certain wavelength for CdSe thin film. The energy band gap is determined using absorption spectra with the help of Tauc relation [12]. Using this relation, a graph is plotted between the square of $(\alpha h\nu)$ and $h\nu$ to obtain a straight line (Fig.3). The extrapolation of straight line to $(\alpha h\nu)^2 = 0$ axis gives the value of the band gap. The energy band gap of this sample is 1.67 eV. It is in well agreement with the value reported elsewhere [13].

3.2 Electrical properties

Electrical conductivity of thin film of CdSe is determined using current-voltage characteristic and dimension of the film at constant voltage (1.0 V). The variation in electrical conductivity of CdSe thin film with temperature is shown in Fig. 4.

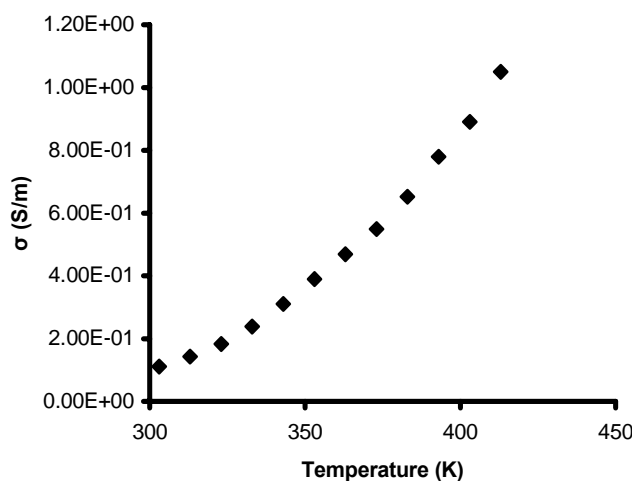


Fig 4. Temperature dependence of electrical conductivity of CdSe thin film.

It is observed that the conductivity increases non-linearly with the increase in temperature. This is explained in terms of structural changes occurring in this thin film with temperature. In as deposited thin film of CdSe, there is some lattice defects, geometrical and physical imperfections randomly distributed on the surface and the volume of the film [14]. The roughness of the surface, grain boundaries and inclusions in the volume are the main components of the geometrical imperfection. The important factor, which is responsible for the physical properties of thin film, is the structure. The film is composed of randomly oriented grains with the appearance of the grain boundaries. An increase of temperature of the films affects the structure significantly causing a considerable increase in the mean size of the grain [15] and a decrease in the grain boundary area. This decrease is due to the migration of the smaller crystallites and joining of those grains, which are similarly oriented, to form bigger crystallites. Because of these structural changes the inter-grain boundary area decreases i.e. there is a decrease in the scattering of electrons. Consequently, the carrier concentration also increases with the increase of temperature. This in turn increases the conductivity of given sample.

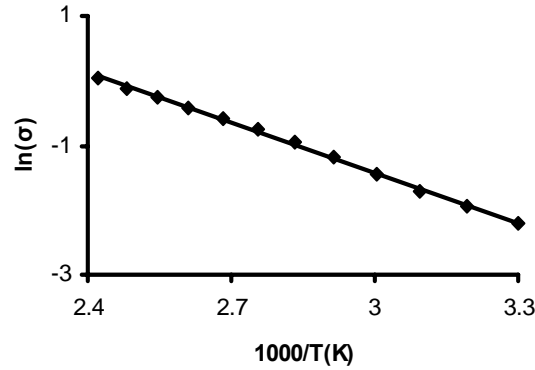


Fig. 5. Variation of $\ln(\sigma)$ versus $1000/T$ for CdSe thin film.

The temperature dependence of electrical conductivity (σ) of CdSe thin film follows the Arrhenius law and is given by

$$\sigma = \sigma_0 \exp(\Delta E_a/kT) \quad (1)$$

where σ_0 is the pre-exponential factor, ΔE_a is the activation energy of the electrical conduction, k is the Boltzmann constant and T is the absolute temperature. The activation energy has been determined by plotting graph between $\ln(\sigma)$ versus $1000/T$ (Fig. 5). It is found that the activation energy of CdSe thin film is 0.34 eV. It suggests that the conduction in these thin films is due to the thermally assisted tunneling of the charge carriers through the grain boundary barrier and transition from donor level to conduction band [16].

4. Conclusions

It was observed from the XRD that CdSe film grows preferentially along c-direction. I-V measurement shows the ohmic nature of the film. The increase in the electrical conductivity with the increase of temperature is due to the increase of grain size and carrier density.

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