Investigation the effect of annealing temperature on the optical properties of CdSe thin films

Investigación del efecto de la temperatura de recocido sobre las propiedades ópticas de películas delgadas de CdSe

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SCIENTIFIC RESEARCH

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ABSTRACT

Introduction: CdSe is an important II–VI semiconducting material due to its typical optical properties such as small direct band gap (1.7 eV) and a high refractive index and, thus, a major concern is focused on the investigation of optical properties of CdSe thin films which is important to promote the performances of the devices of solid -state such as SC (solar cells), thin film transistors, LED (light-emitting diodes), EBPL (electron–beam pumped lasers) and electroluminescent devices. In the present work, CdSe thin films were deposited by thermal evaporation method and the results have been analysed and presented. **Materials and Methods:** CdSe thin films has been deposited on glass microscopic slides as substrates of (75×25×1 mm) under room temperature using PVD technique. CdSe blended powders gets evaporated and condensed on the substrate. The film thickness ($t = 100 \pm 5$ nm) which is measured using Michelson interferometry method. Transmission spectrum, from 200-1100 nm, are scanned using two beams UV–VIS Spectrophotometer (6850 UV/Vis. Spectrophotometer-JENWAY). The deposited films then were annealed at temperature range of (1500C to 3500C) under vacuum to have a stable phase of the material and prevent surface oxidization. **Results and Discussion:** A transmittance spectrum of CdSe thin film is scanned over wavelength range 200 to 1100 nm using a (6850 UV/Vis. Spectrophotometer-JENWAY) at room temperature. The transmittance percentage between the as-deposited film and the annealed films change varies from (17.0%) to (47.0%). It is clearly seen that there is a shift toward higher energy (Blue Shift) in the transmittance spectrum. As annealing temperature increased the transmittance edge is shifted to the longer wavelength (i.e., after annealing the CdSe films shows red shifts in their optical spectra). The band gap was found within the range 1.966-1.7536 eV for CdSe thin film. As annealing temperature increases, the Eg continuously decreases. **Conclusions:** CdSe thin films have been deposited using Physical Vapor Deposition (PVD) Technique. It is found that the transmission for as-deposited films is (17%) and increases to (47%) as annealing temperature increases. Beside this the energy gap for as- deposited CdSe film is (1.966eV) and decreased from (1.909 eV) to (1.7536eV) as the annealing temperature increases. There is a strong red shift in optical spectrum of the annealed CdSe films. There is a gradual shift of the annealed films thin film spectra as compared of bulk CdSe films.

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INTRODUCCTION

Several semiconducting films have been deposited for optoelectronic device applications. Group II-VI compounds, in general, and cadmium chalcogenides, in particular, have attracted intense scientific and technological interest. Several physical and chemical techniques are available for the growth of CdSe thin films [1].

CdSe is an important II–VI semiconducting material due to its typical optical properties such as small direct band gap (1.7 eV) and a high refractive index and, thus, a major concern is focused on the investigation of optical properties of CdSe thin films which is important to promote the performances of the devices of solid -state such as SC (solar cells), thin film transistors, LED (light-emitting diodes), EBPL (electron–beam pumped lasers) and electroluminescent devices [2-4].

CdSe thin films were prepared using different technique such as thermal evaporation(PVD) [1], sputtering [5], electron beam evaporation(EBE) [6], chemical bath deposition(CBD) [7], spray pyrolysis(SP) [8], electrodeposition [9], photoelectrochemical [10], SILAR [11] and photochemical deposition [12].

In the present work, CdSe thin films were deposited by thermal evaporation method and the results have been analysed and presented.

MATERIALS AND METHOD

CdSe thin films has been deposited on glass microscopic slides as substrates of (75×25×1 mm) under room temperature using PVD technique. To clean the glass substrates, the glass substrates has been sinking into hot chromic acid for 24 hours, flashed with acetone and washed with distilled water. The glass substrates ultrasonically cleaned with deionized water for 10 minutes for preparing the samples for the deposition of CdSe thin films. Rotating holder which is hold's 12 samples in a time was used. The chamber was evacuated to 10^{-5} Torr. The source material was heated using molybdenum boat, CdSe blended powders gets evaporated and condensed on the substrate. The film thickness (t = 100 ± 5 nm) which is measured using Michelson interferometry method [13]. Transmission spectrum, from 200-1100 nm, are scanned using two beams UV–VIS Spectrophotometer (6850 UV/Vis. Spectrophotometer-JENWAY). The deposited films then were annealed at temperature range of (1500C to 3500C) under vacuum to have a stable phase of the material and prevent surface oxidization.

RESULTS

Transmittance

A transmittance spectrum of CdSe thin film is scanned over wavelength range 200 to 1100 nm using a (6850 UV/Vis. Spectrophotometer-JENWAY) at room temperature. Figure 1 reveal the diversity of transmittance spectra (T%) versus the wavelength (λ) of annealed and as-deposited investigated samples.
The theory of optical absorption gives the relation between the absorption coefficient α and the photon energy hν, especially, for direct allowed transition as 14

$$\alpha = \frac{A(h\upsilon - E_g)^2}{h\upsilon} \tag{1}$$

Where hν is the photon energy, Eg is the optical band-gap, A is a constant.

A typical plot of $(\alpha h\nu)^2$ versus hν for deposited CdSe thin films is as shown in Figure 2 and are listed in table 1. The linear fit of the plot indicates the existence of the allowed direct band-gap transition.
The band gap was found within the range 1.966-1.7536 eV for CdSe thin film.

These band-gap values were in good agreement with the earlier reported values of band-gap for CdSe nanocrystalline thin films [15].
As annealing temperature increases, the Eg continuously decreases as shown in Figure 3.

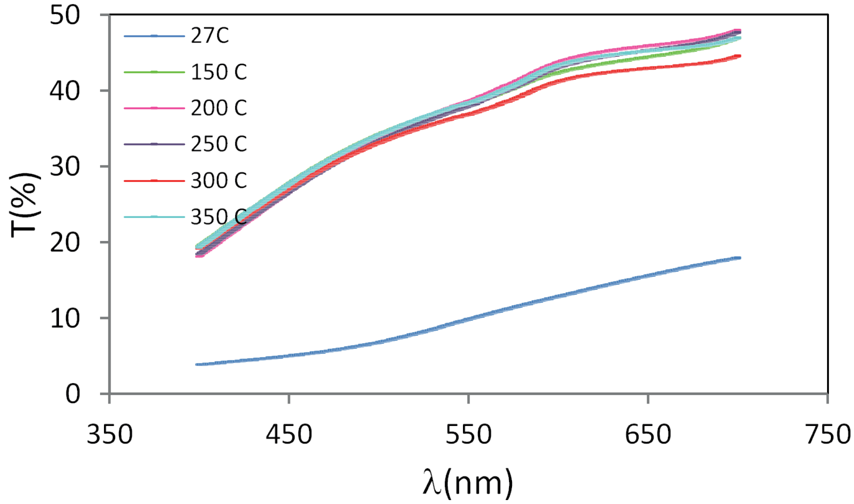

Figure 1. The transmittance (% T) versus wavelength (λ) of annealed and as-deposited CdSe thin films.

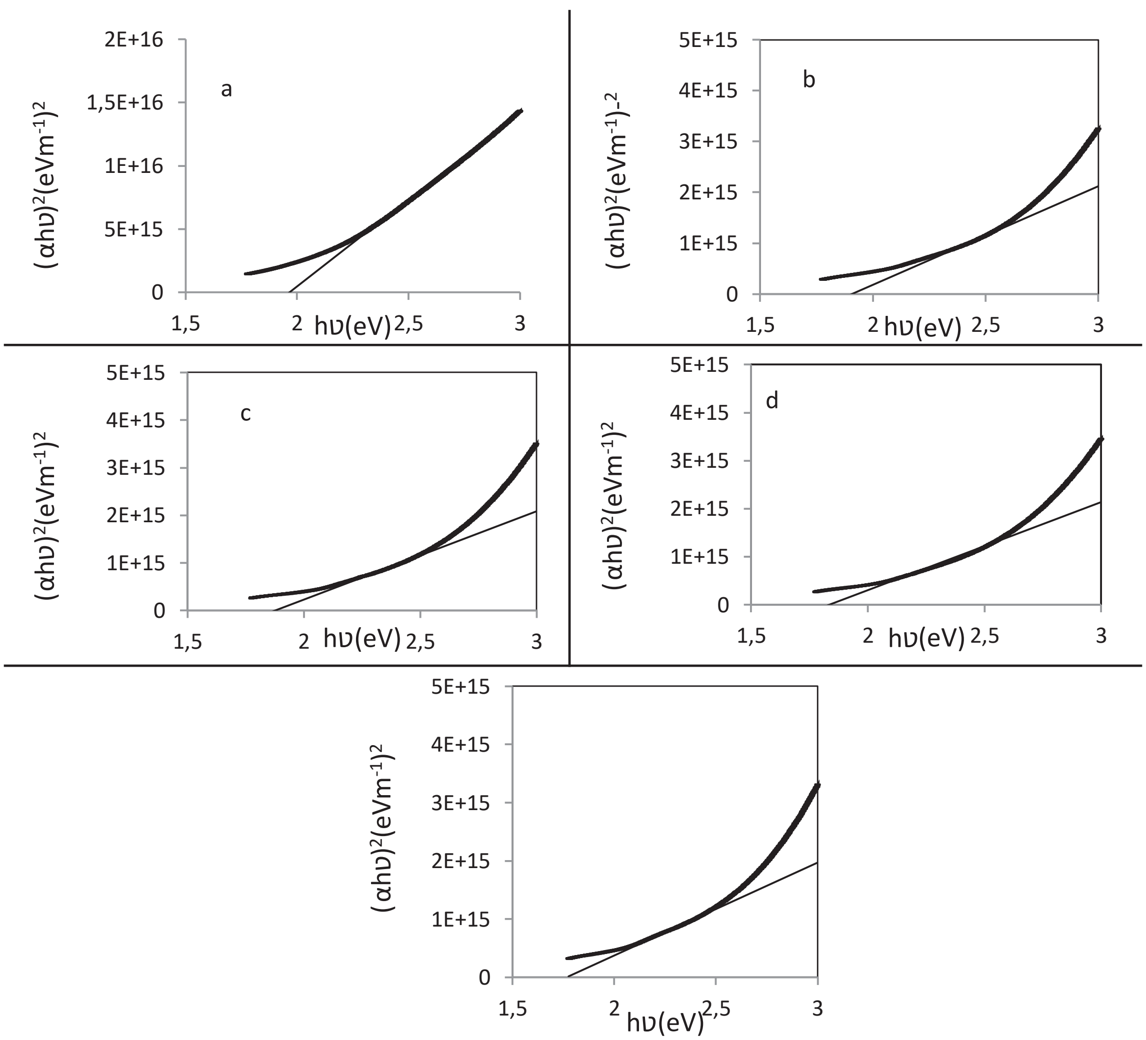

Figure 2. (αhν)2 against hν for CdSe thin films at annealing temperature (a)27 oC,(b)150 oC,(c)200 oC,(d)250 oC, and (e)300 oC.

Table 1. Energy gap of CdSe thin films for different annealing temperature.

Temp	Eg (eV)
27	1.966
150	1.909
200	1.8755
250	1.8256
300	1.7692
350	1.7536

DISCUSSION

It can be seen that transmittance percentage between the as-deposited film and the annealed films varies from (17.0%) to (47.0%). It is clearly seen that there is a shift toward higher energy (Blue Shift) in the transmittance spectrum. As annealing temperature increased the transmittance edge is shifted to the longer wavelength (i.e., after annealing the CdSe films shows red shifts in their optical spectra). The increases in transmittance is believed to be due to the increases in crystallite size and lattice parameters. This leads to a gradual switching in color from red orange to black of the CdSe thin films. Typically; surface morphology, film thickness, and defects grain boundaries affect the thin films transmittance [16, 17, 18]. The large band gap energy value may be due to the size of quantization effect of CdSe which produces a series of discrete states in the valence and conduction bands. The decrease in energy band gap after annealing can be attributed to improvement in the crystallinity with annealing temperature. The increase in crystallite size is due to sinter a small nanocrystallites to form larger crystallites, losing its quantum size. The temperature dependent parameters that affect the band gap are reorganization of the film, selenium evaporation and self-oxidation of the film. The reorganization of the film should occurat all annealing temperatures. By filling the voids in the film one expects denser films and smaller energy gaps [19].

CONCLUSIONS

CdSe thin films have been deposited using Physical Vapor Deposition (PVD) Technique. It is found that the transmission for as- deposited films is (17%) and increases to (47%) as annealing temperature increases. Beside this the energy gap for as- deposited CdSe film is (1.966eV) and decreased from (1.909 eV) to (1.7536eV) as the annealing temperature increases. There is a strong red shift in optical spectrum of the annealed CdSe films. There is a gradual shift of the annealed films thin film spectra as compared of bulk CdSe films.

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