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# Preparation and Physical Characterization of CDS thin Films Deposited by Chemical Spray Pyrolysis

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## ABSTRACT

Optical absorbance spectra of CdS thin films were recorded from UV-Visible spectrophotometer in the range 380-900 nm. The films were prepared by chemical spray pyrolysis by spraying an aqueous solution of cadmium chloride ($CdCl_2$) and thiourea [$(NH_2)_2$ CS] with de-ionized water. The absorbance, refractive index, absorption coefficient increased with the increasing of CdS film thickness, while the extinction coefficient decreased. The energy gap decreased from 2.4 eV for thickness 500 nm to 2.37 eV for thickness 700 nm.

**Keywords:** CdS Thin Film, Chemical Spray Pyrolysis, Optical Properties, Energy Gap.

## I. INTRODUCTION

Cadmium sulphide (CdS) is one of the most promising II-VI compound semi-conductor materials because of its wide range of applications in different kind of hetero junction solar cells such as cadmium telluride (CdTe), copper indium diselenide/sulphide (CIS) and copper indium gallium diselenide/sulphide (CIGS) solar cells [1, 2]. CdS is a direct band gap of 2.42 eV II – IV semiconductor compound at room temperature and it has been studied for many years for various optoelectronic applications. Some applications of CdS thin films including photo detectors, piezoelectric transducers, bolo meters, solar cells, etc. [3].

Many techniques have been reported for the deposition of CdS thin films. These include thermal evaporation [4], sputtering [5], chemical bath deposition [6], spray pyrolysis [7], metal organic chemical vapour deposition (MOCVD) [8], molecular beam epitaxial technique [9], electro deposition [10], photochemical deposition [11] etc.

In this work, the optical properties are studied for CdS thin films prepared by chemical spray pyrolysis.

## II. METHODS AND MATERIAL

### Experimental Details

The CdS thin films were prepared by spraying an aqueous solution of cadmium chloride (CdCl2) and thiourea [(NH2)2 CS] with de-ionized water to form the final spray solution, a few drops of HCl were added to make the solution clear. A total volume of 100 ml was used in each deposition. The spray pyrolysis was done by using a glass atomizer, which has an output nozzle of 1 mm. The glass substrates at a temperature of 350 °C with the optimized conditions that concern the following parameters: spray time was 10 sec, the stopping period 3 minutes to avoid excessive cooling of glass substrate. The carrier gas (filtered compressed air) was maintained at a pressure of 105 Pascal, distance between nozzle and substrate was about 30 cm, solution flow rate 8 ml/min. Thickness of the sample was measured using the gravimetric method and was found to be 300 ± 20 nm. The optical properties are calculated from recording the absorbance spectra via UV-Visible spectrophotometer in the wavelength range (380-900) nm.

## III. RESULTS AND DISCUSSION

From UV-Visible spectrophotometer, we recording the absorbance spectra in the range of 380-900 nm and then calculating the optical properties of CdS thin films. The absorbance spectra relationship with the wavelength is presented in Fig.1. From the figure, it can notice that the absorbance decrease with the increasing of wavelength of CdS thin films, and increases with increasing of thickness. This behavior can be attributed to the increasing of atoms with increasing thickness, lead to increasing the number of collisions for incident photons on CdS thin film.

The variation of extinction coefficient (k) as a function of wavelength (λ) is shown in Fig.2, which can be calculated by the following equation [12]:

$$k = \frac{\alpha\lambda}{4\pi} \quad (1)$$

Where α is the absorption coefficient. The extinction coefficient decreased with the increasing of thickness.

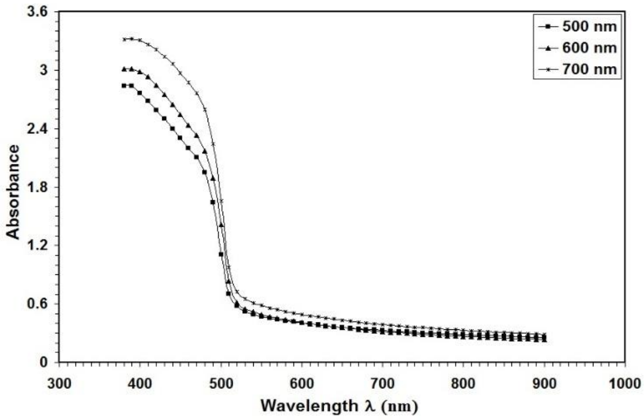


**Figure 1 :** Absorbance of CdS thin films obtained with different thicknesses.

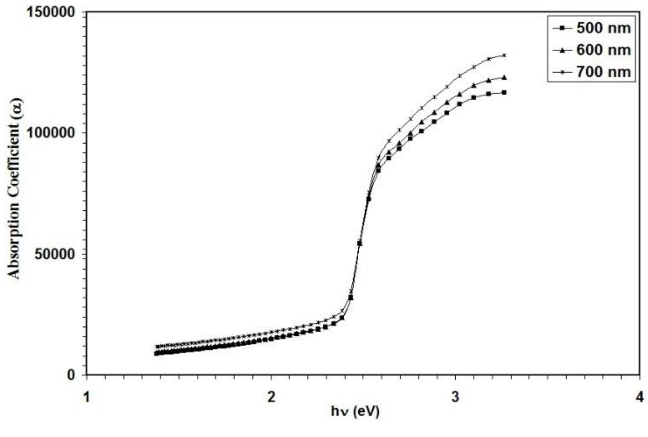


**Figure 2 :** Absorption coefficient of CdS thin films obtained with different thicknesses.

The refractive index (n) can be determined from a transmittance spectrum as a function of the photon energy. Fig.3 represent the relationship between the refractive index with the wavelength. Refractive index decreases with the increasing of thickness for CdS spread thin films

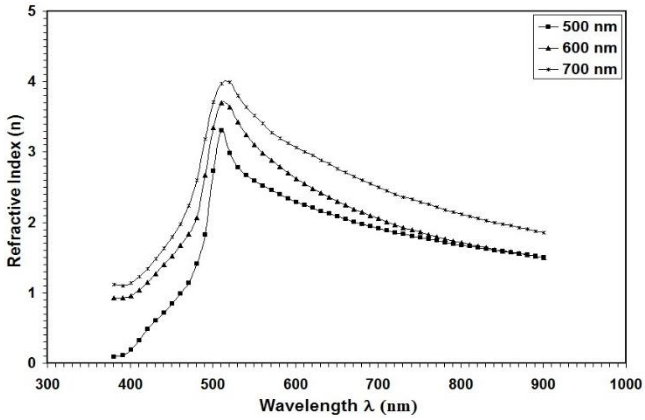


**Figure 3 :** Refractive index of CdS thin films obtained with different thicknesses.

The optical absorption coefficient (α) can be deduced from the absorption spectra using the relation [13]:

$$\alpha = \frac{2.303A}{t} \quad (2)$$

Where t is the thickness of the as deposited CdS thin films. The absorption coefficient values calculated from the transmittance data are about $10^4$ $cm^{-1}$ near the absorption edge as well as in the visible region as shown in Fig.4. From this figure, it can notice that the absorption coefficient increases with increasing of thickness of CdS thin films.

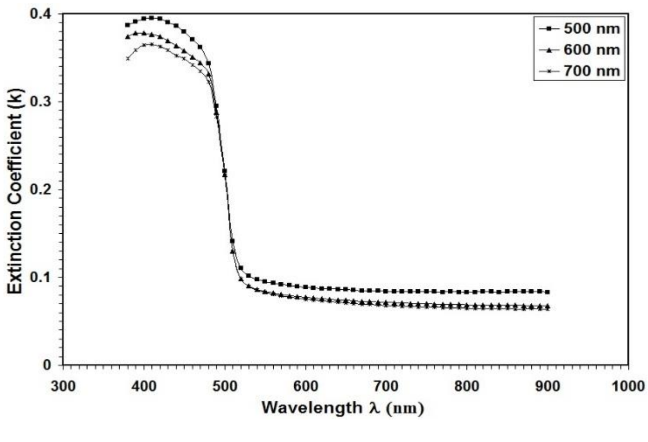


**Figure 4 :** Extinction coefficient of CdS thin films obtained with different thicknesses.

The optical band gap of the CdS thin films was estimated from the plot of $(\alpha h\upsilon)^2$ versus hυ as shown in the Figs. 5-7. The optical band gap was determined by extrapolating the linear portions of the plot at $(\alpha h\upsilon)^2 = 0$. This plot gives n = ½ according to Tauc relation, which indicates that the direct transition dominates in the films. From the Figs.5-7, the optical band gap of prepared CdS thin films was decreased from 2.4 eV for thickness 500 nm to 2.37 eV for thickness 700 nm.

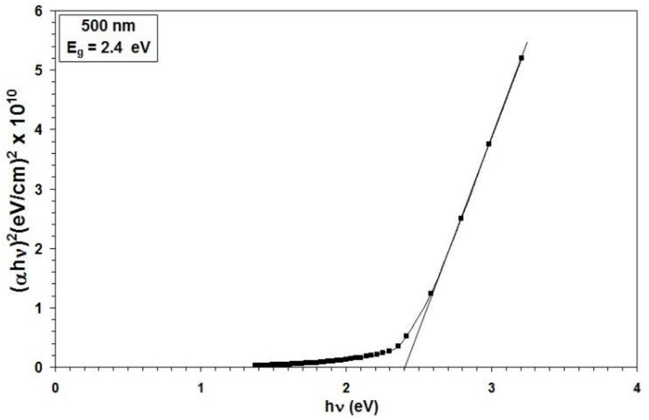


**Figure 5 :** Variation of $(\alpha h\upsilon)^2$ versus photon energy of

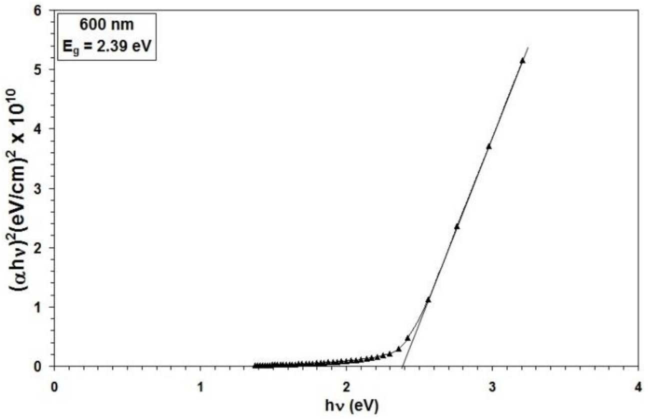


**Figure 6 :** Variation of $(\alpha h\upsilon)^2$ versus photon energy of CdS thin films obtained with 600 nm thickness.

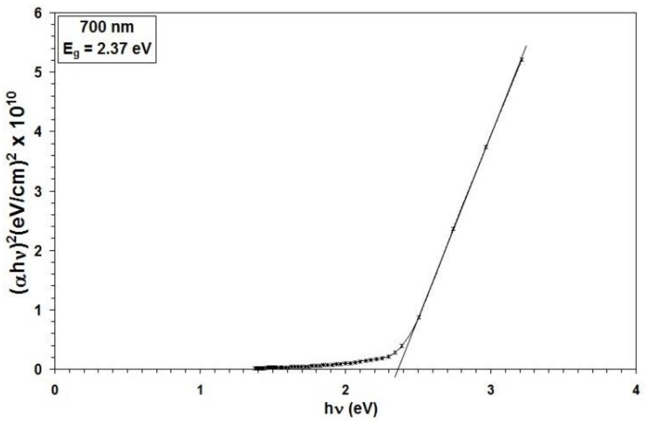


**Figure 7 :** Variation of $(\alpha h\upsilon)^2$ versus photon energy of CdS thin films obtained with 700 nm thickness.

## IV. CONCLUSION

From the obtained results, we can conclude: The absorbance, refractive index, absorption coefficient increased with the increasing of film thickness, while the extinction coefficient decreased for CdS thin films prepared by chemical spray pyrolysis method. The energy gap decreased from 2.4 eV for thickness 500 nm to 2.37 eV for thickness 700 nm. These values of energy gap make these films suitable for various optoelectronic applications.

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