

Structural And Optical Properties Of CdS thin Film By Chemical Bath Deposition Technique

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Abstract

Cadmium sulfide thin film was prepared on glass substrate by a chemical bath deposition technique using aqueous cadmium chloride and thiourea solutions in a basic medium (pH ~ 11.8) at 90°C for 4 hours. The structural and morphological properties of films obtained by CBD were investigated using X-ray diffraction, Scanning and Electron Microscope, Energy Dispersive X-ray Spectrometer, FT-IR Spectroscopy, UV-vis spectroscopy, and photoluminescence. X-ray pattern showed that the CdS thin film deposited without any complexing agent was grown on an amorphous phase. SEM image showed that the CdS thin film deposited homogeneous, uniform grain size and good adhesion to the substrate. The band energy gap value was found as 2.61 eV.

Keywords: CdS thin film, XRD, SEM, EDAX, FT-IR, UV, Photoluminescence.

1. Introduction

Cadmium sulphide (CdS) is an important II-VI compound semiconductor material. It is used extensively in photo sensors, transducers, optical detectors, and other devices. In the last five decades, CdS has been one of the most investigated thin film semiconductors for photovoltaic. Today CdS is considered as the best-suited window material for both CdTe and CuIn(Ga)Se₂ solar cells (1-3). The most important parameter for transparent thin films used for optical window applications is the bandgap energy. There are several deposition techniques used for the deposition of thin film CdS including sputtering(3,4) chemical bath deposition(5), thermal evaporation (6) chemical vapour deposition(7) close space sublimation(8), molecular beam epitaxy(9) and spray pyrolysis (10) screen printing and electrolysis. Each deposition process produces different structural, electrical and optical properties of the CdS thin films. Among the different technique Chemical bath deposition is now widely used for the elaboration of low

cost polycrystalline thin film solar cells because it offers the advantages of economy, convenience and the capability of large area deposition. CdS thin films can be achieved by chemical bath deposition in an alkaline aqueous solution consisting of thiourea, cadmium salts and ammonia. In CBD method ammonia is mainly used as a complexing agent for the cadmium ions in the reaction solution and the bath temperature was maintained at around 90°C and the deposition time was 4 hours. Many researchers investigated the optical properties of CdS thin films, but few have studied the relation between bandgap energy and film thickness and the tailing in the forbidden bandgap (sahay et al 2007, ikhmayies et al 2010 and bilgin et al 2005).

In this work the CdS thin films can be prepared by chemical bath deposition method and measured the structural, optical, electrical and magnetic properties of the films.

2. Materials and method

The glass substrate(35 X 25 X 1)mm used in the present study is first rinsed with distilled water. Then they are treated with NaOH solution. this alkaline agent dissolves fatty material by saponification and renders then wet. After a rinse with distilled water, the substrates are kept in ultrasonic agitator for 30 minutes to remove organic impurities. Finally substrates are cleaned with isopropyl alcohol vapours and hence enhance the removal of surface contaminants. The substrates are then heated in an oven for about 45 minutes at a temperature 100°C. Drying and dust removal finally makes them ready for the coating process. Any slight marks found on the substrates mean that the whole process must be repeated (cachet et al 1995 and Gibson et al 2000).

The chemical bath deposition (CBD) method is employed to deposit CdS thin films on to glass substrates using thiourea as sulphide ion source and cadmium chloride as cadmium ion source in ammonia bath. the molar solutions of CdCl₂(0.05M) and thiourea (0.2M) were prepared using doubly distilled water. NH₄NO₃ solution (0.1M) is then added to the CdCl₂ the pH of solution is maintained at 11.8 with the pH meter for the film deposition. The substrate were immersed in solution contained in glass beaker placed in side a water bath. The bath temperature was maintained at around 90°C and the deposition time was 4 hours. From these condition uniform film deposition on all substrates was achieved. the coated film was processing for characterisation studies such as optical studies, X- ray diffraction, SEM and EDAX.

3. Results and discussion

3.1 Structural, Surface morphology and Elemental Analysis of Cds

Structural, surface morphology and elemental composition analysis of CdS thin films by chemical bath deposition technique using aqueous cadmium chloride and thiourea solutions in a basic medium (pH ~ 11.8) at 90°C for 4 hours.

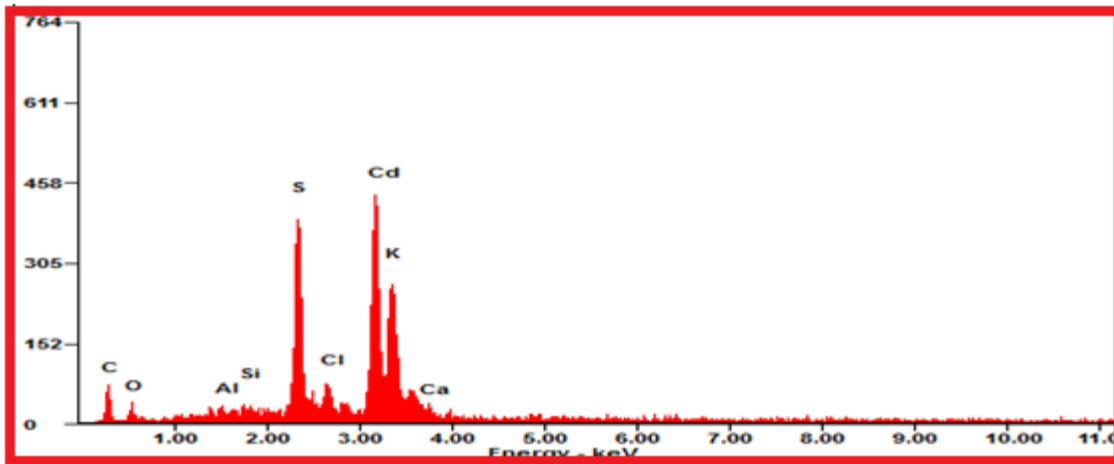


Fig.1 EDAX Spectrum of CdS thin film (5:3:2:1)

Fig.1 shows, EDAX results which are consistent with the formation of thin films of CdS deposited on silica glass substrates. It is widely known that CBD processes are associated with films which possess a relatively high concentration of impurities.

The energy dispersive X-ray spectra shows that the expected elements detected in the thin film. The small percentage of S, Cd, Cl, K, C and O elements is present in the thin films. It is thought that these elements may probably result from chlorite used as substrate.

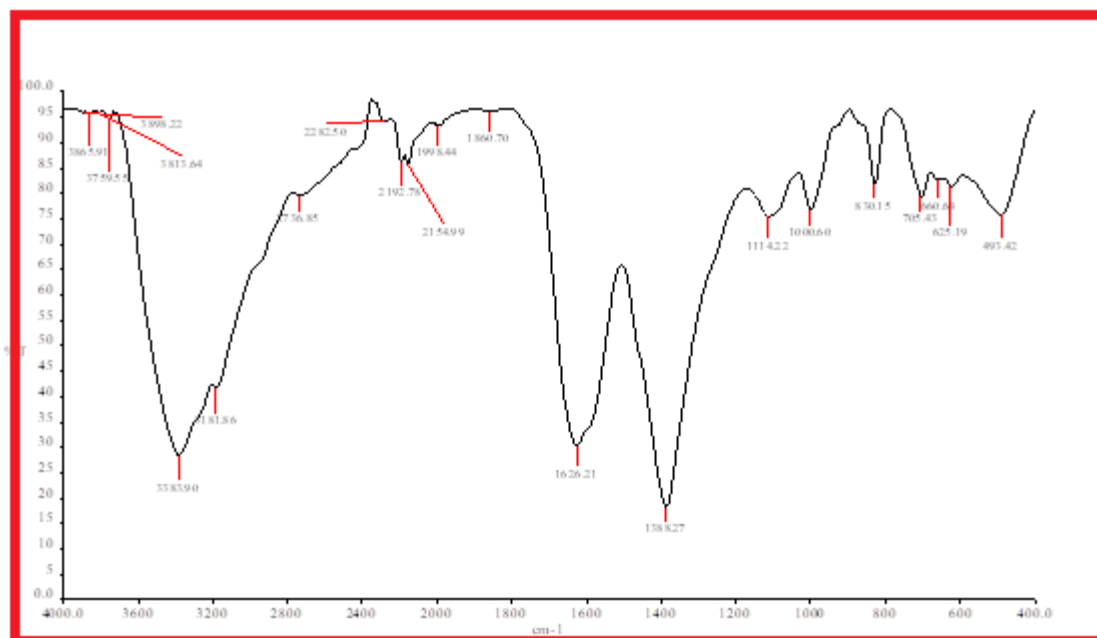


Fig.2 FT-IR spectroscopy Analysis of CdS Thin film

The FT-IR spectra of CdS thin films are shown in Fig.2 and FT-IR spectrum, using PERKIN ELMER Spectrophotometer in the frequency range 400-4000 cm^{-1} with KBr pellet techniques. Figure .1 shows that are the frequency 3383.90 cm^{-1} is due to -OH stretching mode is to present the KOH. The frequency of 3181.86 cm^{-1} is N-H stretching mode were presented in ammonium nitrate are due to NH_2 group. The presence of thiourea in the sample is identified by the frequency 1388.22 and 1114.22 cm^{-1} the stretching C-N and N=O respectively. The frequency of 1000.60 cm^{-1} is due to stretching mode of S=O present in sulphate compounds and finally the frequency of 750.43 cm^{-1} to 625.25 cm^{-1} stretching mode C-X (X is halogen) its present in cadmium chloride. Above all frequency is confirmed to form CdS is presented the in this study.

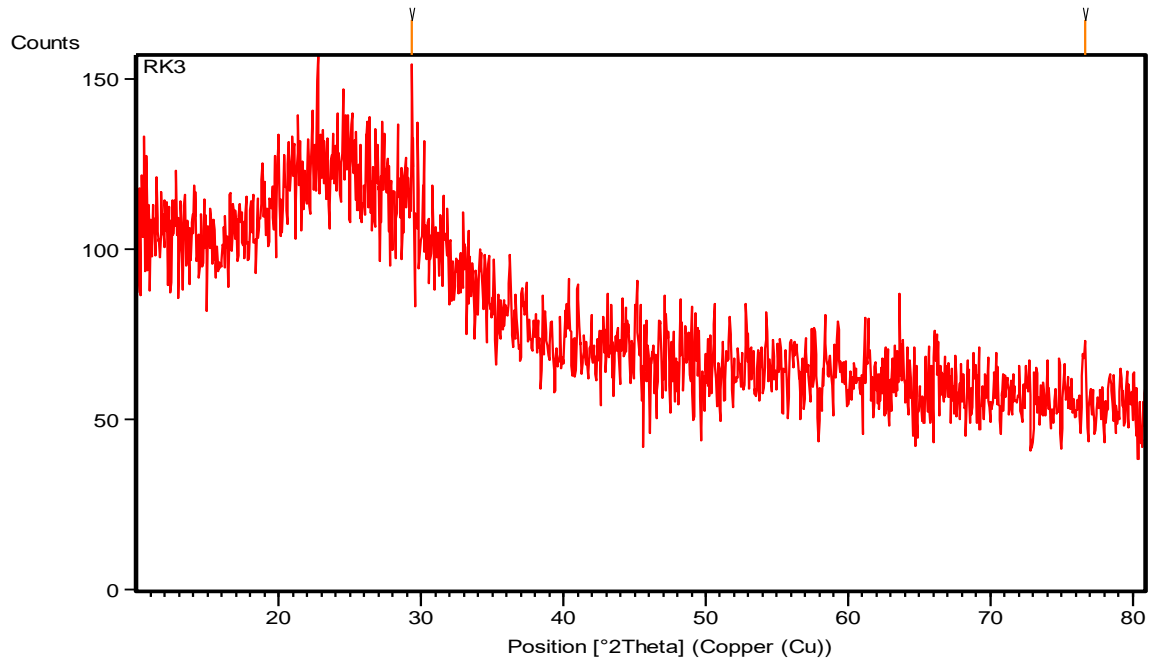


Fig.3 Xrd Analysis of CdS Thin film

Table 1 Peak position of Cds thin film

Pos. [°2Th.]	Height [cts]	FWHM Left [°2Th.]	d-spacing [Å]	Rel. Int. [%]
29.3286	88.79	0.1949	3.04531	100.00
76.6340	19.58	0.3600	1.24239	22.05

Fig.3 shows,XRD analysis is carried out on CdS films and typical diffraction patterns of as grown CdS thin films prepared by CBD technique on glass substrates with different thickness. The spectra are obtained by scanning 2θ in the range $10 - 80^\circ$.The XRD pattern to confirm and presented the CdS thin film on glass substrate. The others smaller peaks were observed (21, 22, 29, 39 and 41) corresponding to the (113,111,100,200 and 110) planes respectively.It is clear from the high intensity peaks which indicate a significant increase in crystallite size with the cubic modification (worscheech et al 1995 and Hjelt et al 1997).

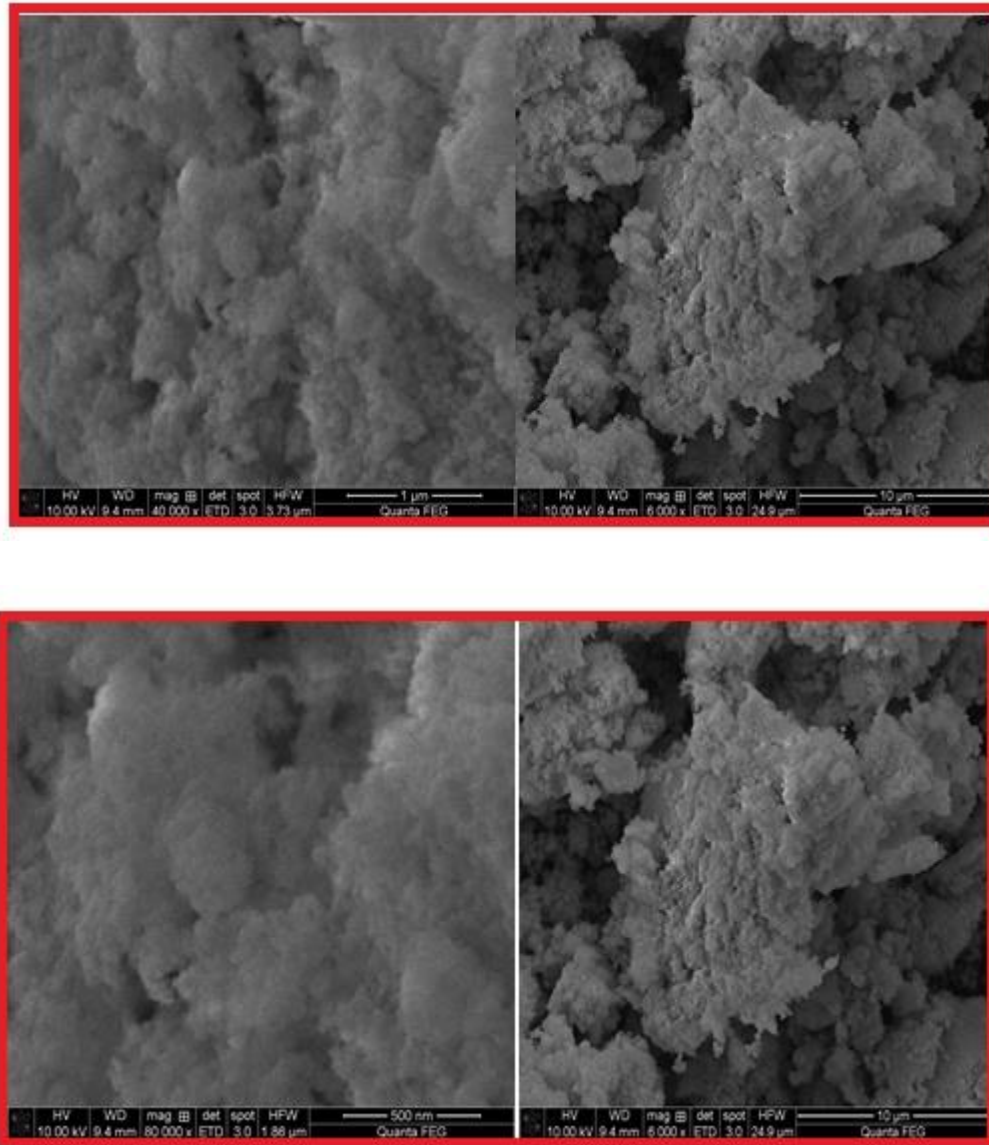


Fig.4 SEM of CdS thin film at different magnitudes

The scanning electron microscopy is a convenient technique to study the microstructure of thin films. It shows that most homogeneous film was obtained in the bath with (5:3:2:1) solution for 4 hours. In this case the slow deposition rate led to small uniform grain size and shape and the good adhesion to the substrate. But not uniformly covered the substrate on the films. We estimated the grain sizes from different grains within the films and found to be about 10 to 500nm.the SEM micrograph shows a cubical morphology and an irregular pattern without any void, pinhole or cracks and those they cover the entire substrate. It is clearly observed that the glassy nature along with amorphous phase of CdS

thin films (nair et al 1987b). The grains are found to be thickly packed and also indicate that the grains are dense, smooth and without any visible pores.

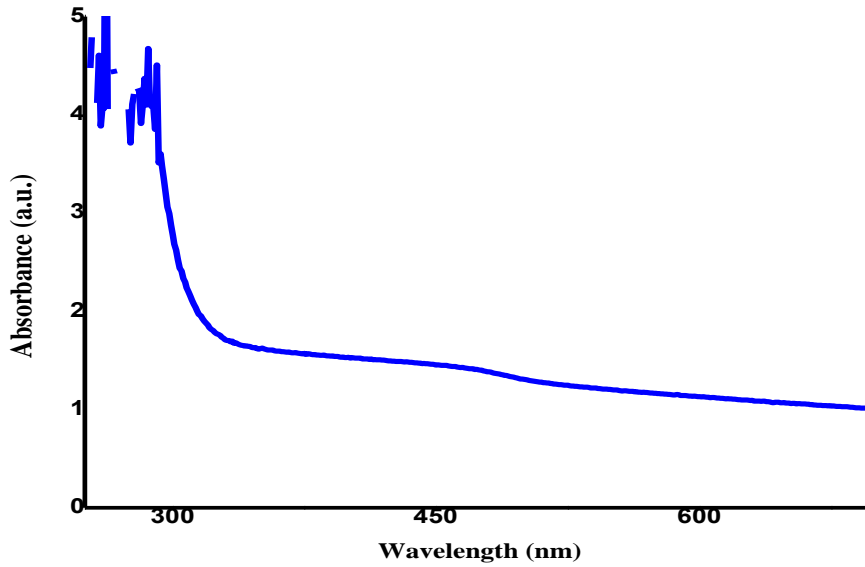


Fig. 5 UV-Visible Spectroscopy Analysis of CdS

3.2 Variation of optical absorption Vs.wavelength for CdS thin film

The plot of $(\alpha h\nu)^2$ versus $h\nu$ is shown in Fig.5. The nature of plot indicates the existence of direct transition. The optical band gap energy “ E_g ” is determined by extrapolating the straight line portion to the energy axis for zero absorption coefficients. The value of E_g for as deposited CdS thin film is found 2.34 eV.

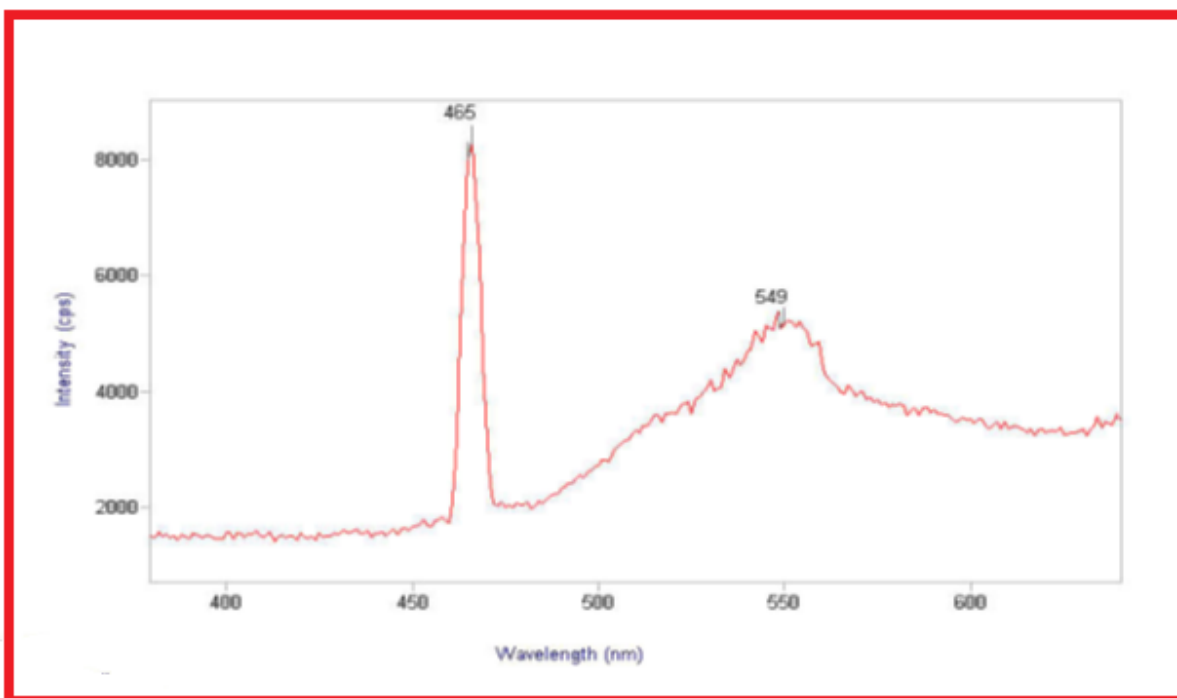


Fig.6 PL spectra of the CdS Thin film

3.3 Analysis of Photoluminescence spectra

Preliminary investigations show that photoluminescence (PL) spectra of the obtained CdS thin films have two distinct bands at ca. 465 nm and ca. 549 nm, respectively. The measured PL excitation spectra corresponding to the two emission bands allows to fix the excitation wavelength at ca. 369 nm suitable to the CdS thin films under consideration. The typical PL spectrum is presented in Fig.3 as reported; the PL spectra of thin films growth by the spray pyrolysis technique consist of a characteristic red band centered at about 698 nm. The apparition of this red band may be assigned to the excess of Cd^{2+} which leads to increase the defect quantity in the films, while the chemical bath deposited CdS thin films reported in has the PL band around 1.72 eV (the red band) due to sulfur vacancies, without the corresponding exaction band. Yet, in any cases, the PL spectrum of the CdS thin film under investigation has no red emission band. One might say that the obtained films are more or less stoichiometric. However, the Energy Dissipative X-ray (EDX) characterization is to be investigating for further detailed information in this regard.

4. Conclusion

CdS thin film was obtained using the chemical bath deposition method. Which is a low cost and simple techniques to growth chalcogenides compounds the particle structure and size was determined using XRD. In the range $10 - 80^\circ$ of 2θ Spectra confirmed and presented the CdS thin film on Glass substrate. The frequency of 1000.60 cm^{-1} and 750.43 cm^{-1} to 625.25 cm^{-1} is confirmed to form CdS. The optical studies confirmed the value of Band gap energy is found to be 2.34 eV.

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