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Characterization of CdS Thin Film Grown by Chemical Bath Deposition

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ABSTRACT

Cadmium sulphide (CdS) thin films were deposited by chemical bath deposition method on glass substrates from aqueous solution. The influence of the solution temperature and pH is investigated in this work. Cadmium sulphate , ammonia and thiourea were used as the source materials for the preparation of the thin films sources. These films were then characterized using UV spectroscopy for studying the optical properties. XRD were used for structural studies. SEM and EDAX revealed the morphological characteristics. The X-ray diffraction (XRD) analysis showed that the prepared CdS films were polycrystalline with hexagonal structure. CdS thin films were obtained with (002) preferred orientation and having crystallite size 50 nm. It was determined from the broadenings of corresponding X-ray diffraction peaks by using Debye Scherrer's formula. Band gap of CdS thin film by UV spectroscopy was 2.42 eV.

Keywords: CdS thin films, UV spectroscopy, SEM and EDAX, Etc..

INTRODUCTION

Cadmium Sulphide is II–VI group binary semiconductor material, widely used as an efficient window layer in thin films based solar cell structures due to its high absorption coefficient, stability, and low resistivity [1].They are used as a window layer in CIGS and CdTe heterojunction based solar cells [5], field effect transistors [10–12], gas sensors [12], photo detectors [10], information storing devices [9] and light emitting diodes. CdS is an n-type of semiconducting material with direct optical bandgap 2.42 eV at room temperature .CdS thin films are prepared bydifferent methods such as spray pyrolysis [2],vacuum evaporation [3], electro deposition [4], sputtering [5] and chemical bath deposition (CBD) [6]. Chemical bath deposition is suitable method for preparing high efficient thin film due to its advantages such as simple, large area films, low temperature and low cost method.Bonding in this compound is a mixture of covalent and ionic types. We have prepared the CdS thin films by chemical bath deposition method on the glass substrate at 70 °C temperature.

CdS has two types of crystal structures- cubic zinc blende and hexagonal wurtzite. The type of structure obtained is depends on deposition parameter such as substrate temperature, pH, concentration of precursor, etc. The investigation of the fundamental properties of CdS thin films is of paramount importance in the understanding and development of modern CdS solar cells. Many researchers have been studying these properties to see how the quality of this layer can be improved for better performance with good optoelectronic properties suitable for photovoltaic applications. The best efficiency recently reported is 22.1% for CdS/CdTe solar cell prepared by vacuum deposition techniques.

METHODOLOGY

The deposition of thin film was carried out by using glass substrate which was initially cleaned by soap solution, double distilled water and ultrasonication. The CdS thin films were deposited in aqueous solution containing 0.1 M cadmium sulphate, 0.1 M Thiourea and ammonia as complexing agent. Add this weighed CdSO4 and ammonia in 50 ml distilled water in the glass beaker and stir this solution continuously for several minutes to become homogeneous solution at moderate rate. Ammonia was added drop by drop in solution to maintain the pH value of the solution is 10 at temperature 70 oC. When the temperature of solution reaches 70oC then adds the thiourea. The cleaned glass substrate was immersed in bath and solution was no stirred during the deposition process. CdS thin film was deposited for 15 minutes then samples were washing under distilled water and dry in air. The CdS thin films obtained were compact, hard, and good adhesion to the glass substrate.
Reaction Mechanism for deposition of CdS thin film

RESULTS AND DISCUSSION

$$CdSO_4 + 4\ NH_4Cl \rightarrow Cd(NH_3)_4^{2+} + Cl^- + 4H_2O$$

$$H_2O \rightarrow H^+ + (OH)^-$$

$$CS(NH_2)_2 + (OH)^- \rightarrow H_2N(COH)NH + SH^-$$

$$Cd(NH_3)_4^{2+} + SH^- \rightarrow \mathbf{CdS} + NH_4^+ + 3NH_3$$

X-ray diffraction Analysis:

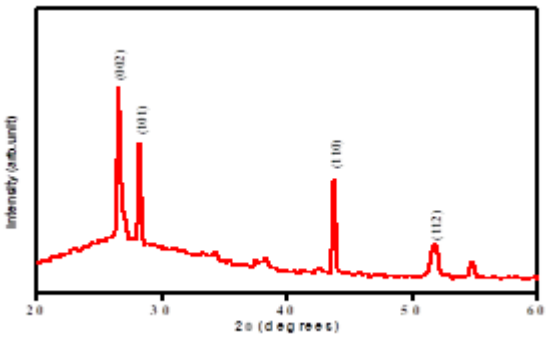

Fig . 1 : XRD Pattern of of CdS thin film

The XRD analysis for as-deposited film has been recorded by X ray diffractometer with scanning angle 20-80 degree using CuKα radiation of wavelength 1.5406Ao. In XRD analysis reveals that a prominent broad peak appear at an angle 2θ = 26.6°, 28.2, 43.7 and 51.8 which correspond to the (002), (101), (110) and (112) planes (JCPDS- 89-2944). The XRD results confirmed that the deposited CdS thin films were polycrystalline in nature with hexagonal structure having (002) plane as the preferred oriented. The

samples deposited at 70 °C have higher peak intensities, indicating better crystallinity. The average crystalline size (t) was calculated using the Debye-Scherrer formula,

$$t = 0.9\lambda/\beta\cos\theta$$

Where λ=1.5409Ao is the X-ray wavelength (CuKα), θ is the Bragg diffraction angle, and β is the full width at half maxima (FWHM) of the XRD peak appearing at the diffraction angle θ=26.6. The average crystallite size was calculated from X-ray broadening peak and Scherer equation was found to be about 50 nm.

Scanning Electron Microscopy (SEM):

Figures show the SEM images of the CdS thin films deposited on glass substrate. Scanning electron microscope (SEM) was used for the morphological study of CdS thin films. Spherical and relatively uniform surface morphology can be clearly seen in as-deposited samples. All the films were compact, uniform and very well adhesive to the glass substrates. The average particle size of CdS thin films was 0.5µm. The bigger grain with less grain boundaries can be obtained by choosing the approximate annealing temperature, ambient condition and annealing time. The as-grown CdS films colour changes with the concentration from greenish yellow to bright yellow.

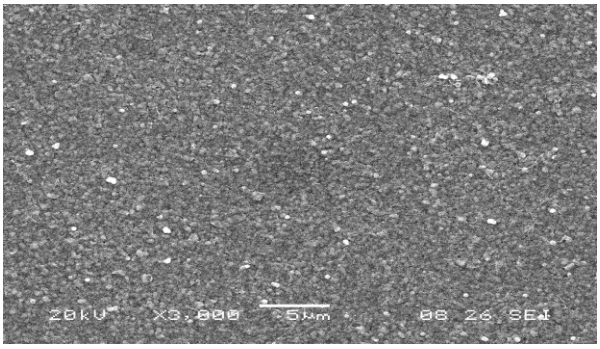

Fig : SEM image of CdS thin film

Energy Dispersive Spectroscopy (EDS):

The elemental analysis of the films was carried out by EDS. The EDS spectra of the CdS thin films confirmed the presence of Cd and S in the thin films. The atomic percentage ratios of Cd: S for samples deposited at 70 °C are 49.74:50.26, which show that the films had a good stoichiometry.

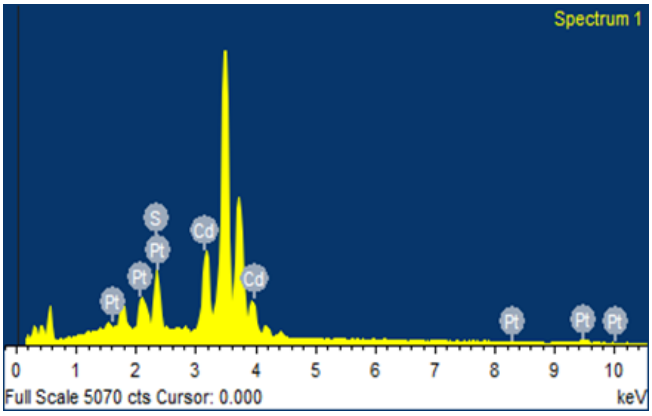

Fig 3. EDS of CdS thin film

Optical Analysis

The optical band gap energy of the semiconductor is an important parameter that plays a major role in the construction of photovoltaic cells. Optical properties of the CdS films were studied in the wavelength ranging from 300 to 800 nm. Figure shows the plots of $(\alpha h\upsilon)2$ versus energy $(h\upsilon)$ for CdS thin films deposited at 70oC. The optical band gap was found to be 2.42 eV (± 0.05) for as-deposited samples.

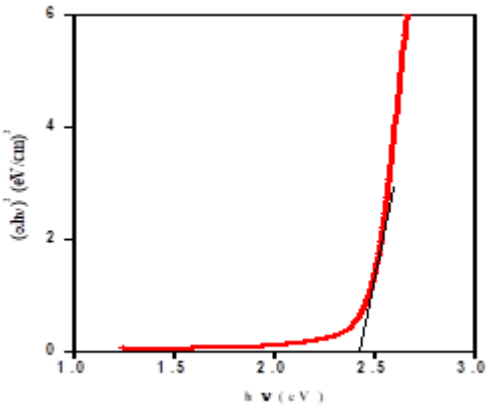

Fig 4. Optical absorption spectra of CdS thin film

CONCLUSION

CdS thin films have been successfully deposited on glass substrates using chemical bath deposition method. XRD results revealed that the films deposited at 70oC were nanocrystalline with hexagonal structure. SEM shows the spherical morphology of films deposited at various concentrations. Uuniform and compact film deposited over the entire substrate. CdS films deposited in presence of ammonia as complexing agent were close to the stoichiometry. The

films have very good stoichiometry with nearly 1:1 cadmium to sulphur ratio. The band gap was estimated is 2.42eV. The band gap of the films was found to be increased upon increasing the concentration of thiourea in the bath.

Conflicts of interest: The authors stated that no conflicts of interest.

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