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Fabrication and Characterization of CdS Thin Films for the Solar Cell Applications

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Abstract-- Solar energy has the potential of becoming a renewable energy alternative to fossils fuels. The thin film technologies reduce the amount of material required in forming the active material of solar cell. CdS being a wide band gap material and with better lattice matching properties made it suitable option for solar cell applications. CdS thin films have been prepared by spray pyrolysis technique. The solution consists of an appropriate aqueous solution of cadmium chloride [$CdCl_2 \cdot 2H_2O$] and thiourea [$CS(NH_2)_2$]in presence of Ammonia surfactant. These CdS thin films were fabricated by spray pyrolysis technique, maintaining parameters such as the solution flow rate-3 ml/min, nozzle to substrate distance-35cm and substrate temperature-300^{0}C. The structural and optical properties of CdS thin films have been investigated by X-ray diffraction (XRD), Scanning Electron Microscope (SEM) and UV-Visible absorption spectroscopy respectively.
Keywords--Spray pyrolysis; CdS Thin film; XRD; SEM; UV-Vis.

Introduction and Experimental

CdS thin films are II-VI semiconductor materials having an energy band gap of 2.42 eVat room temperature. CdS is one of the important materials for the applications in optoelectronic devices [1]. Many methods are used for preparation of CdS thin film such as PVD, CVD, PLD, Sputtering, CBD and Spray pyrolysis method. When comparing all these methods the best method is Spray pyrolysis method, because of simple, faster and uniform deposition of thin films [2]. Spray pyrolysis is a technique which is used to prepare thin films, thick films, ceramic coatings and powders.Thin films are acting as important role in solid state technology. Due to uniform deposition and low production cost the thin films fabricated through this technique are used in various optoelectronic devices [3].

Fabrication of Thin film: Cadmium sulphide (CdS) thin films were fabricated by spray pyrolysis technique, dissolving the precursor materials $CdCl_2 \cdot 2H_2O$ and CH_3CSNH_2 in the required molar ratio in double distilled water along with the ammonia surfactant. The amount of solution was made together as 50ml. The aqueous solution was then sprayed on the preheated glass substrate maintained at temperature 300°C. The structural and optical properties of CdS thin films were studied by XRD, SEM and UV-Visible spectrometer [4].

Results and Discussion

The XRD pattern of CdS thin film is as shown in figure 1. The structure shows that the CdS thin film was in hexagonal phase and these results were matched with standard XRD data JCPDS card number 02-0549. A single peak represented at 25° with the (1 0 0) orientation plane direction. The lattice parameters of the thin film was measured from the above JCPDS card data, i.e. a=b= 4.181 A°, and c=6.682 A°. The width of the peak obviously designates that the dimensions are in the nano range.

The average grain size was measured by Debye-Schereer's equation,

$$D=K\lambda/\beta.\text{Cos}\theta \qquad (1)$$

Where D-is the average grain size of the thin film, λ-is the wavelength of the radiation, β-is the full width half maximum (FWHM) of the peak and θ-is the Bragg's angle.

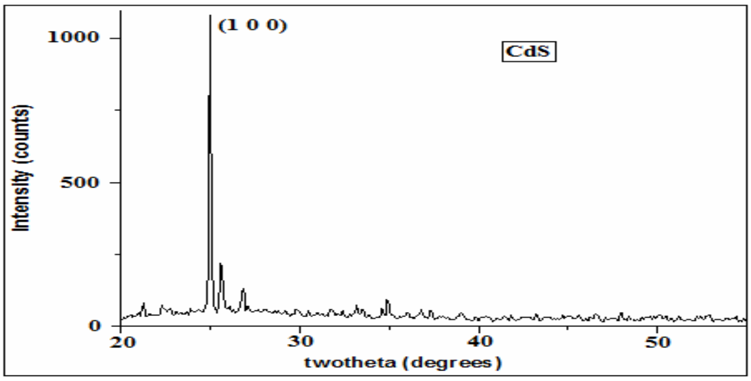

Figure 1. XRD pattern of CdS thin film

The measured average grain size was 11 nm [5].

The grain size, shape and surface properties like morphology were observed by the Scanning Electron Microscope. The SEM image of CdS thin film is as shown in figure 2.This image shows that the film exhibits rough surface and strips like structures.

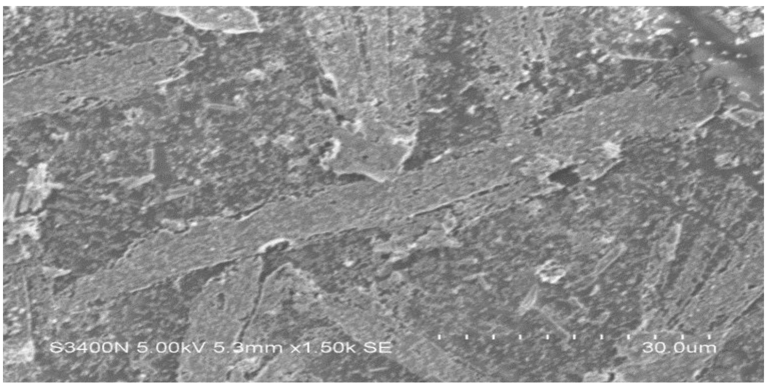

Figure 2. SEM image of the CdS thin film

The optical absorption spectra of the film deposited on glass substrate were studied in the range of 300–1100 nm wavelengths. The above film shows good absorption in entire UV region and a part of visible region. The absorbance was uniform for most of visible region and lower absorbance in infrared region.

The absorption co-efficient (α) of CdS thin films were measured using below equation

$$\alpha=4\pi K/\lambda \qquad (2)$$

Where K is absorbance and λ is wavelength.The thickness of the films have been measured using below equation

$$t=2.303A/\alpha \qquad (3)$$

Where A is absorbance, α is absorption co-efficient. The thickness of the spray pyrolysis deposited CdS thin film was 118 nm.

The absorption spectra, which are the most direct and perhaps the simplest method for probing the band structure of semiconductors, were employed in the determination of the energy gap. The optical band gap was calculated using the Tauc-relation which is given by the formula

$$(\alpha h\vartheta) = A\,(h\vartheta - Eg)^n \qquad (4)$$

Where A is absorbance, hϑ is the photon energy, Eg is optical band gap of the material and α is the absorption coefficient, while n depends on the nature of the transition. For direct transitions n = ½ or ⅔, For indirect transitions n = 2 or 3.

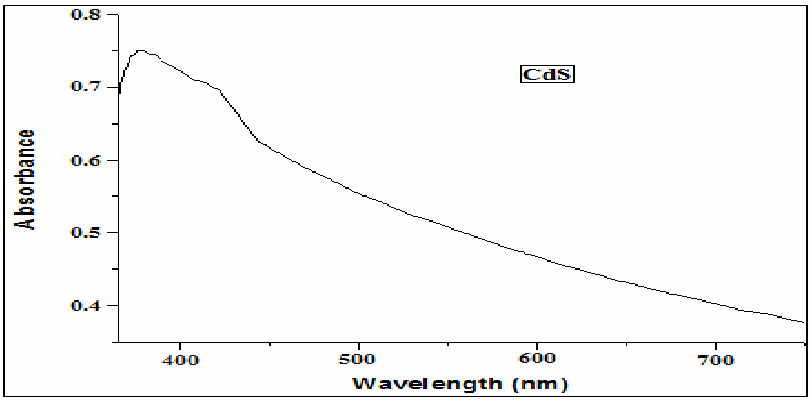

Figure3. Absorption spectrum of CdS thin film

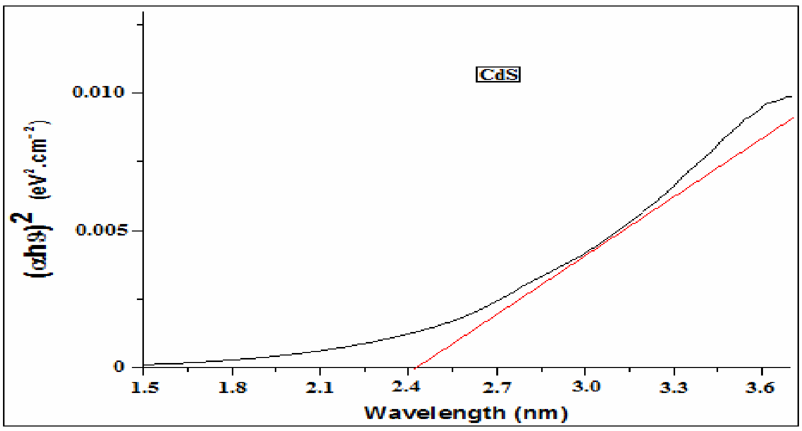

Figure 4. Photon energy of CdS thin film from Tauc-relation

The direct band gap of the films were obtained from the linear portion of $(\alpha h\vartheta)^2$versus hϑ plot as shown in figure 4. The calculated direct band gap was 2.48 eV for CdS thin film.

Conclusions

The CdS thin film was successfully deposited on glass substrate using spray pyrolysis technique at 300°C substrate temperature. XRD results showed that the structure of the CdS thin film was in hexagonal phase. The average grain size was measured to be 11 nm, using Debye-Scherer's formula. The SEM image of CdS thin film showed rough surface and strips like structure. The optical studies showed that the film have high absorbance in the visible region of the spectrum and high transmittance in the NIR region and therefore can be used as solar control device or selective absorber surface device. The thick ness of the film is 118 nm and from

Tauc-relation the calculated band gap was 2.48 eV. This is a way of achieving band gap tuning in semiconductor materials and hence the development of new thin films for efficient photovoltaic application.

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