www.sphinxsai.com

ChemTech

International Journal of ChemTech Research
CODEN (USA): IJCRGG ISSN : 0974-4290
Vol.6, No.3, pp 1913-1915, May-June 2014

ICMCT-2014 [10th – 12th March 2014]
International Conference on Materials and Characterization Techniques

Investigations on structural and optical properties of CdS films fabricated by spin coating technique for optoelectronic applications

I. Rathinamala[1], J. Pandiarajan[2], N. Jeyakumaran[2], N. Prithivikumaran[2]*

[1]Department of Physics, [2]Nanoscience Research Lab
[1]V.V.Vanniaperumal College for Women, [2]VHNSN College,
Virudhunagar, Tamilnadu, India.

***Corres.author: janavi_p@yahoo.com**

Abstract: Nanocrystalline Cadmium Sulphide (CdS) thin films were fabricated by employing an in expensive, simplified sol- gel spin coating technique on microscopic glass substrates. The effect of annealing time on surface morphological, structural and optical properties of the films was studied. SEM studies reveal that the grains are spherically shaped and distributed uniformly over the entire surface of the substrate. The crystallite size obtained through the XRD analysis was found to increase with increase in annealing time, varying from 6.1 nm to 9.3 nm. The films show a predominant hexagonal crystal phase with (0 0 2) orientation plane. The UV-Visible spectral analysis showed that the band gap value decreased with increase in annealing time. These surface morphological, structural and optical study results suggest that the nanocrystalline CdS thin films could be a potential candidate for designing optoelectronic devices.
Keywords - CdS Thin Films; Spin Coating Technique; SEM; EDAX; XRD; UV – Visible.

Introduction and Experimental

Cadmium Sulphide (CdS) nanocrystalline thin films belonging to the cadmium chalcogenide family continues as a subject of intense research due to its potential applications in solar cells especially as a window material for CdS/CdTe solar cells because of its suitable band gap and stability. CdS is one of the important II – VI group semiconductor with a direct band gap of 2.42 eV [1]. Among the various available techniques to coat CdS thin films, the sol – gel spin coating method has many advantages such as simplicity, low cost, and its ability to obtain uniform films with good adherence and reproducibility [2].

In this article we report about the preparation of nanocrystalline CdS thin films using sol – gel spin coating method and also discuss about the effect of annealing time on structural, surface morphological and optical properties of the prepared CdS thin films.

For the deposition of CdS thin film by sol – gel spin coating method two solutions have been prepared. Polyethylene Glycol was dissolved in ethanol and acetic acid was added to ethanoic solution under stirring which was continued for one hour (Solution 1). Cadmium nitrate and thiourea were dissolved in ethanol under stirring and the stirring was continued for one hour (Solution 2). Solution 2 was mixed to Solution 1 and was stirred again for 4 hours to obtain the final sol for deposition of thin films. The spin coating technique was used to deposit thin films using above sol on glass substrates rotating at a speed of 1000 rpm for 30 s. After deposition, annealing of the samples was carried out to remove the solvent and organic residuals. In this work the films were post annealed in air at 300^0C for 45 minute. As a annealing time is one of the parameter, which may influence the stiochiometry and structural properties of the films, in order to study the influence of annealing time on the film properties, two more samples with the annealing time of 60 minute and 75 minute were also prepared.

Results and Discussion

Surface Morphological Analysis

The surface morphology and the elemental analysis of the CdS films were analyzed by scanning electron microscopy and Energy Dispersive X – ray Spectroscopy (EDAX) respectively. The corresponding images of the films are shown in Figure 1. Excepting some small voids and pores, the SEM images of all the films show uniform surface having perfectly spherical grains with well defined grain boundaries. No cluster formation is observed and the grains appear homogeneous and uniform, suggesting uniform nucleation throughout the substrate surface. The micrographs depict that the grains of the CdS films are tightly packed and consequently the surface of the film looks more continuous.

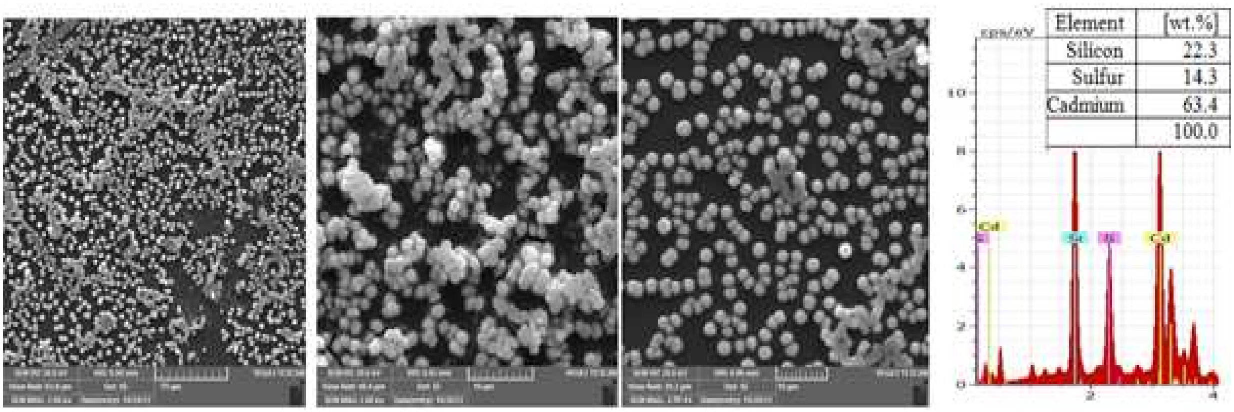

Figure 1: Scanning electron micrograph & EDAX spectra of CdS thin films

From the SEM images, the grain size values of the CdS films were found to be in the range of 950 nm to 1100 nm. The grain size and configuration of the deposited chalcogenide films depend on many parameters such as composition of the solution, deposition time, and nature of the substrate etc. The presence of Si in the EDAX spectrum of the deposited film may be resulted due to the glass substrates.

Structural and Optical Analysis

The structural properties of the spin coated CdS films have been investigated by X – Ray Diffraction (XRD) technique. The patterns show an intense peak at 26.72º indicating a strong preferred orientation along the (0 0 2) plane of the hexagonal phase. The intensity of the (0 0 2) peak found to increase with increase in annealing time of the films. The preferred orientation of CdS film is due to the controlled nucleation process associated with the low formation rate of cadmium sulphide [3]. The average crystallite sizes have been obtained from the XRD pattern using the Debye - Scherrer's formula,

$$D = \frac{k\lambda}{\beta\cos\theta}(nm) \quad (1)$$

where, D is the average crystallite size, k is a constant taken to be 0.94, β is the full width at half maximum (FWHM), θ is the Bragg angle and λ is the wavelength of the X– ray source. The presence of the broad dominant peak in the XRD graph reveals that the CdS thin films are nanocrystalline in nature. As the annealing time is increased, it is seen that crystallite size of CdS particles increases from 6.1 nm to 9.3 nm (Table 1). The crystalline sizes revealed from the SEM pictures are higher than the average crystallite size values calculated from the XRD peaks. Such a difference might be due to the presence of some amorphous phase in the films along with their predominant crystalline phase [4].

The optical study of the spin deposited CdS thin films was done in the wavelength range of 200 – 800 nm. Figure 2 shows the XRD pattern, optical transmittance and direct band gap plots of CdS films annealed at 300^0C for different annealing time.

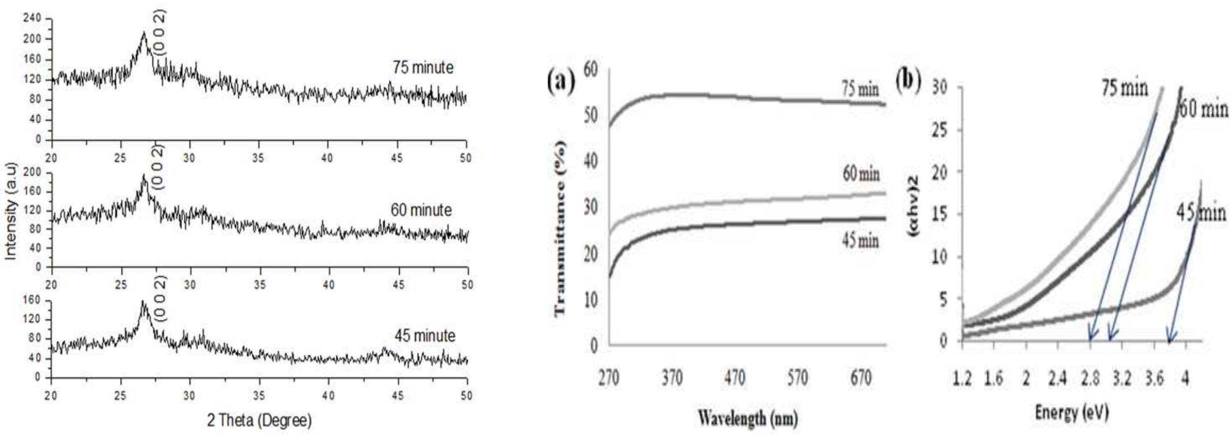

Figure 2: XRD pattern, Optical transmittance and direct band gap of CdS thin films

The transmittance of the films was found to increase considerably with annealing time. As the annealing time increases the band gap decreases according to the UV – Visible absorption spectral study. The band gap energy of the films was determined by studying the dependence of the absorption coefficient α, on photon energy hν, using Tauc's plot as,

$$\alpha h\upsilon = A\,(h\upsilon - E_g)^{1/2} \qquad (2)$$

where A is a constant, E_g is the band gap energy, hν is the photon energy.

Table 1: Structural and Optical data of CdS thin films

Annealing Time (Minute)	X – ray Diffraction Study			UV – Visible Spectral study	
	2 Theta (deg)	d – spacing (Å)	Crystallite Size D (nm)	Optical Band gap (eV)	Transmittance (%)
45	26.72	3.34202	6.1	3.8	23
60	27.10	3.35383	7.8	3.1	28
75	26.52	3.35546	9.3	2.8	54
JCPDS No: 06 - 0314	26.66	3.36700	-----	-----	-----

The optical band gap values obtained (Table 1) using the absorption spectra are greater than the bulk band gap (2.42 eV) and this indicates the formation of nanoparticles and presence of quantum confinement effect in the prepared CdS thin films. The above results suggest that the annealing time has influence over the structural and optical properties of cadmium sulfide films.

References

1. Trujillio O., Moss R., Vuong K.D, Lee D.H., Noble R., Finnigan D., Orloff S., Tenpas E., Park C., Fagan J. and Wang X.W., CdS thin film deposition by CW Nd: YAG laser, Thin Solid Films, 1996, 290-291, 13 - 17.
2. DiLuccio T., Piscopiello E., Laera A.M. and Antisar M.V., Structural studies of thin films of semi conducting nanoparticles in polymer matrices, Mater. Sci. Eng. C, 2007, 27, 1372 - 1376.
3. Wenyi L., Xun C., Qiulong C. and Zhibin Z., Influence of growth process on the structural, optical and electrical properties of CBD - CdS films, Mater. Lett, 2005, 59, 1 - 5.
4. Pal U., Silva–Gonzalez R., Martinez–Montes G., Gracia–Jimenez M., Vidal M.A. and Torres Sh., Optical characterization of vacuum evaporated cadmium sulfide films, Thin Solid Films, 1997, 305, 345 - 350.

*****