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Preparation and Studies of Nanostructured Thin Films of $(CdS)_{0.8}$ $Se_{0.2}$

M S Kale[*], N T Talele [**], D S Bhavsar[*]

[*] Department of Electronics, Pratap College Amalner, MS, India 425001,
[**] Department of Applied Physics, JTM College of Engineering Faizpur, MS, India 425524

Abstract- The $(CdS)_{0.8}Se_{0.2}$ thin films were prepared through using thermal evaporation technique onto rotating microscopic glass substrate. The obtaind samples are studied by X-ray Diffraction (XRD), Atomic Force Microscopy (AFM), Scanning Electron Microscopy (SEM), and UV-VIS Spectroscopy. The micro structural futures are obtained with help of XRD pattern, which confirms the films are polycrystalline in nature having hexagonal structure. The AFM images revealed that, sample consists of well defined nano sized grains with almost uniform size distribution. SEM observation depicts the uniform distribution of grains and all the grains are spherical in nature. The absorbance spectrum exhibits absorption to be dominating mainly in visible spectrum. The variation of optical band gap was represented as a function of thickness.

Index Terms- XRD, AFM, SEM, UV-VIS

I. Introduction

The II-VI group semiconductor especially cadmium sulphoselenium is an important alloy with excellent properties like, good photo conductivity material, response time and band gap [1]. In $CdS_{1-x}Se_x$ the band gap and physical properties can be tailored by doping concentration of Se. [2]. The ternary CdS-Se alloy is found to be an important semiconductor material in wide industrial application because of their excellent optical and mechanical properties. Commercially, this material is used for optical filters, LSI circuits, Discrete and multi element photo resistor, signal memory device, optoelectronic switches, LIS integration, electro photography [3], optical wave guide [4], temperature fiber sensor [5], sharp-cut filter [6], and photo voltaic cell [7], etc.

The thin film synthesis technique affects the properties of the films. There are various techniques which are involved to prepare CdS thin films such as, vacuum evaporation [8] chemical deposition [9], screen printing [10], sputtering [11] and electro-deposition [12]. The vacuum evaporation is a very reliable technique for synthesis of thin film. The thin films prepared by vacuum evaporation technique are uniformed with excellent crystallinity, dense and highly oriented. The qualities and properties of film mainly depend upon pressure, deposition rate, substrate temperature and thickness of the film [13].

In the present work we have synthesized the $(CdS)_{0.8}Se_{0.2}$ alloy films using thermal evaporation techniques and further investigated the structural, micro graphical and optical properties of the films to employ this material for the production of photovoltaic devices.

II. Research elaboration

Preparation of Alloy

The ternary alloy of $(CdS)_{0.8}$ $Se_{0.2}$ compound were obtained melt quench method, by taking appropriate amount of 99.999% pure CdS and Se in an evacuated quartz ampoule. The ampoule with the charge was then sealed under a pressure of 10-6 mbar and was placed in rotating furnace. The temperature of the furnace was raised gradually to 1173 °K and left at this temperature for about 12 hrs. Well mixed charges were then quenched in an ice bath. The $(CdS)_{0.8}$ $Se_{0.2}$ ingot was taken out from the ampoule and made into fine powder and used for film preparation

Synthesis of Thin Film

The films of Cadmium Sulphoselenium $(CdS)_{0.8}Se_{0.2}$ were grown by thermal evaporation technique under pressure of 10^{-5} torr. The source to substrate distance was kept 14 cm. The samples of different thicknesses were deposited under similar conditions. The thickness of the films was monitored by quartz crystal thickness monitor model No. DTM-101 provided by Hind-Hi Vac. The deposition rate was maintained 8-10 Å/sec throughout sample preparation. Before evaporation, the glass substrates were cleaned throughout using concentrated chromic acid, detergent and acetone.

X – Ray analysis were done using Bruker diffractometer with CuKα line. The scanning angle (2θ) range was from 20° - 80°. Surface morphological study of deposited films was carried out by using Scanning Electron Microscope (Zeiss EVO 50), operating with an accelerating voltage 10 KV and Atomic Force Microscopy (AFM). The elemental analysis of the sample was carried out by EDAX (Energy dispersive X-ray Analyzer) technique attached with SEM. The optical abortion spectrums were recorded within the range of 200-900 nm wavelength with the help of UV-VIS Spectrophotometer (Shimadzu – 2600).

III. RESULTS

1. XRD

Figure 1 shows the XRD pattern of $(CdS)_{0.8}Se_{0.2}$ thin film having thickness of 3000Å.

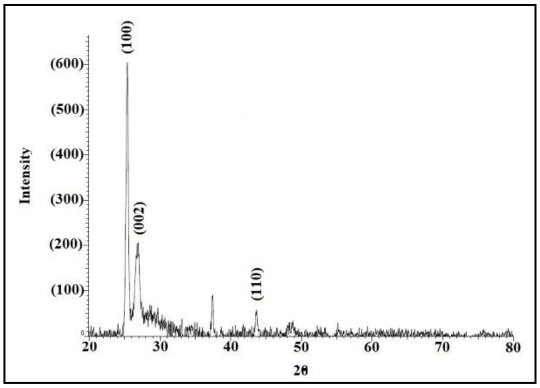

Figure 1 XRD Pattern of $(CdS)_{0.8}Se_{0.2}$ Thin Film

The 2θ peaks observed at 24.8 and 27.8 exhibit the formation of the hexagonal phase of (CdS)0.8Se0.2 which correspond to the (100), (101) planes of reflections. The presence of multiple peaks indicates that the films are polycrystalline in nature. The strong and sharp diffraction peaks show the formation of well crystalline sample. The intensity of the peaks depends on crystalline quality. The average grain size is found to be 251.6 Å by Debye - Scherrer formula,

$$d = \frac{0.94\,\lambda}{\beta\, cos\theta}$$

Where λ is the wavelength of X-Ray source, θ is the diffraction angle, β is Full Width Half Maxima. The value of the lattice parameters obtained from the analysis of x-ray diffraction pattern is a = 4.15 Å, c = 6.76 and unit cell volume was estimated as 101.08 Å.

2. AFM

The surface topology and roughness was studied with the help of AFM. Figure 2 shows 3D image of sample surface with 100 μm^2 areas.

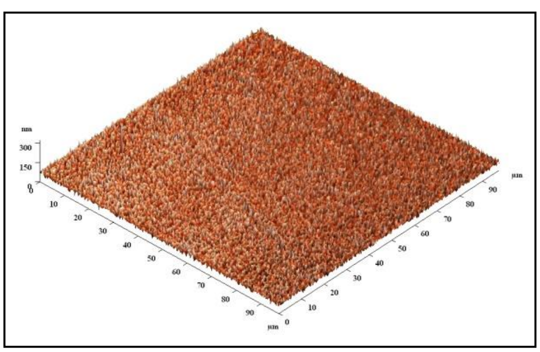

Figure 2 AFM of $(CdS)_{0.8}Se_{0.2}$ Thin Film

The image shows well defined particle somewhat elongated morphology. It should be noted that both height and diameter of islands are of the order of same size. The root mean square value of the surface roughness of the films from different area of the film was calculated. It was observed that the surface roughness of the film is 16nm. This observation infers that the film surface is smooth.

3. SEM:

The SEM micrograph of $(CdS)_{0.8}Se_{0.2}$ Thin Film is shown in figure 3.

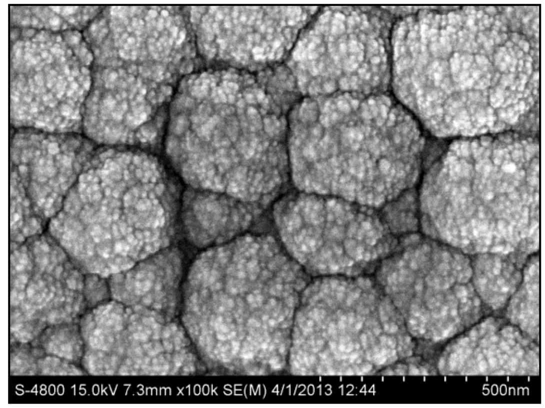

Figure 3 SEM image of $(CdS)_{0.8}Se_{0.2}$ Thin Film

SEM images of $(CdS)_{0.8}Se_{0.2}$ Thin Film on the glass substrates reveals the uniform distribution of spherical grains over total coverage of the surface of the substrate. The surface showing uniform and smooth spherical grains without any defects like cracks and pinholes. The average microcrystalline size was found to be within the range of 170-221 nm. On the other hand crystalline dimension of the same sample as determined by using XRD analysis is 251nm.

4. EDAX:

The elemental composition of $(CdS)_{0.8}Se_{0.2}$ Thin Film was determined by using Energy Dispersive Analysis by X rays, attached with SEM, is shown in figure 4.

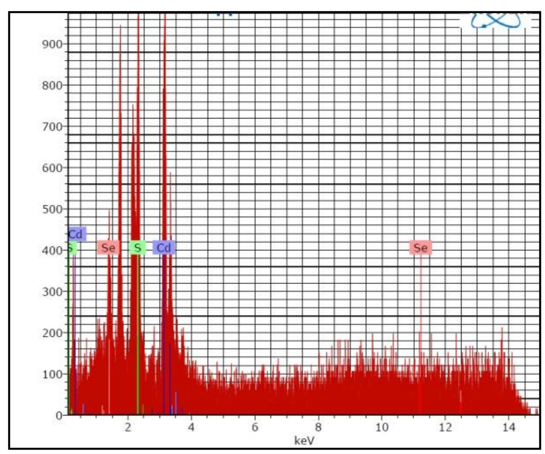

Figure 4 EDAX Pattern of $(CdS)_{0.8}Se_{0.2}$ Thin Film

The average atomic percentage of Cd, S and Se was found to be (44.49) : (46.83): (8.68) respectively. The presence of other peaks in spectrum is may probably result from glass used as substrate.

5. UV-VIS:

The optical band gap of the films was estimated with the help of absorbance and transmission spectra recorded in 200-900 nm wavelength range by employing a Shimadzu 2600 UV-VIS Spectrophotometer.

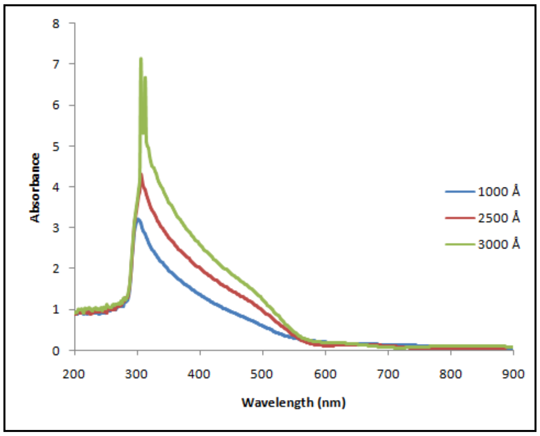

Figure 5 Absorbance Spectra of $(CdS)_{0.8}Se_{0.2}$ Thin Film

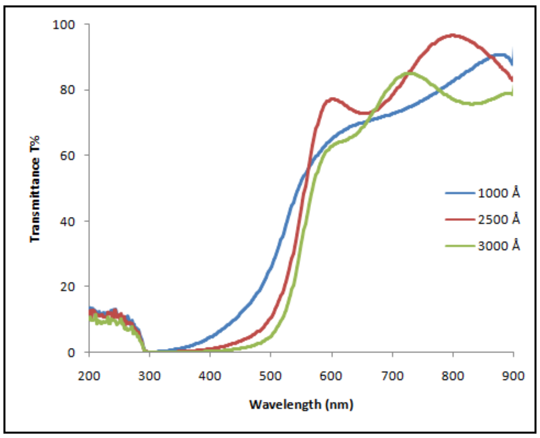

Figure 6 Transmittance Spectra of $(CdS)_{0.8}Se_{0.2}$ Thin Film

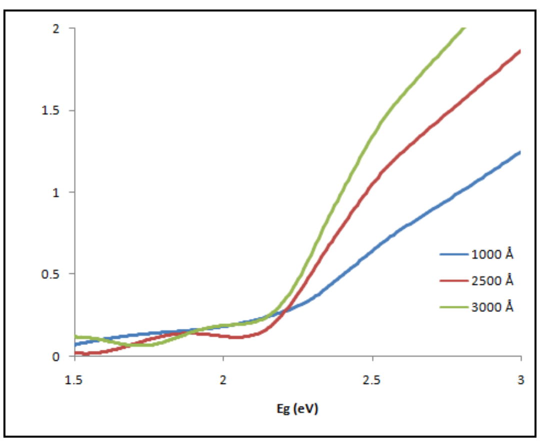

Figure 7 Plot of Energy Band Gap of $(CdS)_{0.8}Se_{0.2}$ Thin Film

It is observed that the absorbance of the $(CdS)_{0.8}Se_{0.2}$ films enhance continually from the near IR towards the visible region. The highest absorbance is found at wavelength near 300 nm. It is observed that as deposited $(CdS)_{0.8}Se_{0.2}$ thin films have lower transmittance in the UV visible region and moderate to higher transmittance in the IR region as shown in Figure 6. This higher transmittance of $(CdS)_{0.8}Se_{0.2}$ films makes it suitable as a window material for fabrication of PV devices. The band gap energy (Eg) of $(CdS)_{0.8}Se_{0.2}$ thin films were obtained from absorbance spectra for the corresponding wavelength graphs as shown in figure 7. The estimated value of the band gap energy is 2.0 – 2.2 eV.

IV. CONCLUSION

The XRD study illustrates the formation of polycrystalline $(CdS)_{0.8}Se_{0.2}$ thin film having hexagonal structure. The AFM images reveals that, sample consists of well defined nano sized elongated grains with almost uniform size distribution while SEM reveals that films were uniformly deposited over the substrate and particles were found to be spherical in shape. The presence of elemental constituents was confirmed with the help of EDAX spectrum. The optical band gap of the sample varies from 2.0 to 2.2 eV which can be used for efficient photo voltaic devices.

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AUTHORS

First Author – M. S. Kale, M.Sc., Pratap College Amalner, milindkale616@yahoo.com
Second Author – N. T. Talele, M.Sc., JTM College of Engineering Faizpur, narayantalele@rediffmail.com
Third Author – D. S. Bhavsar, Ph. D., Pratap College Amalner, deelip_bhavsar4@yahoo.com.

Correspondence Author – M. S. Kale, milindkale616@yahoo.com, deelip_bhavsar4@yahoo.com,
Contact number- 9975343123.