STRUCTURAL PROPERTIES OF THE PHOTOCHEMICALLY GROWN CdS THIN FILMS

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Cadmium Sulfide (CdS) thin films were successfully deposited on glass (SLG) substrate using photochemical deposition technique. The films were characterized for structural investigations by X-Ray Diffraction (XRD), Atomic Force Microscopy (AFM). X-ray diffraction patterns showed that the films have highly oriented crystallites with a preferential orientation along the c-axis (002) perpendicular to the substrate plane. AFM measurements showed that the average grain size of the CdS thin films is 480 nm.

Keywords: CdS thin films, photochemical deposition, atom force microscopy, grain size.
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1. INTRODUCTION

Recently, CdS thin films have received intensive attention due their very important role on the photovoltaic technology and optoelectronic devices. Cadmium sulfide (CdS) thin films are widely used as universal window layers in thin film solar cells based on the different active-layer materials, such as cadmium telluride (CdTe), copper indium diselenide (CIS), and copper indium gallium diselenide (CIGS) [1-4]. CdS has a band-gap of 2.42 eV which causes considerable absorption of sunlight in the short wavelength region. CdS thin films has been obtained by several methods, such as, electrodeposition, vacuum evaporation, screen printing, photochemical deposition, CBD, spray pyrolysis, and sputtering. The experimental details of deposition of CdS thin films by photochemical deposition (PCD) are reported earlier [5]. In [6, 7] showed schemes for the photochemical deposition of CdS thin films.

In this work, an attempt was made to obtain thin CdS films by photochemical deposition using a system of ultraviolet lamps with a total power of 60 W. The results of structural characterization of the films are given.

2. EXPERIMENTAL

The scheme presented in this work for photochemical deposition is very simple and inexpensive. It is assembled from several UV lamps with a total power of 60 W. Fig.1 show construction for photochemical deposition of CdS. Ultraviolet light falls on the converging lens, the UV rays are collected and placed on a glass base placed in a specially prepared solution, depending on the composition of the solution, a suitable layer can be obtained. The following solution is prepared to obtain a thin films of CdS: to prepare the aqueous solution, mix 75 ml of 0.2 M cadmium sulphate ($CdSO_4$) and 50 ml of 0.2 M sodium thiosulfate ($Na_2S_2O_3$) and place in a test glass with a diameter of 10 cm. A magnet is placed inside the glass flask and the glass flask filled with solution is placed on maqnetic stirrer. After a few seconds, H_2SO_4 is added. The speed of the stirrer is 300 rpm. The settling process is carried out at room temperature for 1.5 hours. After deposition, the films were annealed at a temperature 500^0C. The thicknesses all of the studied films determined from the spectroscopic ellipsometry fit were around 300 nm. The power of the UV radiation source is 60 W.

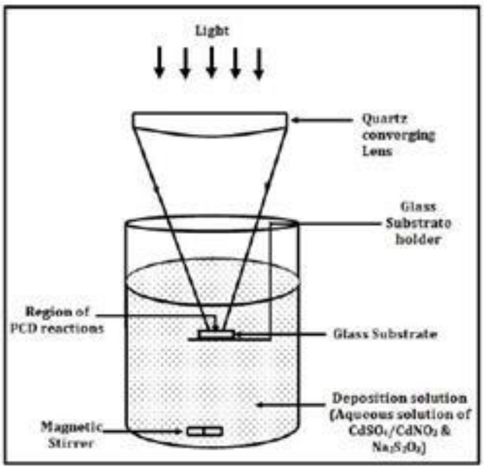

Fig.1. Construction for photochemical deposition of CdS thin films.

Photochemical reaction for deposition of CdS thin films:

$$CdSO_4 \rightarrow Cd^{2+} + SO_4^{2-}$$

In aqueous solution, $Na_2S_2O_3$ decomposes into the following ions

$$Na_2S_2O_3 \rightarrow 2Na^{+} + S2O_3^{2-}$$

Free sulfur is released as a result of dissociation during irradiation

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$$S_2O_3^{2-} + h\nu \rightarrow S + SO_3^{2-}$$

It is known that sulfur can be released in an acidic environment

$$2H^+ + S_2O_3^{2-} \rightarrow S + H_2SO_3$$

Electrons are formed under the influence of UV radiation of $S_2O_3^{2-}$ions

$$2S_2O_3^{2-} + h\nu \rightarrow S_4O_6^{2-} + 2e^-$$

Electron generation can also occur when SO_3^{2-} and $S_2O_3^{2-}$ ions combine under UV radiation.

$$SO_3^{2-} + S_2O_3^{2-} + h\nu \rightarrow S_3O_6^{2-} + 2e^-$$

and finally step

$$Cd^{2+} + S + 2e^- \rightarrow CdS$$

X-Ray diffraction (XRD) analyses of the CdS thin films were carried out using Bruker D2 Phaser (Germany) diffractometer in θ-2θ scan mode with Ni-filtered CuKα radiation (λ=1.54060 Å) source.

Topography analysis of the thin films was performed in Smart SPM 1000 AIST NT (Tokyo Instruments, Japan).

3. RESULTS AND DISCUSSION

The XRD patterns of the CdS thin films deposited by PCD and annealed at 500^{0}C exhibit prominent broad peaks at 26.5^0 and 44^0 which can be attributed to hexagonal wurtzite structure with p63mc space group and lattice parameters *a* and *c* of 4.121 Å and 6.716 Å, respectively. The films have highly oriented crystallites with a preferential orientation along the c-axis (002) perpendicular to the substrate plane.

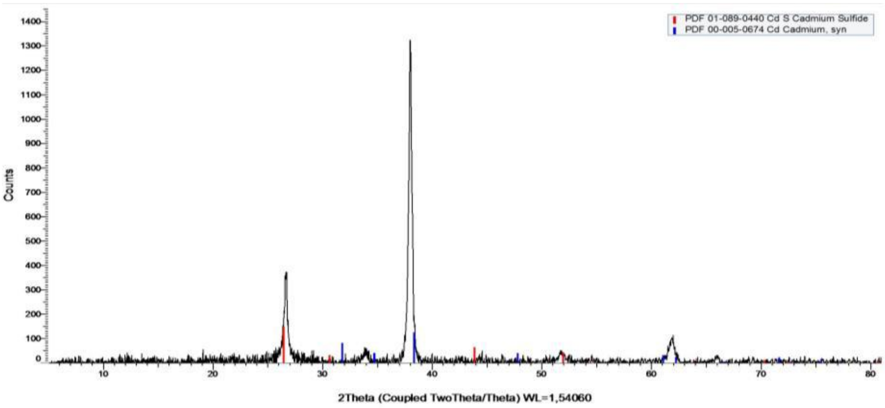

Fig.2. X-ray diffraction spectra of CdS thin films deposited by PCD.

Atom Force Microscopy (AFM) measurements were performed to study of surface morphology of the CdS thin films. Figure 3. illustrates the AFM images of the films annealed at 500^{0}C (Fig.3a- 2D image), Fig. 3b- 3D image). Scanning area is 1.0 x1.0 μ^2. AFM measurement results showed that the grain sizes of the CdS thin films is 480 nm.

a) b)

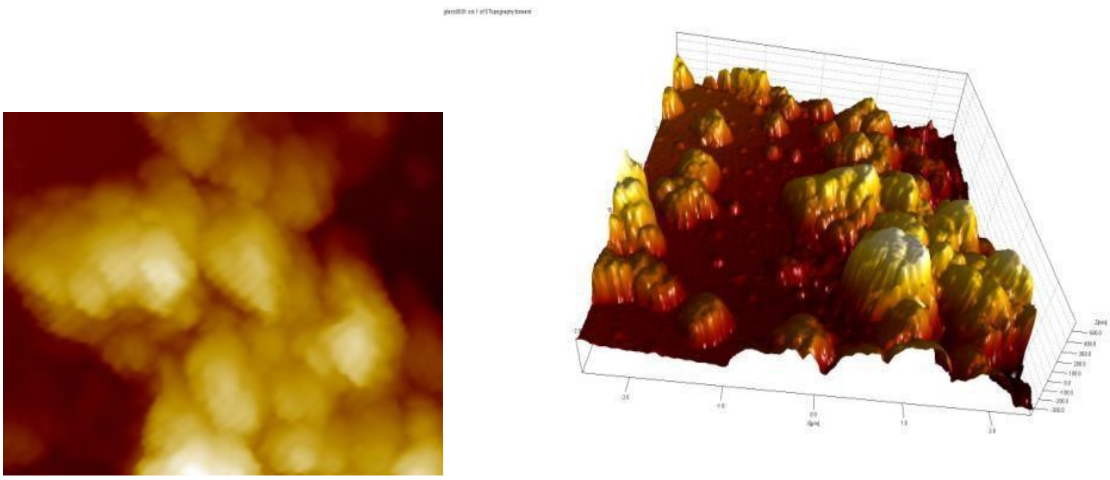

Fig. 3. AFM image of CdS thin films (a-2D image, b-3D image.

4. CONCLUSION

CdS films were successfully obtained under ultraviolet irradiation with a power of 60 W on glass substrates. The X-ray analyses of the CdS thin films deposited by PCD and annealed at 500^0C exhibit peaks at 26.5^0 and 44^0 which can be attributed to hexagonal wurtzite structure with p63mc space group and lattice parameters *a* and *c* of 4.121 Å and 6.716 Å, respectively. AFM measurement results showed that the grain sizes of the CdS thin films is 480 nm. Large grain size means smaller pinholes between grains, which is the reason for the reduction of defects. And this, in turn, can lead to an increase in the efficiency of future thin-film solar cells, the window layer of which is CdS.

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