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The Effects of Sputtering Time on Cds Thin Film Solar Cell Deposited by DC Plasma Sputtering Method

Azhar K. Sadkhan
Applied Science Department, University of Technology, Baghdad, Iraq.

Sabah H .Sabeeh
Applied Science Department, University of Technology, Baghdad, Iraq.
sabahhabeeb@gmail.com

Mohammed K. Khalaf
Ministry of Science and Technology, Baghdad, Iraq.
azharazhar118@yahoo.com

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***Abstract**-CdS thin films of different thickness have been prepared by dc sputtering technique on glass slides for a window layer of solar cells. The CdS target were sputtered in different sputtering times (1,1.5,2.5,3) hrs, working pressure (2×10^{-2}) mbar and discharge voltage(2) kV.The structure of the nanoparticles films was investigated of CdS thin films by X-ray diffraction (XRD).The XRD patterns showed that the films were hexagonal (wurtzite) structure having strong preferential orientation along the (002) plane with particle size in the range of (41.04-41.46-41.88-42.53) nm, the peak at (002) preferred orientations of the films are shifted a little from left to right side and films converted to crystalline form. The morphology of the nanoparticles films was studied by atomic force microscopy (AFM) which indicates that the average grain size of CdS thin film is in the range of (41.3-44.2-51.6-50.08) nm. The roughness of films surface increases with increasing the sputtering time, which can be useful for the solar cell.*

***Keywords**- Cadmium Sulphide, Plasma, DC sputtering*

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1. Introduction

Among the environmentally friendly PV applications is a solar cell. The solar cell is a device that converts sunlight directly into electricity in two different methods, solar thermal and photovoltaic effect [1].Thin film solar cells are significantly cheaper, since they use few micrometers or nanometer in thickness or fewer layers of semiconductor materials. Due to their flexibility. It can be put out onto roofs or other surfaces, or used for roof tops and floor flat, the surface of buildings and another flat base that exposed to the sun light [2]. Different type of the solar cells has been studied, but among them, the heterojunction thin film solar cells on single crystalline Si are preferred due to their high conversion efficiency [3]. CdS/Si solar cell, it has a wide and direct band gap of about 2.4 eV so CdS thin films are widely used as the window material in heterojunction solar cells to avoid optical transition losses [4]. CdS are a member of II-VI group of semiconductors[5,6].Pure CdS is normally an n-type semiconductor, this type of conductivity is essentially due to the non-stoichiometry arose from the excess Cd in the CdS lattice[7]. There are various methods employed for deposition the CdS thin films such as spray pyrolysis, pulsed laser deposition, chemical vapor deposition, chemical bath deposition, and sputtering [8]. In the present work, DC plasma sputtering technique has been used to prepare and study the effect of increasing the sputtering time on the structural properties of CdS thin films. The main advantages of this method are prepared thin films have good adhesion to the substrate, high purity thin film and keep the properties of the material after deposition as stoichiometric.

2. Experimental Details

PV Cells are made up of a PN junction fabricated in a thin wafer or layer of semiconductor (usually silicon). Homemade plasma sputtering system of dc plasma sputtering technique has been implemented to deposit CdS thin films on glass substrates. CdS target of 50mm diameter and 3mm thickness was housed in cathode assembly. The target sputtering carried out under a different sputtering time of order of (1, 1.5, 2.5, 3) hr and fixed working pressure (2×10-2) mbar of argon gas. The deposition glass substrates have washed by ethanol to remove any oil or dust on the substrates surface, then dried with soft or optical paper, and then this slides will be ready to be used. The (XRD) instrument was used in this work is Japanese type (Shimadzu 7000), with source radiation of Cukαwith 1.5406A wavelength, AFM Scanning prop microscope (SPM ntegra NT-MDT) was used to measure grain size and roughness of CdS thin films.(SEM) Japanese type with a magnification of 100000X used to study properties of films surface. More details are in our previous work [9].

3. Results and Discussion

The values of the film thickness as a function of the change of the sputtering time at 0.2mbar and discharge voltage was 2kV is given in Figure 1. From this figure, one can be noticed that the film thickness was increased when the sputtering time increased. This increase is due to the number of atoms deposited on the substrate with increasing the sputtering rate.

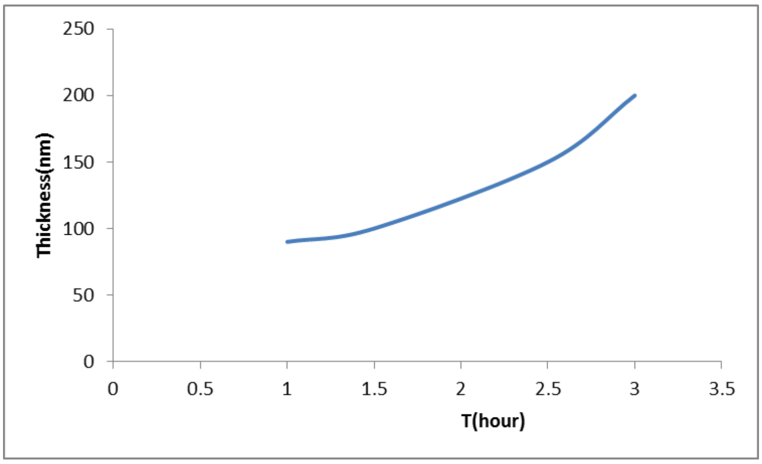

Figure 1: The variation of the films thickness as a function of sputtering time

Figure 2 shows XRD pattern of CdS thin films deposited at room temperature on glass substrates by using different sputtering time, it can be seen that the diffraction peak is sharp and well defined when the film that prepared with sputtering time (3) hour because have (200 nm) thickness more than the films which prepare in (1, 1.5, 2.5) hour, CdS films have (002) plane, this peak position of this figure closely corresponding to the peaks positions of (JCPDS) file no. (79-0043) is indicating that the film is polycrystalline in nature with hexagonal structure correspond to reflections from this plane that increasing with increase the sputtering time and the thickness of these films [10]. The crystallite size (D) of the CdS thin film was calculated using the full width at half maximum (FWHM) of the peak. It is calculated by using the Scherrer Debye equation (1) and all the results were shown in Figure 2 [11].

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

Where k is the shape factor which taken as 0.9, λ is the X-ray wavelength (1.5406A°), β is the full width at half-maximum (FWHM) and θ is the angle between the X-ray beam and the sample surface (Bragg'sangle) [11].

It is clear from the Figure 3, the grain size of the films increase with increasing sputtering time, this result due to increase the yield density of ejected atoms [12].

It can be observed that the root mean square having maximum values when the sputtering time equal to 3 hours which regarded the optimize value in the DC plasma sputtering system which was used in this work.

Table 1 shows the values of average grain size and roughness with different sputtering time. It is clear from the table that roughness increase when the sputtering time increase, Roughness is the most important parameter because an optimum roughness facility the photons absorption, a high roughness produces high absorbs of sun light due to increased number of photons falling on the surface of the surface deposition [13].

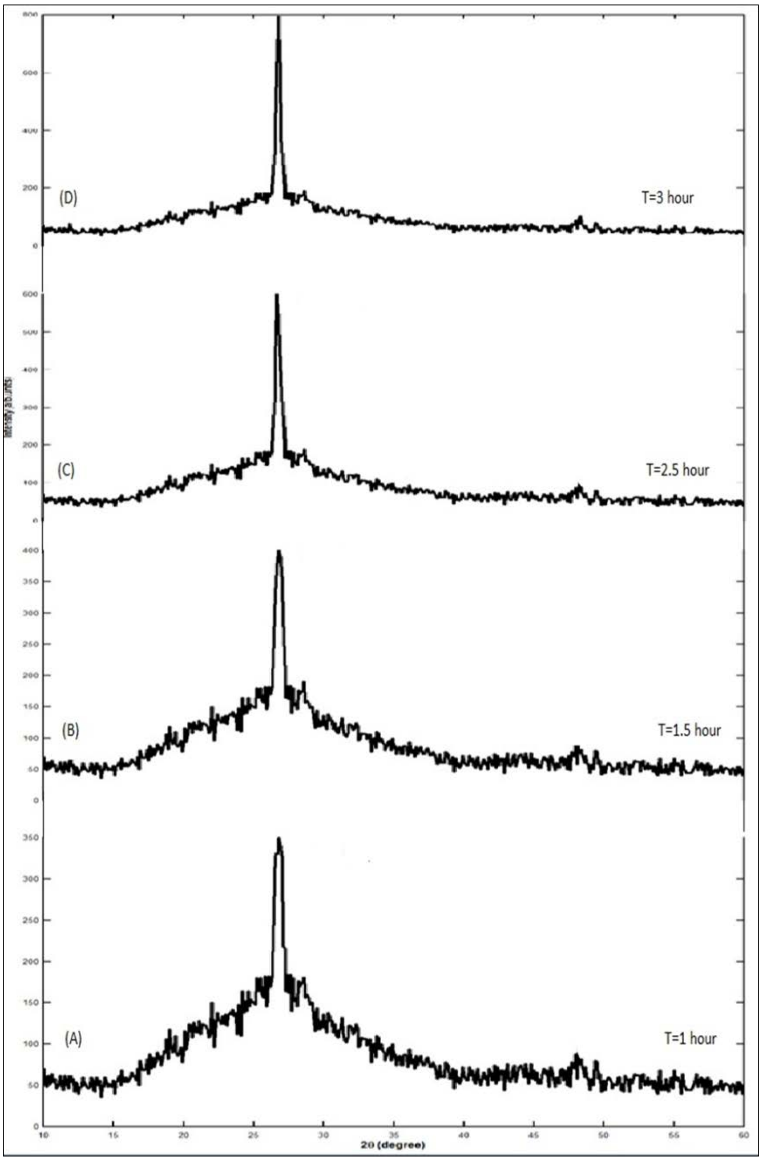

Figure 2: XRD pattern of hexagonal structure CdS thin film at (A) 1 hour (B) 1.5 hour (C) 2.5 hour (D) 3 hour with (P=2×10-2mbar, V=2Kv)

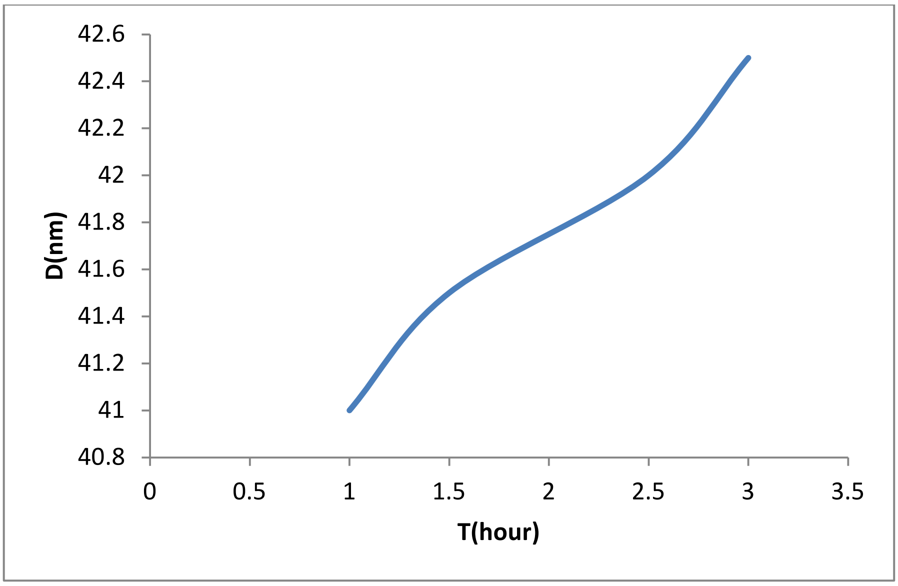

Figure 3: The variation of the grain size as a function of sputtering time

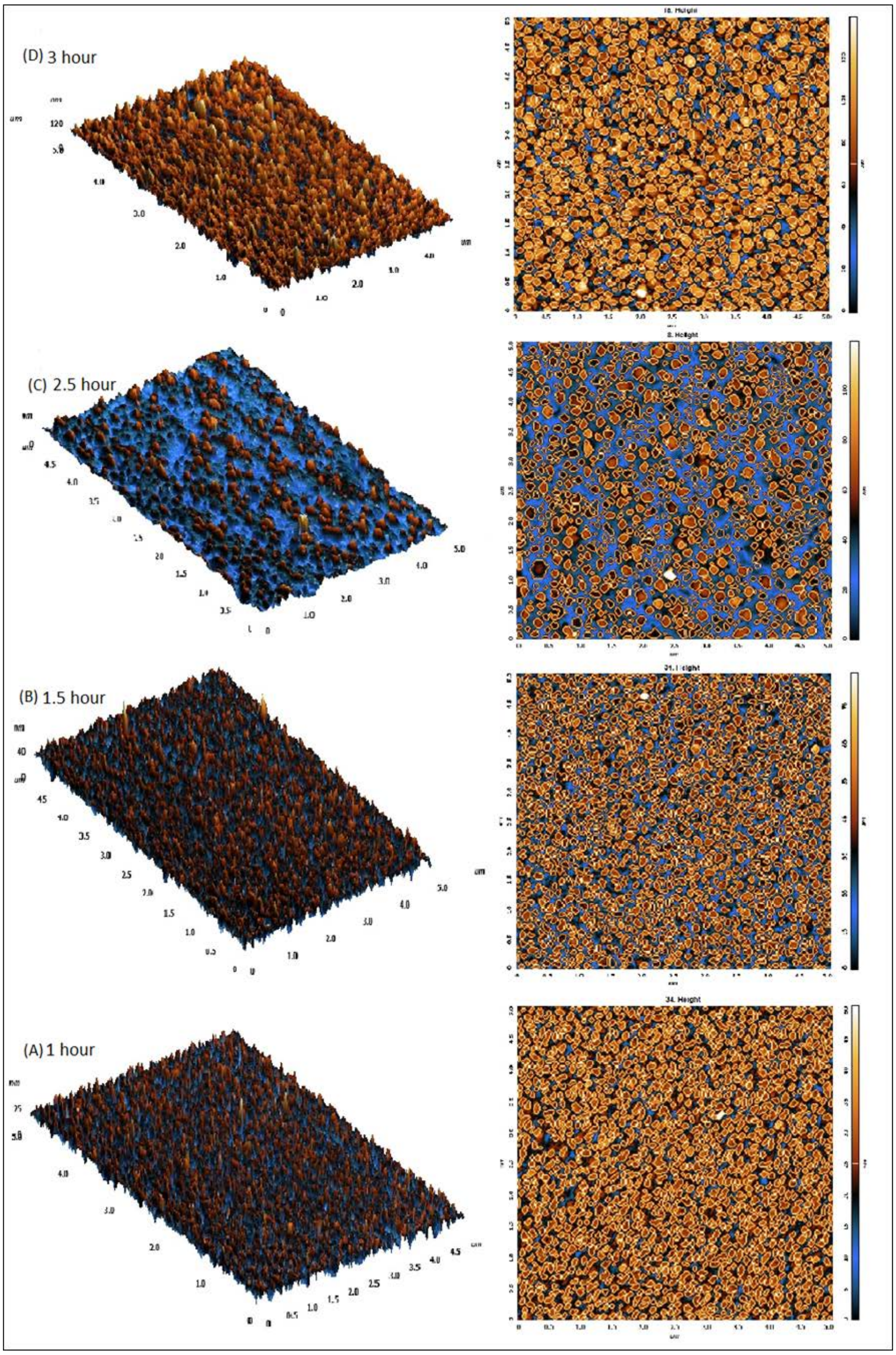

Figure 4: AFM images of CdS thin film at (A) 1 hour (B) 1.5 hour (C) 2.5 hour (D) 3 hour with (P=2×10-2mbar, V=2Kv)

Table 1: Values of grain size and roughness at different sputtering time

Sputtering time (hour)	Average grain size (nm)	Root mean square (nm)	Average roughness (nm)
1	41.3	4.131	3.270
1.5	44.2	6.752	5.328
2.5	51.6	12.393	9.601
3	50.08	17.150	13.650

4. Conclusion

A simple DC plasma sputtering technique was used to preparation of nanocrystalline, homogenous and dense CdS thin films. Our successful efforts of sputtered CdS films on substrates have been done by sputtering time have optimized to control the structural, morphology, crystallinity characteristic of CdS specimens. From XRD the CdS thin films are hexagonal structure; the diffraction peak is sharp and well defined indicating that the films are polycrystalline in nature. The results of AFM revealed that grain size and roughness increase with increasing the sputtering time and thickness. The CdS specimens have a good structural properties and hence suitable for solar cell application, as shown in our proviso work.

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