THE ROLE OF THICKNESS ON STRUCTURAL PROPERTIES OF THIN CdS FILMS PREPARED BY PULSE LASER DEPOSITION

M.F.A. Alias, Muhamed Salman and A.A.J.Al-Douri[1]

Department of Physics, College of Science, University of Baghdad
P.O. Box 47162 Jadiriyah, Baghdad, Iraq
[1]Department of Applied Physics, College of Sciences, University of Sharjah.UAE

Abstract

This paper describes the structural properties of thin cadmium sulphide (CdS) films deposited onto glass substrate prepared by using pulse laser deposition technique (PLD) at various thicknesses. The films structure was characterized by X-ray diffraction (XRD) and various structural parameters were reported as a function of film thickness. The XRD analysis confirmed that the prepared CdS films reveal cubic and mixed hexagonal and cubic phases with predominant (111) orientation. The crystallite grain size was found to be 12.1 and 51.9 nm for film thickness 130nm and 780 nm respectively.

Keywords: Polycrystalline CdS film, pulse leaser deposition, structural properties.

I. INTRODUCTION

Thin film has great importance in many fields ,like filters, capacitor, transistor, electric switches, solar cell and detectors[1].Cadmium sulphide (CdS) is an II-VI compound semiconductor and it is an n-type semiconductor with 2.42eV direct band gap ,also it is considered as one of important material for opto-electronic devices fabrication [2,3]. This material has also used as efficient window material in solar cells [4]. There are several techniques to prepare CdS thin film such as thermal evaporation, sputtering, chemical vapor deposition, electro deposition, spray pyrolysis, pulse laser deposition and chemical bath deposition [5-8]. The thin CdS films consist either in cubic (zinc blend) or hexagonal (wurtizite) phase, or even a single predominant phase with share the cubic and hexagonal phases [9,10].

In the present work, the structural properties of thin cadmium sulphide (CdS) films prepared using pulse laser deposition technique (PLD) are studied at various thicknesses. The roles of thickness on structural parameters are investigated.

II. EXPERIMENTAL PROCEDURE

Thin cadmium sulfide films were deposited onto glass slides substrate using pulse laser deposition technique. CdS pellet of 99.999 purity (from Blazers' company) were used as the source material. The temperature of the substrate was room temperature (300K). Thin CdS films were deposited at different thickness (t=130,330,470,670 and 780) nm. Film thickness measurement was done using optical interferometer method.

The structure of CdS films has been examined by Shimadzu X-ray diffraction (XRD) system with monochromatic Cu-Kα radiation. The evaluation of the grain size (G.S) was quantified by using Scherrer's formula [11,12].

$$G.S = k\lambda / B\cos\theta \qquad (1)$$

where k is the shape factor, which is approximately 0.9 and λ is the wavelength of the X-ray used (λ= 1.5406 Å), B is the full-width-at- half – maximum (FWHM) of the Bragg reflection under the considerations in radians and is θ is the angle between X-ray beam and reflecting planes)was used for the calculation of the crystallite sizes . The path difference is m λ and inter planner spacing (d_{hkl}) is determined using Bragg's equation [13].

$$2d_{hkl}\sin\theta = m\lambda \qquad (2)$$

III. RESULTS AND DISCUSSION

CdS thin films deposited onto the glass substrate were examined by X-ray diffraction (XRD) technique to find the structural characterization of the films. Figure (1) shows the typical XRD pattern of CdS thin film at 130nm thickness. All peaks are not sharp (broad peak) indicating that the average crystallite size is small (means that the structure is nano crystalline), which is due to size effect the peaks in diffraction broaden and their widths became large as the partials became smaller. The strong XRD peak observes at 2θ =25.52 corresponds to the diffraction angles of the (111) plane of cubic (zinc blend) CdS structure. The weaker peak is seen at 2θ equal to 42.23, 53.224 also corresponds to cubic CdS with (220) and (311) planes respectively. Therefore, the CdS film deposited on a glass substrate by plus Laser deposition has cubic structure .This results also indicates that the grown film is polycrystalline.

Figure (2) shows the XRD pattern of the thin CdS film with 330nm thickness. The strong XRD peak appears at 2θ =27.417 corresponds to the diffraction angles of the (111) plane of cubic CdS. Another peaks appeared at 2 θ equal to 44.39 and 51.775 correspond to cubic structure of CdS with (220) and (311) planes respectively. Also there is a peak at 2 θ equal to 48.02 to plan 103 respectively for hexagonal (wurtizite) structure. This result indicates that the grown film is polycrystalline and when the thickness increases the peaks appear sharper.

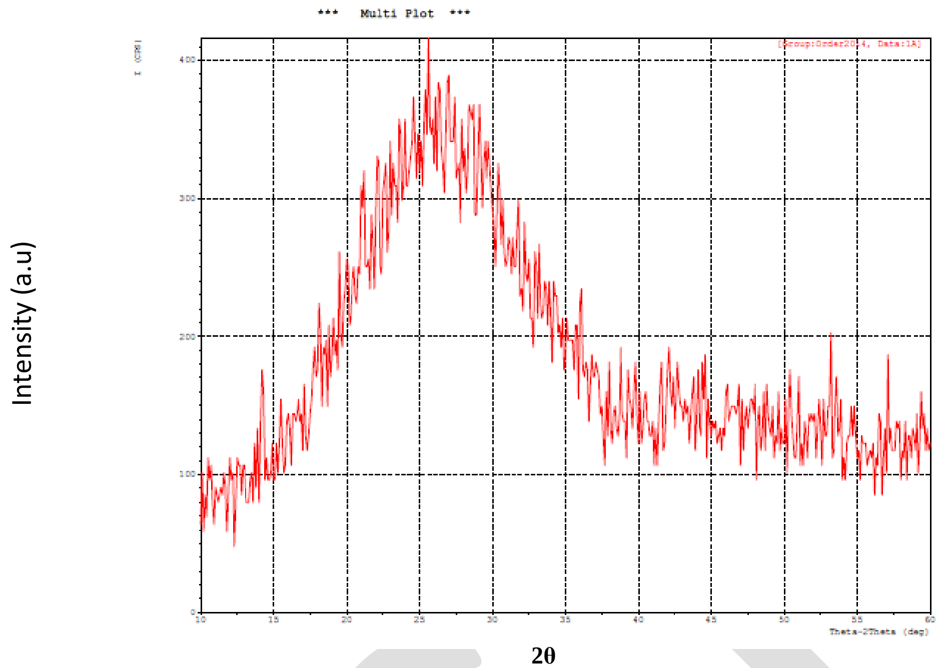
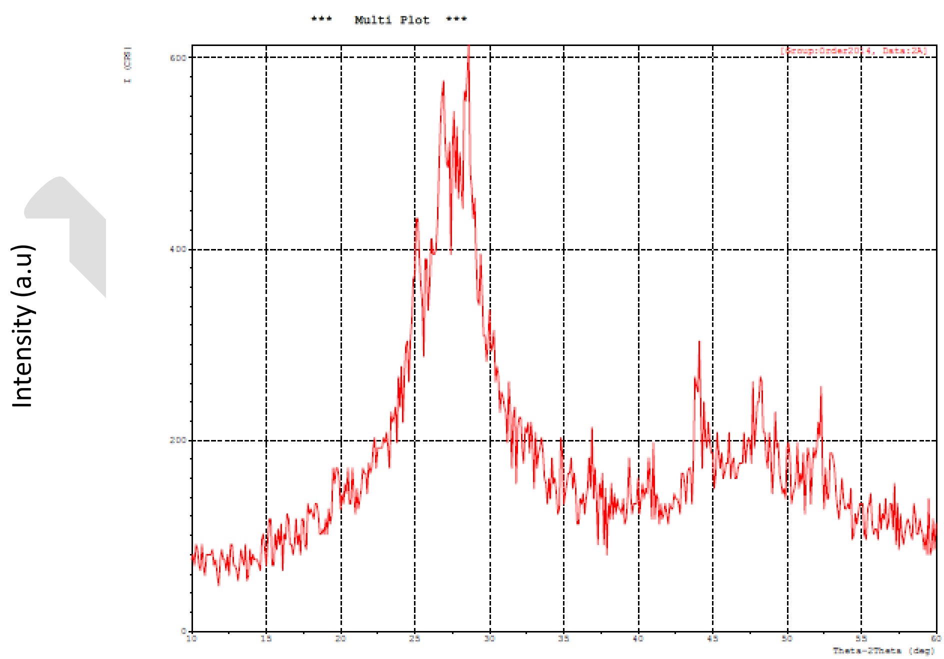


Fig.1. XRD pattern for thin CdS film at 130nm thickness.



2θ

Fig.2. XRD pattern for thin CdS film at 330nm thickness.

Figures (3-5) show the XRD measurements results of CdS films form at different thicknesses of 470,670 and 780 nm on glass substrate. All the patterns show polycrystalline diffraction pattern of cubic (zinc blend) and hexagonal (wurtizite) structure according to the ASTM card. It is observed from figure (3) the diffraction peaks for film with t=470 nm which are observed for (111), (220) and (311) planes of high intensity located at 2θ=26.8051 and low intensity at 2θ=43.289 and 2θ=51.107 respectively. Also there are 2 θ for hexagonal structure which are 26.8051 and 47.5151 for (002) and (103) plan respectively. As the thickness increases, the CdS film shows a strong and clear peaks growth along for (111),(220) and (311) also another peak appear for hexagonal (wurtizite)structure. For both thickness 670 and 780 nm, the prepared films have cubic and hexagonal (zinc blend and wurtizite) structure with clear peaks. These films which thickness is more than 130 nm have polycrystalline structure of cubic and hexagonal phases. These results are in a agreements with result shown by other researchers using different techniques for fabrication [14, 15].

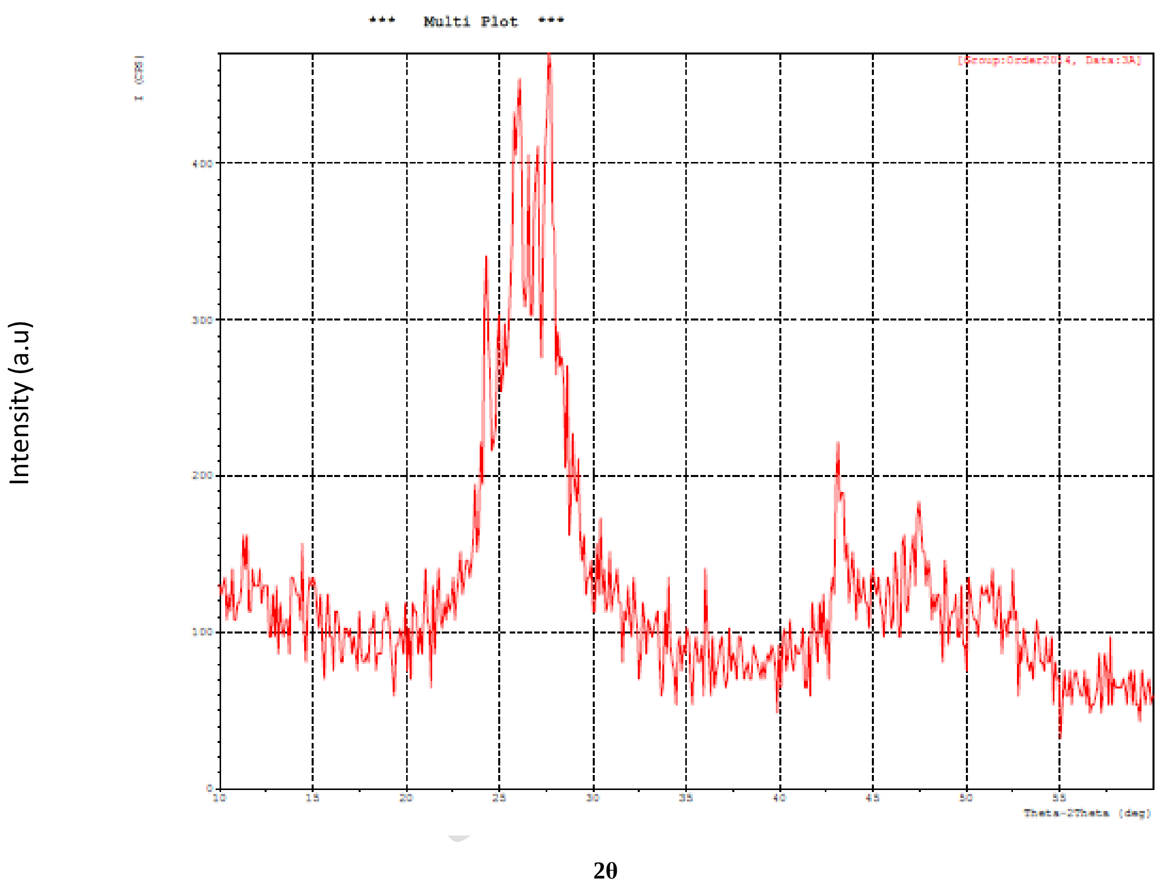
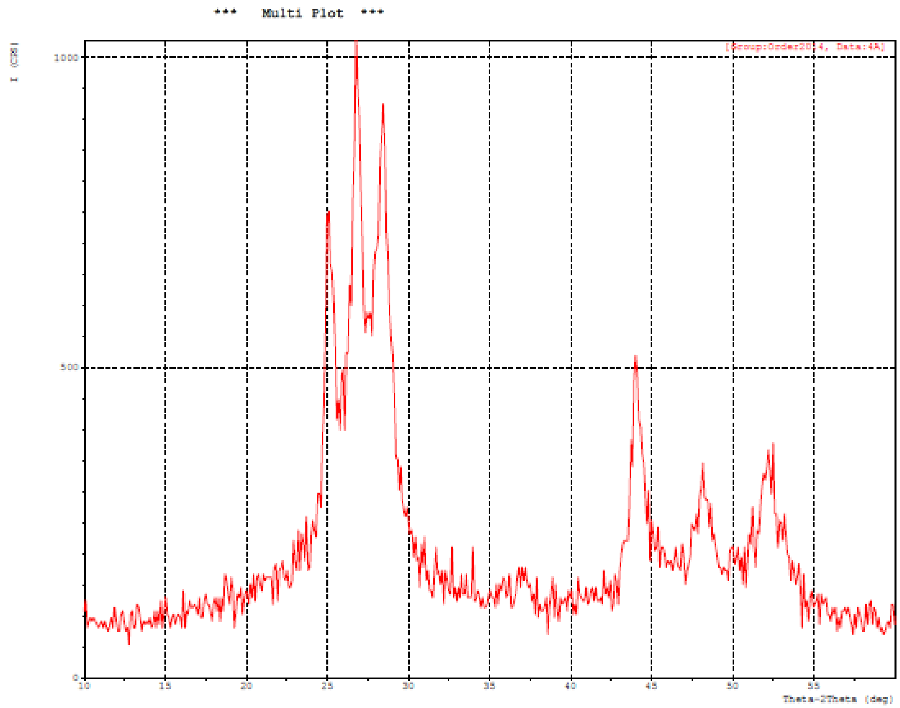


Fig.3. XRD pattern for thin CdS film at 470nm thickness.

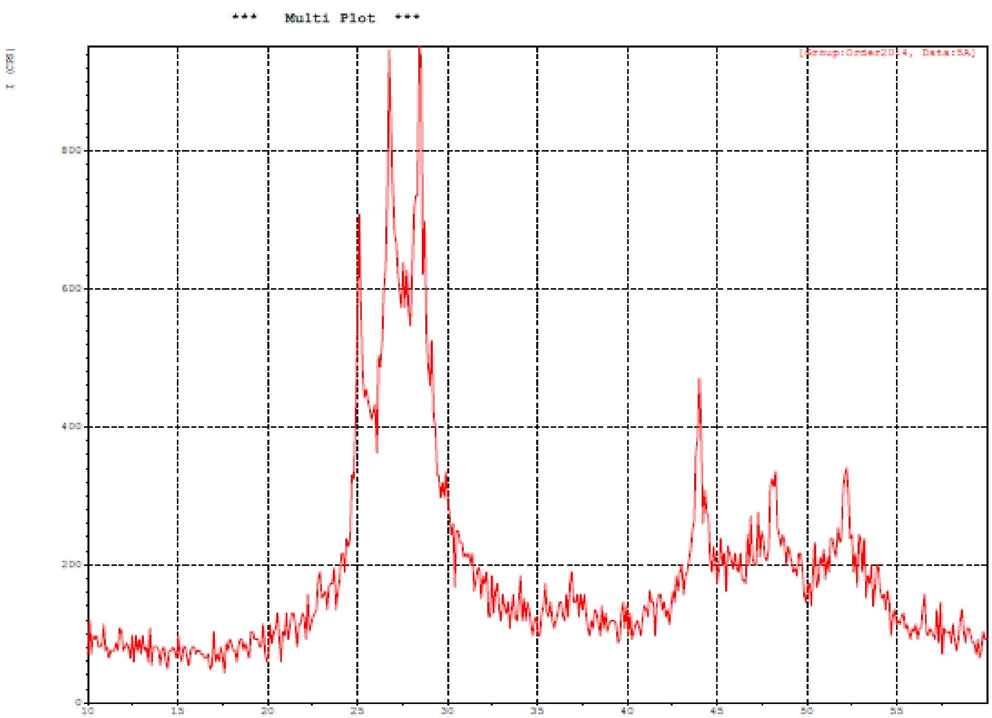
Intensity (a.u)



2θ

Fig.4. XRD pattern for thin CdS film at 670nm thickness

Intensity (a.u)



2θ

Fig.5. XRD pattern for thin CdS film at 870nm thickness

The full width at half maximum (FWHM) of the CdS thin films at different thicknesses grown on glass substrate has been deduced from Figs. (1-5). It is observed the full width at half maximum (FWHM) for the preferred orientation (111) decrease as the thickness is increased, at the same time, the grain size increases , that indicates thin CdS films crystalline increase with thickness (t). All these values are tabulated in Table (1).

Table .1 . XRD parameters, 2θ, d_{exp}, d_{sta}, hkl and grain size for CdS film.

t(nm)	2θ	d_{exp}	d_{st}	hkl	G.S (A)	Structure
130	25.52	3.480	3.36	111	12.1	cubic
	42.229	2.138		103		
	53.224	1.719	1.753	311		
330	26.2	3.398	3.359	002		hexagonal
	27.1	3.28	3.36	111	30.5	cubic
	44.395	2.038	2.058	110		cubic
	48.026	1.892	1.871	103		hexagonal
	51.775	1.764	1.753	311 112		Cubic and hexagonal
470	26.805	3.32	3.36	111	45.4	Cubic and hexagonal
	43.289	2.088	2.058	110		Cubic
	47.515	1.912	1.899	103		Hexagonal
	51.106	1.785	1.753	311		Cubic
670	27.617	3.22	3.36	111	51.1	Cubic
	28.385	3.141	3.163	101		Hexagonal
	44.103	2.05	2.06	220		Cubic
	48.118	1.889	1.871	103		Hexagonal
	52.124	1.753	1.732	201		Cubic and Hexagonal
780	25.131	3.54	3.36	100		Hexagonal
	27.622	3.226	3.36	111	51.9	Cubic
	28.339	3.146	3.16	101		Hexagonal
	43.962	2.057	2.06	220 110		Cubic and Hexagonal
	48.281	1.883	1.68	103		Hexagonal
	52.05	1.755	1.75	311		Cubic
	53.91	1.699	1.68	222		Cubic

IV. CONCLUSIONS

Thin cadmium sulphide (CdS) films deposited onto glass substrate were prepared using pulse leaser deposition technique (PLD) at various thicknesses. The XRD measurements indicate that:

- All prepared CdS films are polycrystalline
- The structure of the CdS films is zinc blend for CdS film with 130 nm thickness, and mixed from cubic and hexagonal phases for thickness ≥ 330 nm.
- The main peak correspond to the (111) plane.
- The peaks become strong and clear or sharp with increasing thickness.
- The grain size increases with increasing thickness.

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