

**Spectral study to investigate the structural properties of thin CdS films
with different thicknesses by X-ray diffraction**

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Muhammad A. al_Aani ****

*Dept. of Chemistry college of Education –Al-Raze Uni. of Diyala

**Dept. of Physics College of Sciences Uni. of Tikreet

Abstract

A polycrystalline CdS Films have been evaporated by thermal evaporation technique with different thicknesses under vacuum of about 8×10^{-5} mbar and substrate temperature of about 373 K on glass substrates, the films annealed at 573K for different duration times (60, 120 and 180 min.). The structural properties of the films have been studied by X-ray diffraction technique, some structural parameters like miller indices, d_{std} , d_{exp} , I/I_0 and I/I_0 have been calculated and compared for the CdS alloy and films.

Key/ structural proparties CdS or thin film CdS

دراسة طيفية للكشف عن بعض الخصائص التركيبية لأغشية كبريتيد الكادميوم الرقيقة
بأسماك مختلفة بواسطة حيود الأشعة السينية

أبتسام خليل البياتي*، أحمد محمد عبيد**، رشا عباس عبد الله** و محمد عبد الوهاب العاني**

*قسم الكيمياء- كلية التربية الرازي – جامعة ديالى

**قسم الفيزياء- كلية العلوم – جامعة تكريت

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الخلاصة :

تم تحضير اغشية كبريتيد الكاديوميوم متعددة التبلور بواسطة تقنية التبخير الحراري، باسماك مختلفة و تحت ضغط حوالي 10^{-5} ملي بار ودرجة حرارة أرضية حوالي 373 كلفن على شرائح من الزجاج. الخصائص التركيبية للأغشية تم دراستها بتقنية حيود الأشعة السينية. بعض الخصائص التركيبية مثل معاملات ميلر و المسافة بين المستويات (العملية و النظرية) و الشدة النسبية (العملية و النظرية) تم حسابه و مقارنتها لسبيكة و اغشية كبريتيد الكاديوميوم.

المفتاح / الخصائص التركيبية لكبريتيد الكاديوميوم او غشاء كبريتيد الكاديوميوم .

Abstract

A polycrystalline CdS Films have been evaporated by thermal evaporation technique with different thicknesses under vacuum of about 8×10^{-5} mbar and substrate temperature of about 373 K on glass substrates, the films annealed at 573K for different duration times (60, 120 and 180 min.). The structural properties of the films have been studied by X- ray diffraction technique, some structural parameters like miller indices, d_{std} , d_{exp} , I/I_0 $_{\text{std}}$ and I/I_0 have been calculated and compared for the CdS alloy and films.

1- Introduction

CdS is considered at present one most promising materials for photonic devices. It has also high absorption coefficient in the visible range of the solar spectrum and its band gap is closed to the optimum value for efficient solar energy conversion. The material can be prepared in n- type and p- type forms so that solar cells can be formed in both homojunction and heterojunction configurations ⁽¹⁾. CdS films have been prepared by several method, such as chemical bath deposition, electrodeposition, pulsed laser deposition and rf magnetron sputtering. Since nonvacuum techniques of films deposition are inherently susceptible to contamination ⁽¹⁾, only vacuum-deposition technique has been studied in this paper.

2- Experimental Work

CdS thin films have been deposited via thermal evaporation technique in vacuum higher than 8×10^{-5} mbar under controlled growth conditions of various thickness (500, 1000, 1500, to 2000Å), the substrate temperature was 423 K, the films annealed at 573K for different duration times (60, 120 and 180 min.). CdS starting material with 99.999 % purity. The glass slide substrates were cleaned with acetone, ethanol, and rinsed with deionised water in an ultrasonic cleaner and finally etched in a 10% HF solution. The crystal structure of these films was checked by x-ray diffraction technique using $\text{CuK}\alpha$. The films thicknesses were investigated by weight method.

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3- results and discussion

Figure (1) illustrates the x-ray diffraction spectrum for CdS powder which was prepared by thermal evaporation technique. The spectrum of CdS powder is compared with ASTM cards of CdS structure, and indicated a polycrystalline structure of pure hexagonal phase. This result is in agreement with those of El-Assali *et al* ⁽²⁾, Punnoose *et al*. ⁽³⁾ and Al Dhafiri⁽⁴⁾. The spectrum of CdS powder exhibited sharp peaks at (100), (002), (101), (102), (110), (103) and(112), and weak peaks at (004) and (202).

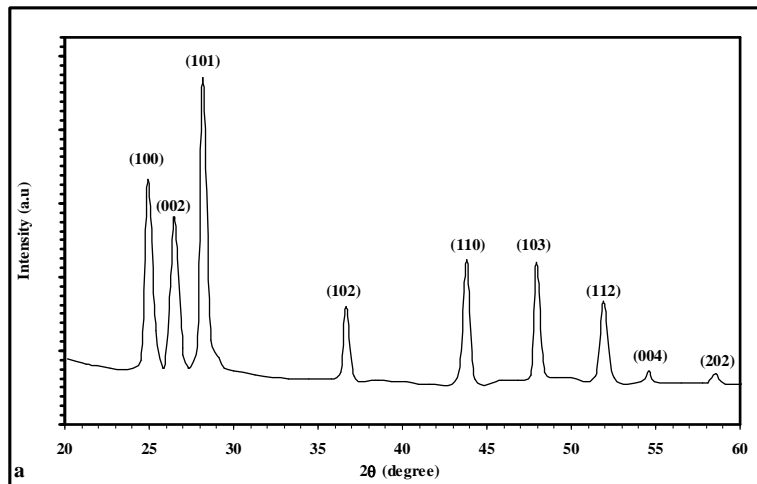


Fig. (1) The x-ray diffraction spectra for CdS Powder

3-1 The effect of thicknesses

The as-deposited CdS films grown on slide glass substrates is hexagonal wurtzite structure with a preferential orientation of the (002) diffraction plane. The dependence of X-ray diffraction intensity on film thickness was shown in Figs. (2, 3, 4 and 5)

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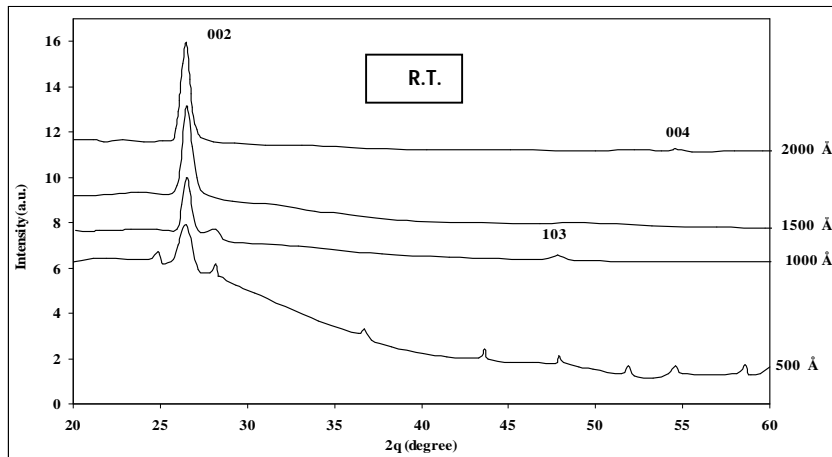


Fig.(2) x-ray diffraction of thin CdS films as deposited for different thicknesses

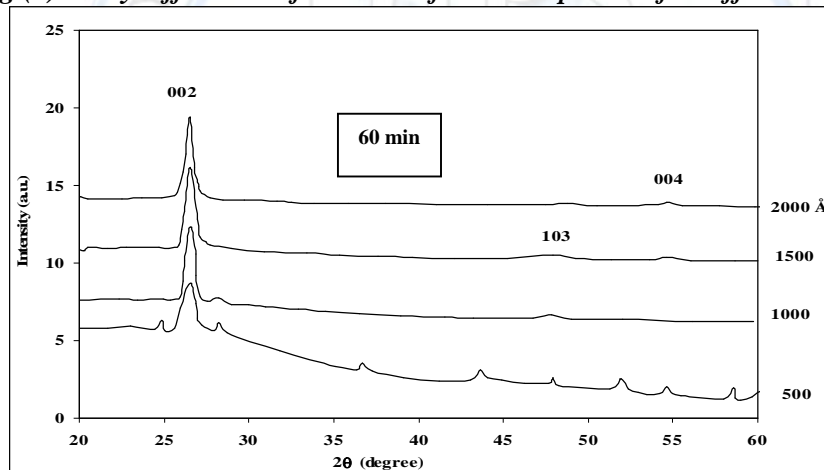


Fig.(3) x-ray diffraction of thin CdS films annealing for
60 min. for different thicknesses

The thickness had a pronounced effect on the x-ray diffraction spectra of the CdS thin films as shown in Figs. (2, 3, 4 and 5) and table 1. A comparison between the spectra of the films shows that there is more crystallization and more orientation of the crystal growth in the case of the thicker film. The plane (002) became more stronger than the other planes. These results coincide with Ngamnit et al ⁽¹⁾, R.A. Almatooq⁽⁵⁾ and Shadia et al ⁽⁶⁾.

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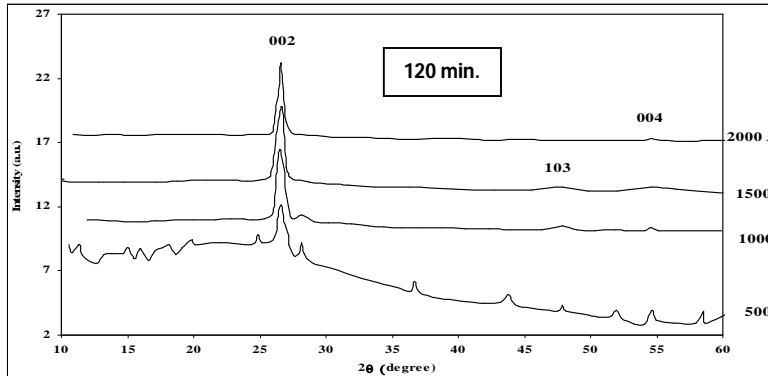


Fig.(4) x-ray diffraction of thin CdS films annealing for 120 min. for different thicknesses

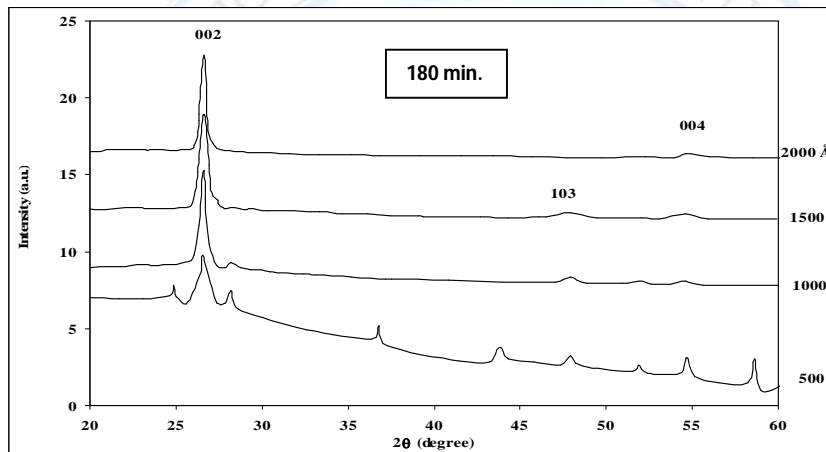


Fig.(5) x-ray diffraction of thin CdS films annealing for 180 min. for different thicknesses

Fig. (6) showed the relation between the grain size and the thickness, a slight increasing in the grain size values before 1000 Å, but after 1500 a clearly increasing in the grain size values.

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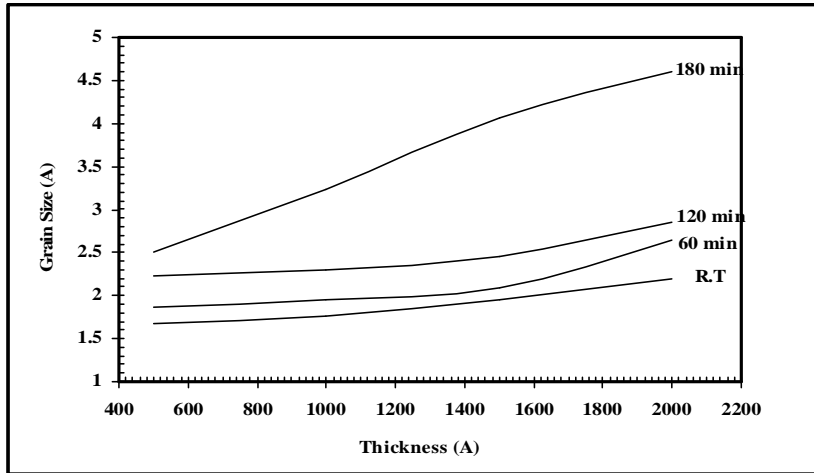


Fig. (6) Thicknesses Vs grain size

Table -1- shows the structural parameters of thin CdS films for different thickness

	hkl	2θ	(I/I ₀) _{std.}	d _{stan.} (Å)	(I/I ₀) _{exp.}	d _{exp.} (Å)	B (Å)
CdS alloy	100	24.9	62	3.694	70.6	3.573	
	002	26.6	91	3.341	59.3	3.348	
	101	28.2	100	3.15	100	3.162	
	102	36.7	29	2.44	34.1	2.447	
	110	43.8	48	2.064	47.62	2.066	
	103	47.9	50	1.895	46.72	1.898	
	112	51.9	31	1.758	35.51	1.761	
	004	54.6	5	1.667	15.39	1.680	
	202	58.6	3	1.572	14.55	1.574	
500 Å	hkl	2θ	(I/I ₀) _{std.}	d _{stan.} (Å)	(I/I ₀) _{exp.}	d _{exp.} (Å)	
at RT	100	24.87	62	3.737	5.89	3.577	
	002	26.5	91	2.992	28.15	3.361	1.6758
	101	28.17	100	1.953	6.71	3.165	
	102	36.7	29	1.62	3.60	2.447	
	110	43.61	48	3.747	6.06	2.074	
	103	48	50	2.768	5.24	1.898	
	112	51.91	31	2.287	5.73	1.760	

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	004	54.6	5	1.928	5.56	1.680	
	202	58.55	3	3.726	5.89	1.575	
at 60 min	100	24.87	62	3.737	5.89	3.577	
	002	26.5	91	2.992	50.25	3.361	1.7586
	101	28.2	100	1.953	8.84	3.162	
	102	36.71	29	1.62	7.53	2.446	
	110	43.67	48	3.747	9.00	2.071	
	103	48	50	2.768	5.56	1.898	
	112	51.91	31	2.287	7.04	1.760	
	004	54.6	5	1.928	9.98	1.679	
	202	58.6	3	3.726	11.62	1.574	
at 120 min	100	24.87	62	3.737	10.80	3.577	
	002	26.5	91	2.992	51.06	3.348	1.9517
	101	28.2	100	1.953	12.93	3.162	
	102	36.71	29	1.62	12.77	2.446	
	110	43.8	48	3.747	10.64	2.065	
	103	48	50	2.768	7.20	1.898	
	112	51.91	31	2.287	7.04	1.760	
	004	54.6	5	1.928	12.60	1.678	
	202	58.55	3	3.726	14.73	1.575	
at 180 min	100	24.87	62	3.737	12.44	3.577	
	002	26.5	91	2.992	51.88	3.348	2.1919
	101	28.2	100	1.953	13.58	3.162	
	102	36.78	29	1.62	14.89	2.441	
	110	43.82	48	3.747	12.27	2.064	
	103	48	50	2.768	8.18	1.898	
	112	51.91	31	2.287	7.20	1.760	
	004	54.6	5	1.928	16.86	2.143	
	202	58.62	3	3.726	25.70	1.573	

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1000 Å	hkl	2θ	(I/I ₀) _{std.}	d _{stan.} (Å)	(I/I ₀) _{exp.}	d _{exp.} (Å)	B (Å)
at RT	002	26.5	91	2.992	37.48	3.361	1.8743
	101	28.19	100	1.953	2.62	3.163	
	103	47.8	50	2.768	2.45	1.901	
at 60 min	002	26.5	91	2.992	78.07	3.348	1.9517
	101	28.2	100	1.953	3.11	3.162	
	103	47.87	50	2.768	3.27	1.899	
At 120 min	002	26.6	91	2.992	88.38	3.348	2.0950
	101	28.2	100	1.953	3.76	3.162	
	103	47.87	50	2.768	4.26	1.899	
	112	51.91	31	2.287	2.13	1.761	
	004	54.6	5	1.928	3.76	1.680	
At 180 min	002	26.65	91	2.992	96.07	3.348	2.6384
	101	28.2	100	1.953	5.24	3.162	
	103	47.92	50	2.768	5.24	1.897	
	112	51.88	31	2.287	3.11	1.761	
	004	54.6	5	1.928	4.09	1.680	
1500 Å	hkl	2θ	(I/I ₀) _{std.}	d _{stan.} (Å ⁰ Å)	(I/I ₀) _{exp.}	d _{exp.} (Å)	B (Å)
at RT	002	26.5	91	2.992	63.67	3.361	2.2257
at 60 min	002	26.5	91	2.992	81.34	3.348	2.2973
	103	47.9	50	2.768	3.76	1.898	
	004	54.6	5	1.928	3.44	1.680	
At 120 min	002	26.6	91	2.992	90.51	3.348	2.4562
	103	47.9	50	2.768	4.09	1.898	
	004	54.6	5	1.928	4.75	1.680	
At 180 min	002	26.65	91	2.992	98.04	3.348	2.8495
	103	47.9	50	2.768	4.75	1.898	

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	004	54.6	5	1.928	6.22	1.680	
2000 Å	hkl	2θ	(I/I ₀) _{std.}	d _{stan.} (Å)	(I/I ₀) _{exp.}	d _{exp.} (Å)	B (Å)
at RT	002	26.5	91	2.992	70.87	3.361	2.4990
	004	54.6	5	1.928	2.29	1.680	
at 60 min	002	26.5	91	2.992	81.67	3.348	3.2377
	004	54.6	5	1.928	2.95	1.680	
At 120 min	002	26.6	91	2.992	93.29	3.348	4.0706
	004	54.6	5	1.928	3.44	1.680	
At 180 min	002	26.65	91	2.992	100.00	3.348	4.5960
	004	54.6	5	1.928	3.76	1.680	

4. Conclusions

Good quality, adherent, uniform and pine-hole free CdS films with different thickness are obtained by thermal evaporation method. The films have hexagonal wurtzite structure with a preferential orientation of (002) plane. The larger grain size was at 180 min. and 2000Å

5. References

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