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

**Ebtisam K.al- Bity*, Ahmad M. obead **, Rasha A. Abdullah**,**

**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 about 373 K on glass substrates, the films annealed at 573K for different duration times (60, 120 and180 min.). The structural properties of the films have been studied by X- ray diffraction technique, some structural parameters like miller indices, dstnd, dexp, I/Io stnd and I/Io 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 الكاديوم الرقيقة بأسماك مختلفة بواسطة حيود 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

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

Ebtisam K.al- Bity*, Ahmad M. obead **, Rasha A. Abdullah**,
Muhammad A. al_Aani **

## الخلاصة

تم تحضير اغشية كبريتيد الكادميوم متعددة التبلور بواسطة تقنية التبخير الحراري، بأسماك مختلفة وتحت ضغط حوالي $10^{-5}$ ملي بار ودرجة حرارية أرضية حوالي 373 كلفن على شرائح من الزجاج. الخصائص التركيبية للأغشية تم دراستها بتقنية حيود الاشعة السينية. بعض الخصائص التركيبية مثل معاملات ميلر والمسافة بين المستويات (العملية والنظرية) والشدة النسبية (العملية والنظرية) تم حسابه ومقارنتها لسبيكة واغشية كبريتيد الكادميوم.

**المفتاح** / الخصائص التركيبية لكبريتيد الكادميوم او غشاء كبريتيد الكادميوم.

## Abstract

A polycrystalline CdS Films have been evaporated by thermal evaporation technique with different thicknesses under vacuum of about $8 \times 10^{-5}$ mbar and substrate temperature of about 373 K on glass substrates, the films annealed at 573K for different duration times (60, 120 and180 min.). The structural properties of the films have been studied by X- ray diffraction technique, some structural parameters like miller indices, $d_{stnd}$, $d_{exp}$, $I/I_o$ stnd and $I/I_o$ have been calculated and compared for the CdS alloy and films.

## 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.

## Experimental Work

CdS thin films have been deposited via thermal evaporation technique in vacuum higher than $8x10^{-5}$ 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 $CuK_\alpha$ . The films thicknesses were investigated by weight method.

## 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).

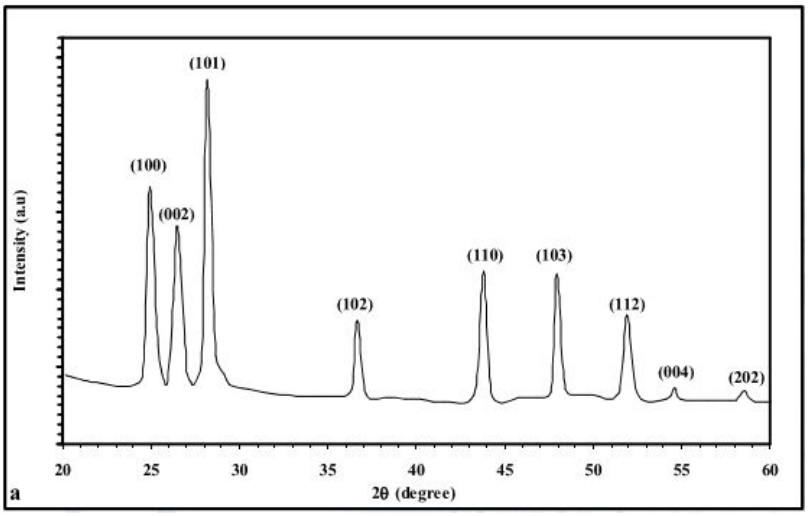


**Fig. (1) The x-ray diffraction spectra for CdS Powder**

## 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)

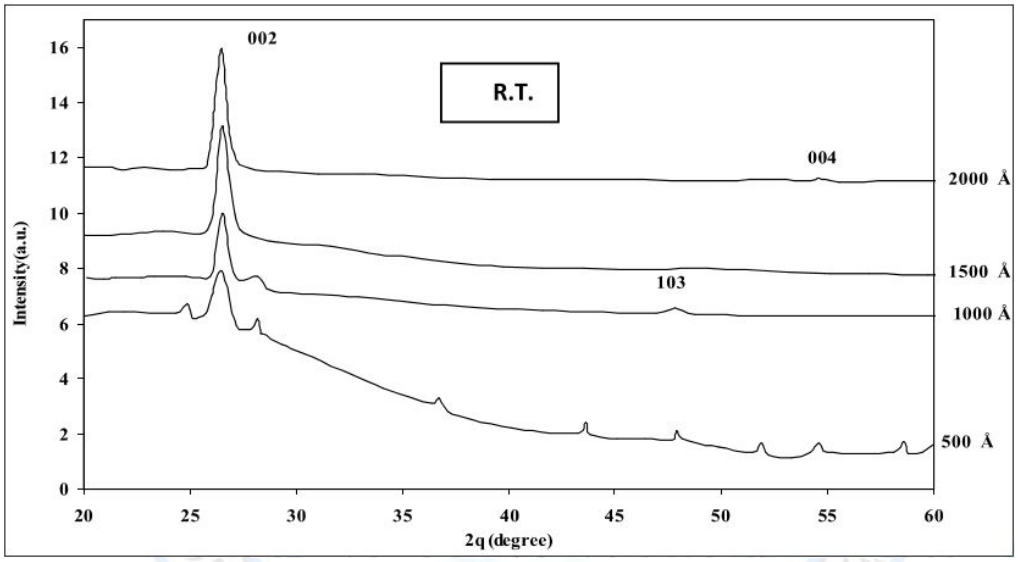


**Fig. (2) x-ray diffraction of thin CdS films as deposited for different thicknesses**

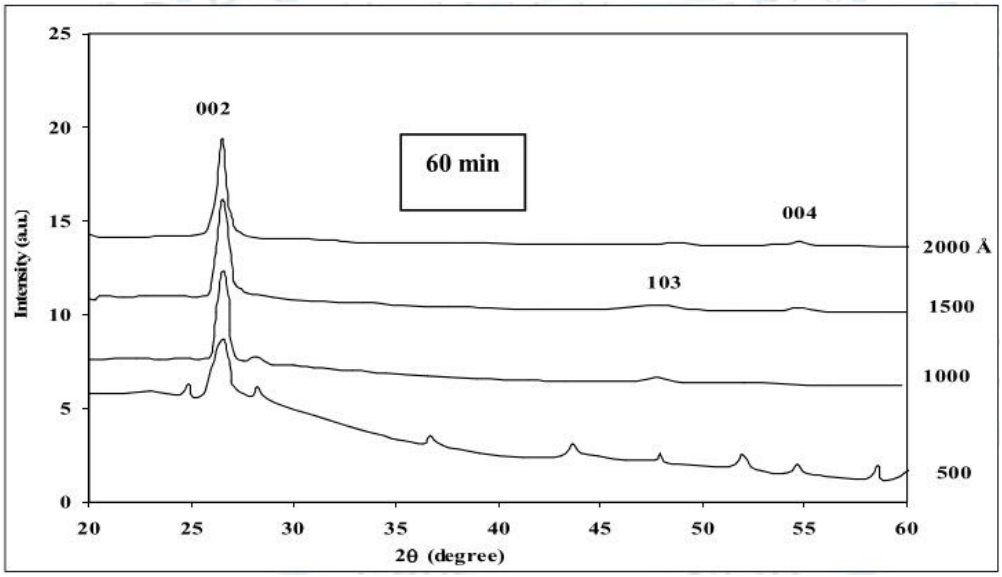


**Fig. (3) x-ray diffraction of thin CdS films annealing for 60 min. for different thicknesses**

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].

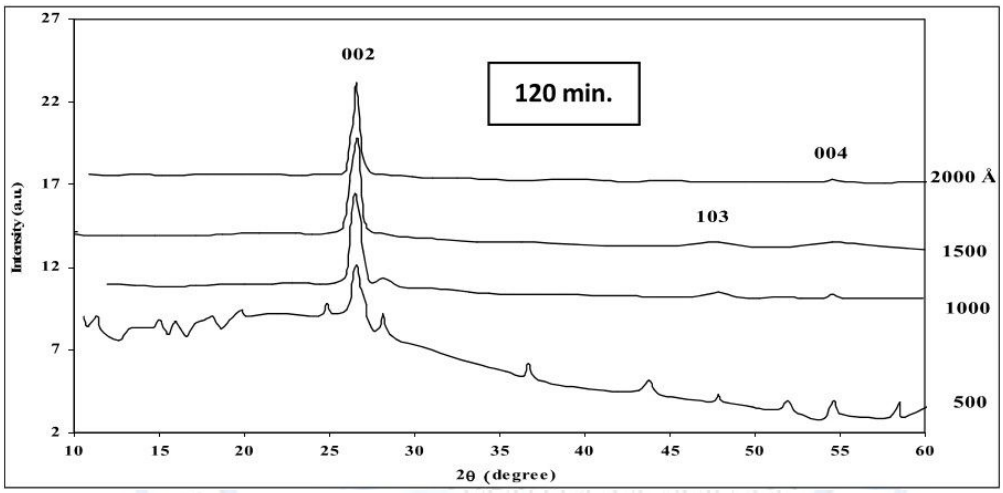


**Fig. (4) x-ray diffraction of thin CdS films annealing for 120 min. for different thicknesses**

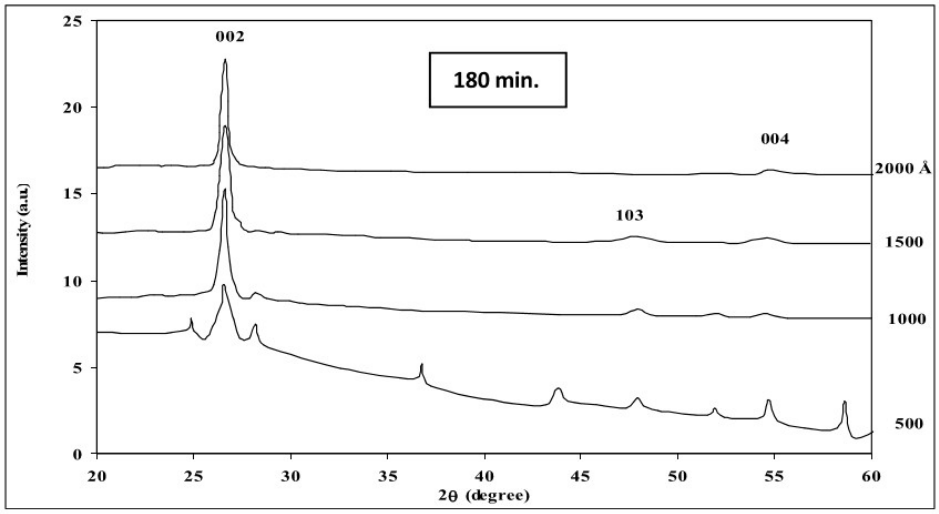


**Fig. (5) x-ray diffraction of thin CdS films annealing for 180 min. for different thicknesses**

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

Ebtisam K.al- Bity*, Ahmad M. obead **, Rasha A. Abdullah**, Muhammad A. al_Aani **

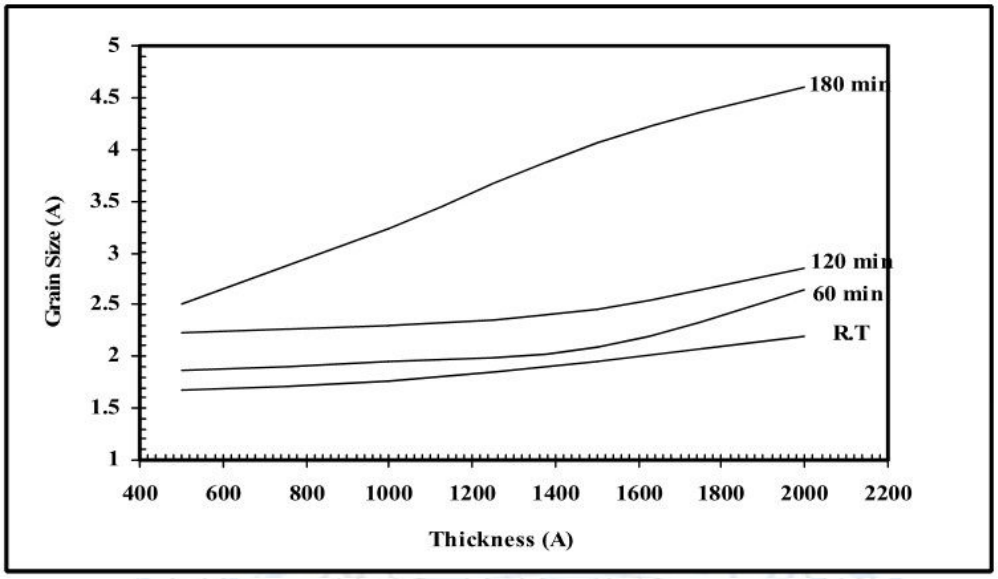


**Fig. (6) Thicknesses Vs grain size**

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

| | hkl | 2θ | $(I/I_0)_{stnd.}$ | $D_{stan.}$( 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** | $(I/I_0)_{stnd.}$ | $D_{stan.}$( 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 | |
| | 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 | |
| **1000 Å** | **hkl** | **2θ** | **$(I/I_0)_{stnd.}$** | **$D_{stan.}$( 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** | **$(I/I_0)_{stnd.}$** | **$D_{stan.}$( 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 | |
| | 002 | 26.65 | 91 | 2.992 | 98.04 | 3.348 | 2.8495 |
| **At 180 min** | 103 | 47.9 | 50 | 2.768 | 4.75 | 1.898 | |
| | 004 | 54.6 | 5 | 1.928 | 6.22 | 1.680 | |
| **2000 Å** | **hkl** | **2θ** | **$(I/I_0)_{stnd.}$** | **$D_{stan.}$( 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 | |

## 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.

## References

1. Ngamnit Gaewdan and Thitinai Gaewdan "Technical Digest of the international PVSEC" Bangkok, Thailand 2004, pp:581- 582.
2. K.El Assali, M.Boustani, A.Khiara, T.Bekkay, A.Outzourhit, E.L.Amiziane, J.C.Bernede and J.Pouzet, "*Phys. State Sol.*" (a) 178, 701 (2000).
3. A.Punoose, M.Marafi, G.Prabu and F.El Akkad "*Phys Stat. ol.*" (a) 177, 453, (2000), pp. 453-457.
4. A.M. Al Dhafiri "*Crys. Res. Techno.*", 37, 9, (2001), pp. 950-957.
5. *Rasha A. Al_Matooq " Study of Photovoltaic Characterestics of CdS/CdTe Heterojunction. M.Sc. thesis. University of Baghdad 2006,*
6. *Shadia J. Ikhmayies, Riyad N. Ahmed-Bitar "Amarican journal of Applied Sciences" 5 (9): 1141-1143, 2008.*