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Study the Effect of Thermal Treatment and Variation of CdS Thickness on Structural Properties of CdS/CdTe Heterojunction

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ABSTRACT

A polycrystalline CdS/CdTe heterojunction prepared by thermal evaporation technique at substrate temperature of 373 K and heat treatment for annealing temperature 573 K for different duration times of annealing (ta) 60 and 120 min. under vacuum of (10-5) mbar and different thicknesses of CdS layer of about 1000Å, 1500Å and 2000Å. The X-ray diffraction (XRD) technique shows polycrystalline structure and had a mixture of cubic and hexagonal structure.The recrystallization of films enhanced thermally represented by increasing the grain size. The CdS/CdTe heterojunction with the higher thickness of CdS layer shows better crystal structure.

Introduction

II-VI semiconductors compounds of considerable interest because of their extensive use in the fabrication of photovoltaic devices cells [1,2]. Cadmium telluride (CdTe) is one of the most promising polycrystalline materials for thin film solar cells due to its physical properties: It has a direct band gap (approximately 1.5 eV) with a high absorption coefficient (larger than 105 cm-1 at wavelengths around 700 nm), so that only thin film layers (a few microns) are needed for the absorption of the most of the solar spectra photons with energy higher than the band gap, and it can be obtained as p-type. Some of the commonly used low cost growth techniques for CdTe thin film production include electrodeposition, spray pyrolysis and close-spaced sublimation [3]. Irrespective of the growth process the grain size and surface morphology of CdTe films are two of the important parameters that affect the performance of active devices such as solar cells made on such layers. Therefore, understanding the microstructure and evolution in polycrystalline CdTe films is important to further develop an understanding of the performance of devices employing these layers. Polycrystalline films are used in a wide variety of applications in which their average grain size, distribution of grain size and distribution of grain orientations affect their performance and reliability.

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These grain structure characteristics are often defined by grain formation and growth during the film formation period. However, they may also be modulated through post-deposition process steps involving high temperature annealing [3].

Experimental Work

A polycrystalline CdTe thin films of 8000Å thickness were prepared by thermal evaporation technique (Edward Coating system E306A) under a vacuum of pressure of the order (10-5) mbar. We use a standard CdTe alloy, of purity (99.999) % on corning glass substrate, cleaned by methanol and washing in ultrasonic vibrator with deionized water, and then dipping in 10% HF solution for 2 mints.

A CdS layers with different thicknesses (1000, 1500 and 2000) Å were thermally deposited on the CdTe layer and the CdS 1000Å /CdTe 8000Å hetrojunction annealed for different duration times (60 and 120 min.) under vacuum of pressure of the order (10-5) mbar at 523 K.

X-ray diffraction technique was used to investigate the heterojunction structures. The experiments were carried out using Cu Kα radiation of average wavelength 1.54056 Å. It was operated with a target current and voltage of 25 mA and 40 KV respectively. The diffraction pattern was recorded between 2θ = (10°- 60°). By comparing the interplaner distance for different planes (dhkl) value with ASTM card for CdTe and CdS have been examined the

structure. The grain size (D) was calculated using XRD analysis from Scherrer relation [4]

$$D = 0.9\lambda/\beta\cos\theta$$

Where λ is X-ray wavelength, β is the full width at half maximum intensity (full width at half maximum intensity (FWHM)) and θ is the diffraction angle (Bragg angle). The grain size was calculated using FWHM of (111) plane.

Results and Discussion

The diffraction pattern spectra of CdS/CdTe heterojunction annealed under vacuum at 523 K for different duration times of annealing and different thicknesses of CdS layer are illustrated in Figures (1) and (2) respectively. The spectra of the as prepared and annealed CdS/CdTe heterojunction have a polycrystalline structure consist of cubic (zinc blend structure) and hexagonal (wurtizite structure) phases, these figures show a good agreement with ASTM cards. Similar results have been observed by many researches which have prepared CdS/CdTe heterojunction with different preparation methods and conditions, Heiba [2], Al Dhafiri [4], Enriques and Mathew [5], myeres et. al.[6], Lee et. al. [7], Nakamura et. al.[8], Mountinho et. al.[9], Bayhan and Erçelebi [10], Shalimova et. al.[11], Pandey et. al.[12], Arizp-Cháves et. al.[13], Latitha et. al.[14], Chandra et. al.[15] and Romeo et. al.[16]. The XRD parameters of CdS/CdTe heterojunction annealed under vacuum at 523 K for different duration times of annealing and different thicknesses of CdS layer are tabulated in Table (1).

The effect of variation duration times of annealing on structure of CdS/CdTe heterojunction

The as deposited heterojunction shows identified as polycrystalline CdTe with a cubic structure. It exhibits high preferential orientation along (111) and some low intensities of (002), (110) and (311) peaks. X-ray diffraction spectra of CdS/CdTe heterojunction annealed at 523 K for 60 and 120 min, are shown in Fig. (1). The annealed junctions exhibit a preferential orientation along (111) direction of the cubic structure. The (002), (110) and (311) peaks are more intense than those of the as deposited heterojunction. The FWHM of the peaks after annealing are smaller than those of the as deposited heterojunction. These results show that the heat treatment enhances the recrystallization of CdS/CdTe. These results was in agreement with Romeo [16] and Rami et. al.[17].

Such crystallinity improves with increasing the time of annealing have observed by Al-Dhafiri [4] and Enriques and Mathew [5]. There is slight shift in peak position was observed in (111) plane towards the higher diffraction angle (smaller lattice parameter), due to thermal stress [16], it may be attributed to the dependence on composition which includes the stochiometry of CdTe compound [6, 11]. The crystal structure improvement is due to rearrangement in the CdS/CdTe crystallites [4, 17]. The increasing in intensity with increasing the duration times of annealing may be permitting better grain growth by maintaining the preference for the (111) plane [5].

The effect of CdS thickness on structure

Fig.(2) Shows the X-ray diffraction patterns of CdS/CdTe heterojunction with different thicknesses of CdS layer. A comparison between the spectra of the three heterojunction shows that there is more crystallization and more orientation of the crystal growth in the case of the thicker CdS layer, espatially in the CdS peaks (002), and (311).

Also one can observe a slightly decreasing in the intensities of CdTe peaks. This result are agreement with Shadia et. al.[18] and Ngamnit et. al. [19]. The XRD spectra are presented in Fig.(2) showing the influence of variation of thicknesses of CdS layer of about 1000Å, 1500Å and 2000Å on CdS/CdTe heterojunctions. Generally it can be observed that the intensity of (002) plane of CdS have been increased and the FWHM of peaks have been decreased considerably with increasing the CdS thickness this results show that this variation of thickness enhance the recrystallization of the films.

The grain size results

The recrystallization induced by thermal treatment leads to increase grain size in both CdTe and CdS layer as shown in figures (3,4) respectively, and reduction in defects density [16],[17].

From Figure (3) and Table (1), the grain size results shows that a small fluctuation in this values were noted as the duration times of annealing was increased.

Fig (5) and Table (2) shows the increasing in the grain size values with increasing the CdS thickness. We can observe that the grain size values at different

thicknesses are larger than that consisted by annealing as shown in Tables (1,2).

The increase in the thickness of CdS layer should lead to increase in the crystallinity of the CdTe layer [20].

XRD spectra for CdS/CdTe heterojunction that annealed under vacuum (10-5) mbar at 523 K for different duration times of annealing and different thicknesses of CdS layer have a polycrystalline structure consist of a mixture of cubic and hexagonal phases. The recrystallization of films enhanced thermally. crystal structure represented by increasing the grain size of the preferred orientation (111) of the CdTe layer.

CdS/CdTe heterojunction with different thicknesses of CdS layer have increasing the intensity of (002) CdS layer.

References

1- S. T. Sundari, V. Swaminthan, A. K. Tyagi and T. Mahalingam, (2000), "Phys. Stat. Sol. (a)", Vol. 177, pp. 495-502.

2- Z.K.Heiba, (2003), "Crys. Res. Technol.", Vol. 38, pp. 488-49.

3- E. Bacaksiz , M. Altunbaş, S. Yılmaz, M. Tomakin, and M. Parlak, (2007)," Cryst. Res. Technol", Vol. 42, No.9, pp. 890 – 894.

4- A.M. Al Dhafiri, (2001), "Crys. Res. Techno.", Vol. 37, No. 9, pp. 950- 957.

5- J.P. Enriquez and X. Mathew, (2004), "Solar Energy & Solar Cells", Vol.81, pp. 363-369.

6- T.H. Mayers, H.W. Edwards and J.F. Schetzina , (1981), "J. Appl. Phys.", Vol. 52, No. 6, pp.121-124.

7- Jae. Hyeong Lee, Dong-Gun Lim and Jun-Sin Yi , (2003), "Solar Energy Materials & Solar Cells" , Vol.75,pp. 235-242.

8- K.Nakamura, M.Gaton, T.Fujihara, T.Toyama and H.Okamoto , (2003) , "SolarEnergy materials & Solar Cells" ,Vol.75, pp.185-192.

9- H.R.Moutinho, F.S.Hasson, S.Abulfotuh, L.L.Kazeriski, (1995), "J.Vac.Sci.Techno.", (a), Vol.13, No. 6, p.213.

10- H.Bayhan and Ç. Erçelebi, (1998),"Tr. J. of Phys.", Vol. 22, pp. 441- 451.

11- K. El Assali, M. Boustani, A.Khiara, T.Bekkay and J.Pouzet,

(2000), "Phys.State sol.", (a),Vol.178, p. 701.

12- S.K.Pandey, U.Tiwari, R.Raman, C.Prakash, V.Krishna, V.Dutta and K.Zimik , (2005), "Thin Solid films", Vol. 473, pp. 54-57.

13- H. Arízpe- Chävez, R. Ramírez-Bon, F.J.Epinoza-Beltrán and O.Zelaya- Angel, (1999) ,"Superficies Vacio", Vol. 8, pp. 120-124.

14- S. Lalitha, R.Sathyamoorthy, S.Senthilargsu, A. Subbarayan and K. Natarajan , (2004), "Solar Energy Materials & Solar celles", Vol. 28, p.187.

15- S. Chandra, S.T. Sundri, G Reghavan and A.K. Tayaji, (2003),"J. Phys. D: Appl. Phys.", Vol.36,p. 2121.

16- A. Romeo, (2002), "Growth and Characterization of High Efficiency CdTe/CdS Solar Cells", Ph.D.Thesis, Swiss Federal Institute of Technology, Zürich.

17- G.G. Rusu and M. Rush, (2000), “Solid State Communication”, Vol. 116, p. 363.

18 -Shadia J. Ikhmayies and Riyad N. Ahmed-Bitar, (2008), "American Journal of Applied Sciences",Vol.5, No.9, pp. 1141-1143.

19- Ngamnit Gaewdang and Thitani Gaewdang, (2004), "Technical Digest of the international PVSEC-14", Vol. 123, pp.581-582.

20- K. Nakamura, M. Gotoh, T. Fujihara, T.Toyana and H. Okamoto, (2003), "Solar energy material and solar cells", Vol. 75, pp. 185-192.

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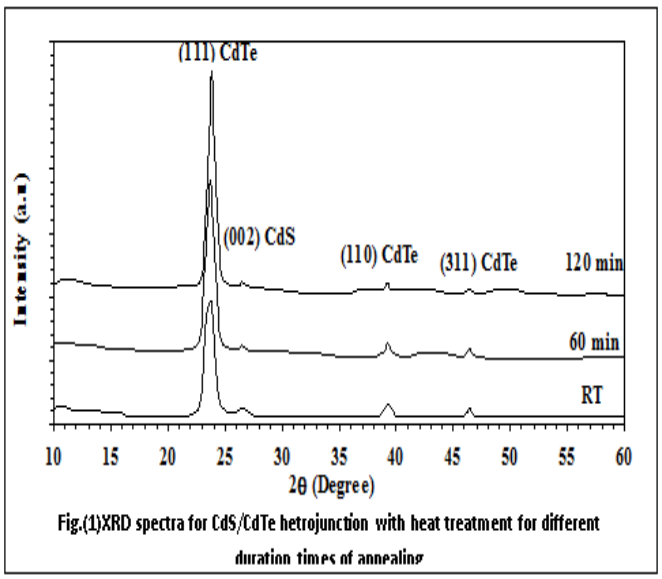

Fig.(1)XRD spectra for CdS/CdTe hetrojunction with heat treatment for different duration times of annealing

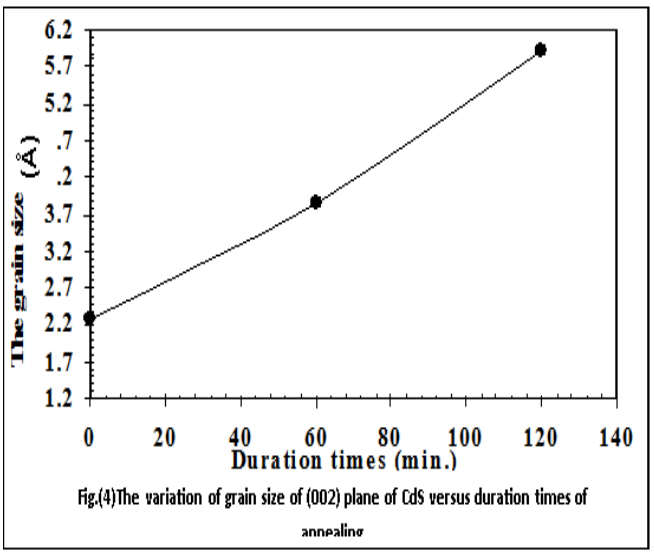

Fig.(4)The variation of grain size of (002) plane of CdS versus duration times of annealing

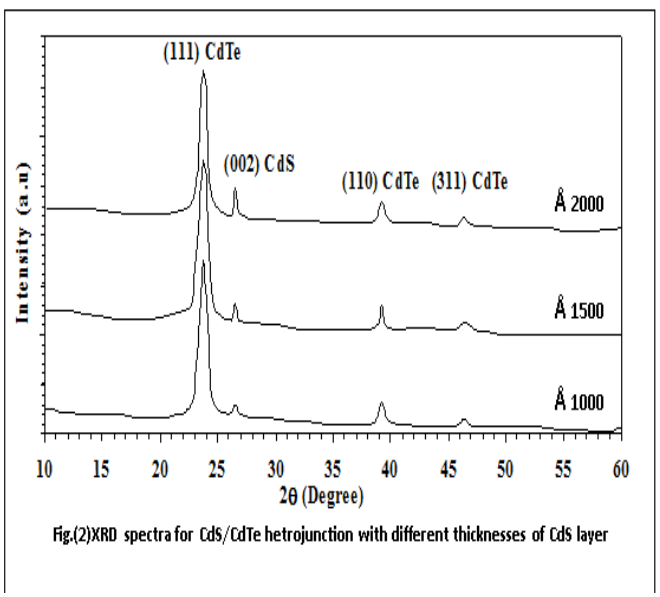

Fig.(2)XRD spectra for CdS/CdTe hetrojunction with different thicknesses of CdS layer

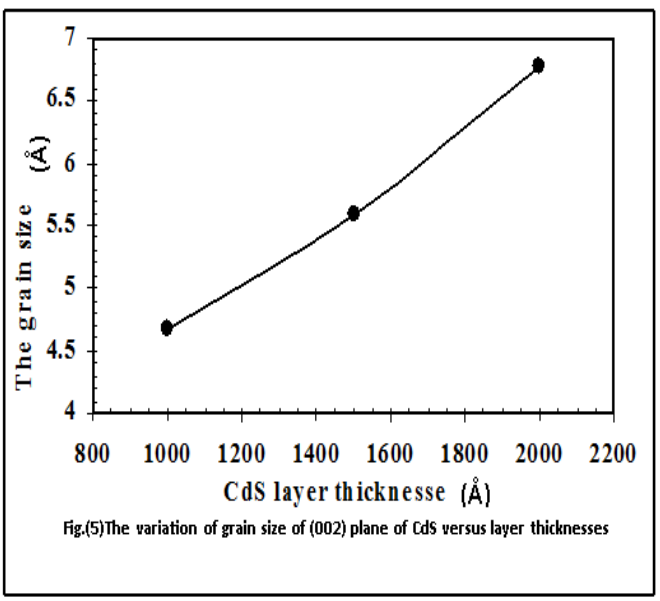

Fig.(5)The variation of grain size of (002) plane of CdS versus layer thicknesses

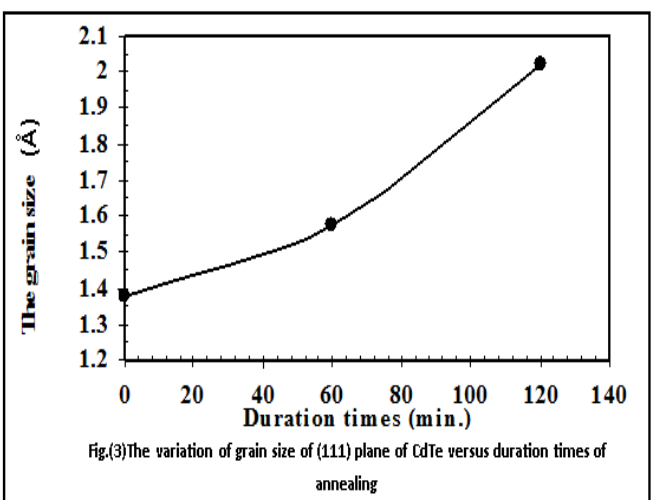

Fig.(3)The variation of grain size of (111) plane of CdTe versus duration times of annealing

Table (1) The XRD parameters for CdS/CdTe heterojunctions annealed at 523K for different duration times of annealing

Duration times of	CdS/CdTe heterojunction with different duration times of annealing								
annealing (min)	Hkl	2θ	$(I/I_0)_{stan.}$	$d_{stan.}$(Å)	$(I/I_0)_{exp.}$	$d_{exp.}$(Å)	structure	Material	D(111)Å
0	111	23.7	100	3.747	54.79	3.751	cub.	CdTe	1.3754

120				60				1000				1500				2000			
311	110	002	111	311	110	002	111	111	002	20	hkl	311	110	002	111	311	110	002	111
46.4	39.2	26.5	23.8	46.4	39.2	26.5	23.77	23.76	26.5	2θ		46.4	39.2	26.5	23.76	46.4	39.2	26.5	23.76
30	60	91	100	30	60	91	100	100	91	$(I/I_0)_{stan.}$		30	60	91	100	30	60	91	100
1.928	2.287	3.36	3.747	1.928	2.287	3.36	3.747	3.747	3.36	$d_{stan.}$(Å)		1.928	2.287	3.36	3.747	1.928	2.287	3.36	3.747
2.339	3.887	2.819	100	3.175	5.111	2.478	81.35	47.55	2.617	$(I/I_0)_{exp.}$		2.4	6.536	5.111	45.84	43.5	6.536	5.111	45.84
1.955	2.296	3.361	3.735	1.955	2.296	2.296	3.74	3.742	3.361	$d_{exp.}$(Å)		1.955	2.296	3.361	3.742	3.742	2.296	3.361	3.742
cub.	hex.	hex.	cub.	cub.	hex.	hex.	cub.	cub.	hex.	structure		cub.	hex.	hex.	cub.	cub.	hex.	hex.	cub.
CdTe	CdTe	CdS	CdTe	CdTe	CdTe	CdS	CdTe	CdTe	CdS	Material		CdTe	CdTe	CdS	CdTe	CdTe	CdTe	CdS	CdTe
-	-	5.9349	2.0241	-	-	3.8496	1.5742	1.6099	4.6701	D(111)Å		-		5.5858	1.7277	-	-	6.7827	1.7934
CdTe	CdTe	CdS	CdTe	CdTe	CdTe	CdS	CdTe	CdTe	CdS	Material		CdTe	CdTe	CdS	CdTe	CdTe	CdTe	CdS	CdTe
cub.	hex.	hex.	cub.	cub.	hex.	hex.	cub.	cub.	hex.	structure		cub.	hex.	hex.	cub.	cub.	hex.	hex.	cub.
1.955	2.296	1.955	3.742	1.955	2.296	2.296	3.361	3.742	2.617	$d_{exp.}$(Å)		1.955	2.296	2.296	3.361	1.955	2.296	1.955	3.742
1.928	2.287	3.36	3.747	1.928	2.287	2.287	3.36	3.747	3.36	$(I/I_0)_{exp.}$		1.928	2.287	2.287	3.36	1.928	2.287	2.287	3.36
2.54	6.505	8.828	43.5	2.4	6.536	6.536	5.111	45.84	91	$(I/I_0)_{stan.}$		2.4	6.536	6.536	5.111	2.4	6.536	6.536	5.111
30	60	91	100	30	60	91	100	100	91	$d_{stan.}$(Å)		30	60	91	100	30	60	91	100
46.4	39.2	26.5	23.76	46.4	39.2	26.5	23.77	23.76	26.5	2θ		46.4	39.2	26.5	23.76	46.4	39.2	26.5	23.76
311	110	002	111	311	110	002	111	111	002	hkl	CdS layer (Å)	311	110	002	111	311	110	002	111
120				60				1000			Thickness of	1500				2000			

Table (2) The XRD parameters for CdS/CdTe heterojunctions with different thicknesses of CdS layer

CdS/CdTe heterojunction with different thicknesses of CdS layer								
1000	111	23.76	100	3.747	47.55	3.742	cub.	CdTe	1.6099
002	26.5	91	3.36	2.617	3.361	hex.	CdS	4.6701

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دراسة تأثير المعاملة الحرارية و تغير سمك كبريتات الكادميوم على الخصائص التركيبية للمفرق الهجيني CdS/CdTe

كاظم عبدالواحد عادم غصون حميد محمد ايناس سليمان يوسف

الخلاصة :

تم تحضير المفرق الهجيني CdS/CdTe بواسطة تقنية التبخير الحراري بحرارة أرضية حوالي 373 مطلقة، و تم تلدينها بدرجة 523 مطلقة بفترات زمنية مختلفة (60 و120 دقيقة) تحت ضغط (5-10) ملي بار. تم تحضير المفرق أيضا بأسماك مختلفة من طبقات كبريتيد الكادميوم 1000, 1500 و2000 انكستروم. تم دراسة حيود الأشعة السينية (XRD) ووجد إن التركيب متعدد البلورات و قد كان خليط بين الطورين المكعب و السداسي. وان عملية إعادة التبلور للأغشية المحتثة حراريا قد ازدادت وذلك من خلال زيادة الحجم الحبيبي. يظهر المفرق الهجينيCdS/CdTe ذو طبقات كبريتات الكادميوم الأكثر سمكا تركيب بلوري أفضل.