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Effect the Thickness on the Electrical Properties and (I-V) Character of the (CdTe) Thin Films and Find the Efficiency of Solar Cell CdTe/CdS

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Abstract:

Thin films of CdTe were prepared with thickness (500, 1000) nm on the glass substrate by vacuum evaporation technique at room temperature then treated different annealing temperatures (373,473,and 573)K for one hour. Results of the Hall Effect and the electrical conductivity of (I-V) characteristics were measured in darkness and light.at different annealing temperature results show that the thin films have ability to manufacture solar cells, and found that the efficient equal to (2.18%) for structure solar cell (Algrid / CdS / CdTe /glass/ Al) and the efficient equal to (1.12%) for structure solar cell (Algrid / CdS / CdTe /Si/ Al) with thick ness of (1000) nm with CdTe thin films at RT.

Keywords: Thin films CdTe, Thermal evaporation technique, Solar cell.

Introduction:

For several decades, enormous attention has been focused on the development of thin film semiconductors using inorganic binary compounds in order to develop low-cost and high efficiency photovoltaic thin-film solar panels. CdTe has been recognized as a suitable candidate and promising material among the group II-VI compounds to convert light into electricity due to its near-ideal direct energy band gap and high optical absorption coefficient (1) CdTe is a crystalline compound formed from cadmium and tellurium. It is II–VI semiconductor with zinc blende crystal structure. It is used as an infrared optical window and a solar cell material.it is usually sandwiched with cadmium sulfide to form a p–n junction photovoltaic solar cell and is a direct band gap (2) CdTe is one of the most promising photovoltaic (PV) thin film materials for solar cell applications with the conversion efficiency of 21.5%, reported by First Solar in February 2015(3) For the optical properties, it can emit the light with wavelength 855 nm which belongs to red color, it has fluorescence in the visible range, It has the greatest electro – optic coefficient of the near electro–optic effect among II–VI compound crystals(2) CdTe is of low cost thin film photovoltaic cells because of its direct band gap and have high absorption coefficient. CdTe could be doped with both n- and p- type materials (4) CdTe could be doped with both n- and p- type materials using a large number of preparation methods / techniques such as vacuum deposition (5), electro-deposition (6), (7), metal-organic chemical vapor deposition (8), (9), close-space sublimation (10), (11) Photovoltaic (PV) solar energy conversion is an attractive method for clean energy generation. PV technology comes at the top end of the renewable energy list, and therefore worldwide research is continuing to develop low-cost and high-efficiency solar panels. The CdS/CdTe-based thin film solar cell is progressing forward, entering into large scale manufacturing by the First Solar Company (12).

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Materials and Methods:

Experimental Work

In this research, we have arranged a thin layer of cadmium spectra on glass bases at R.T., and studied the effect of annealing temperature and change of thicknees In this study, 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, were prepared by thermal evaporation technique (Edward Coating system E306A) under a vacuum of pressure of the order ($3*10^{-5}$) mbar.

The value of the electrical connection was measured using a (Keithly 2182A) Nano voltmeter device. It was found that was two activation energy and a change in the values of the concentration of the charge, carrier's mobility and the Hall coefficient.

The characteristics of (I-V) in darkness and light were calculated using the (Keithly 6517B) Electrometer device. It was found that the thin films had the potential to manufacture solar cells and was found the efficiency of hybrid differs (Algrid / CdS / CdTe / Al), (Algrid / CdS / CdTe / Si/Al).

Results and Discussion:

The measurements were carried out at annealing temperature (373,473,573) K and thicknees (100, 500) nm Figure (1) shows varies in the values of the concentration charge and hall mobility of charge carriers and the hall coefficient as a function of annealing temperature and thicknees. Table (1) shows that the values of Hall coefficient for all films are p-type. These results are agree with the results of Alias et al, (13) The concentration of the charge carriers increases with the increase of annealing temperature, while the values of decrease with the increasing of annealing temperature.

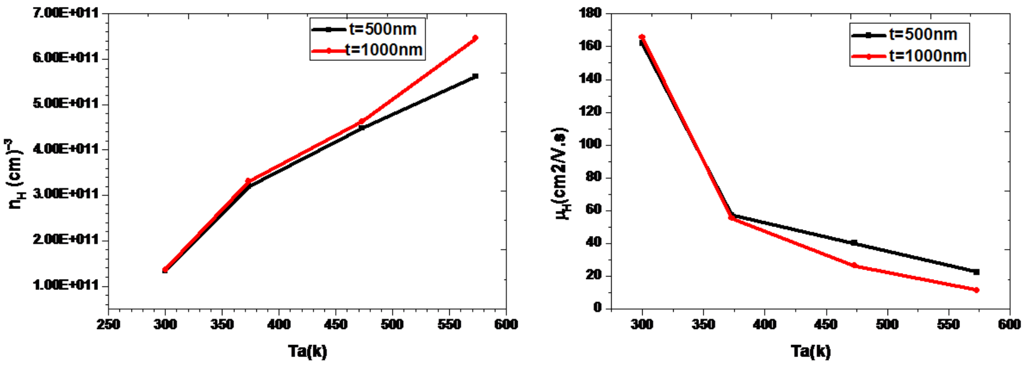


Figure 1. Varies of carrier concentration values (n), hall mobility (μH) for (CdTe) thin films at different annealing temperatures and thickness

Table 1. Varies carriers the concentration values (n), the hall mobility (μH) and the Hall factor (R H)for thin films (CdTe) with different temperatures and thickness

Thickness (nm)	Ta(K)	Carrier Concentration n_H (cm^{-3})	Hall Mobility μ_H (cm^2/vs.)	RH (cm ^{3} /c)	σ Conductivity (Ω.cm)$^{-1}$	type
500	300	1.33E+11	1.62E+02	1.44E+07	3.45E-06	p
	373	3.20E+11	5.70E+01	2.60E+07	2.91E-06	p
	473	4.48E+11	4.00E+01	3.81E+07	2.87E-06	p
	573	5.62E+11	2.23E+01	4.21E+07	2.01E-06	p
1000	300	1.37E+11	1.61E+02	4.39E+07	3.62E-06	p
	373	3.31E+11	5.53E+01	4.77E+07	2.93E-06	p
	473	4.63E+11	2.63E+01	6.56E+07	1.95E-06	p
	573	6.46E+11	1.13E+01	7.14E+07	1.17E-06	p

The values of the D.C. conductivity (σ d.c) hall mobility were calculated using equation (14).

$$\boldsymbol{\sigma} = \frac{\mathbf{1}}{\boldsymbol{\rho}} = \frac{\mathbf{L}}{\mathbf{R\,A}} \ldots. (1)$$

Were **ρ** is resistivity R is restart and L,A are the dimension of the sample calculated the activation energy at different annealing temperature in Figure (2) shows the relationship between (lnσ) for thin films (CdTe) and the temperature (1000 / T) of at annealing temperatures (573,300)K for thickness 1000 (nm)and (473) K for thickness 500 (nm), as electrical conductivity decreases with increasing annealing temperature increased number of carriers As shown in Table (2) and also shows the presence of two energies for activation (Ea1, Ea2) These results are agree with the results of Mustafa et al, (15)

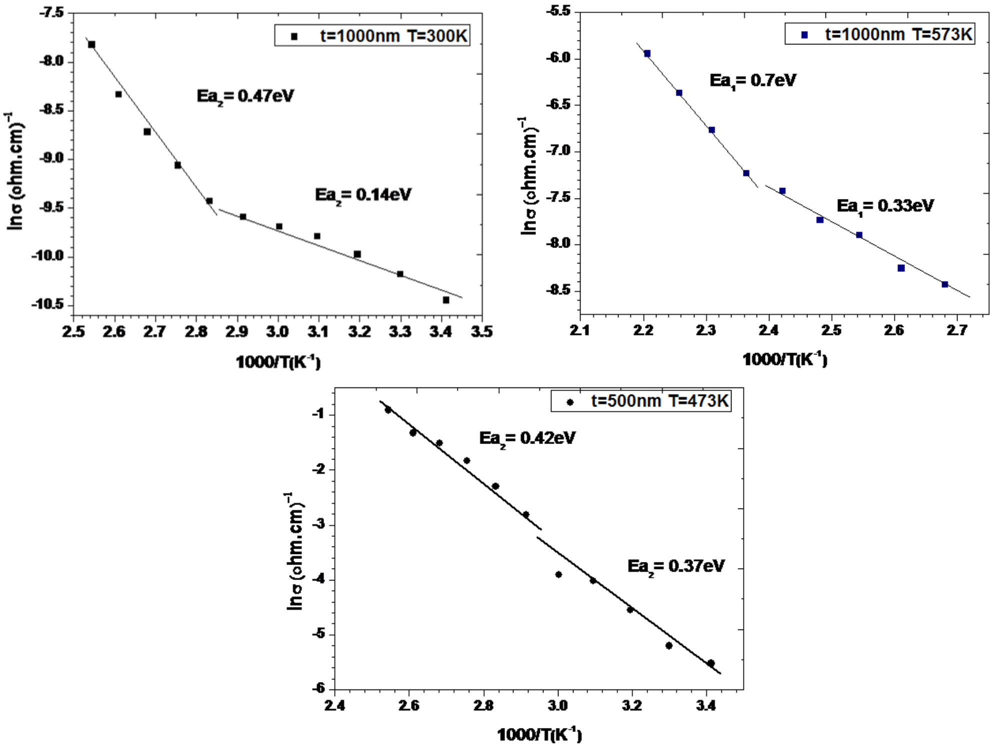


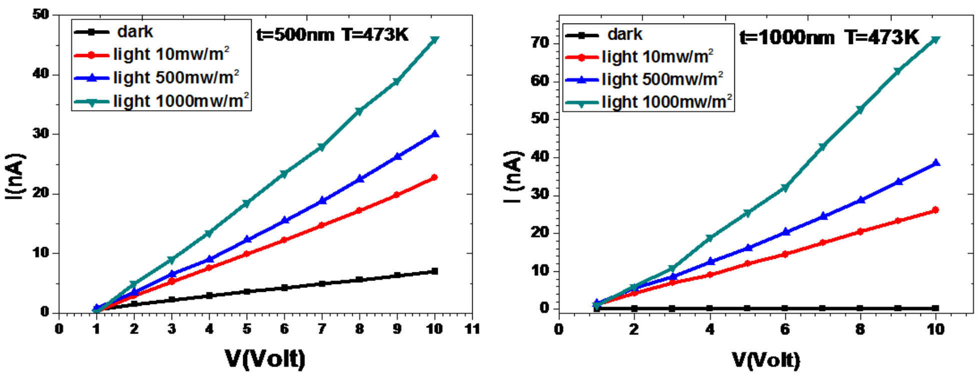
Figure 2. Varies (lnσ with 10^3 / T) for CdTe thin films as a function at annealing temperature (300,573,473) K with thickness (500-1000) nm

Table 2. Electrical conductivity and activation energies of the CdTe thin films as a function of the temperature of (473)K for thickness (500) nm, (573,300) K for thickness nm (1000)

Films thickness (nm)	Ta(K)	E_{a1} (eV)	Range (K)	E_{a2} (eV)	Range (K)	$\sigma_{R.T}$ $(\Omega.cm)^{-1}$
500	473	0.37	293-333	0.42	343-393	2.87E-06
1000	300	0.14	293-343	0.47	353-393	3.62E-06
	573	0.33	373-413	0.7	423-453	1.17E-06

The characteristics of (I-V) of (CdTe) thin films with thickness (500,1000) nm and temperature (473) K were measured in the case of darkness, where these measurements were performed in the absence of light and then measured in the case of illumination (Illumination) with intensities (10,500,1000) mw/m^2 at external voltage as shown in Table (3), and in Figure (3) The efficiency of the cell (η) (efficiency) according to the relationship (2)(13)

$$\eta = \frac{P_m}{P_{in}} = \frac{V_{oc}\, I_{sc}\, FF}{P_{in}} \quad \ldots (2)$$



(a) **(b)**

Figure 3. Measurements (I-V) characteristics in the case of dark and thin films illumination (CdTe) with thickness (a) (500) nm and (b) For (1000) nm at annealing temperature (473) K .

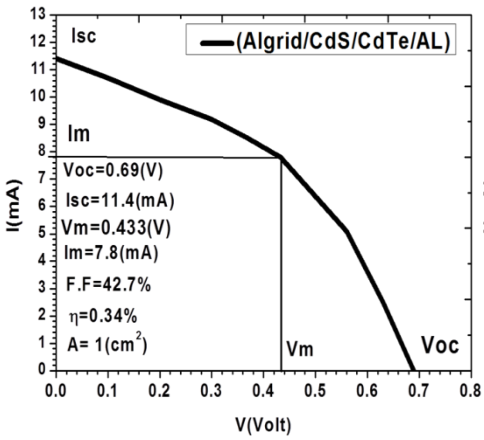
Table 3. Shows the results of (I-V) measurements in case of darkness and light of 1000nm thickness

t=1000nm		d=27cm	d=16cm	d=10cm
T=200c		I=10mw/m2	I=500mw/m2	I=1000mw/m2
V(volt)	I(nA) dark	I(nA) light1	I(nA) light2	I(nA) light3
1	0.07	1.3	1.5	1.1
2	0.08	4.2	5.5	6
3	0.1	7	8.5	11
4	0.13	9	12.5	19
5	0.15	12	16.1	25.5
6	0.16	14.5	20.3	32.2
7	0.17	17.5	24.4	43
8	0.18	20.4	28.7	52.8
9	0.19	23.2	33.5	63
10	0.2	26.1	38.5	71.3

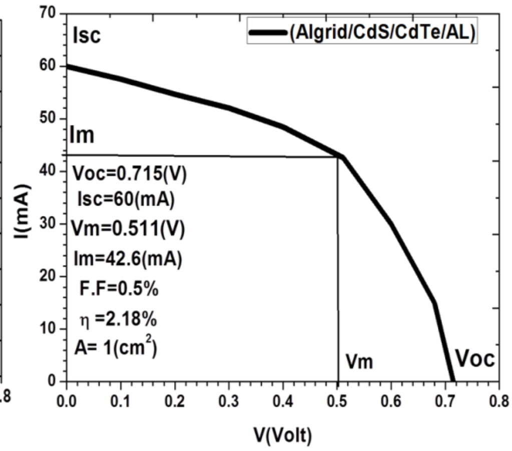
Table 4. Shows the results of(I-V) measurements in case of darkness and light of(500)nm thickness

t=500nm		d=27cm	d=16cm	d=10cm
T=200c		I=10mw/m2	I=500mw/m2	I=1000mw/m2
V(volt)	I(nA) dark	I(nA) light1	I(nA) light2	I(nA) light3
1	0.6	0.3	0.8	0.1
2	1.5	2.9	3.5	5
3	2.2	5.3	6.5	9
4	2.9	7.6	9	13.5
5	3.6	9.9	12.3	18.5
6	4.2	12.2	15.5	23.5
7	4.9	14.7	18.8	28
8	5.6	17.2	22.5	34
9	6.3	19.8	26.2	39
10	7	22.8	30	46

Were $\mathbf{V_{oc}}$ Open Circuit Voltage $\mathbf{I_{sc}}$ Short Circuit Current $\mathbf{F.F}$ fill factor and $\mathbf{P_{in}}$ power to in the solar cell was obtained where the efficiency of (η =2.18%) for solar cell (Algrid / CdS / CdTe /glass/ Al) Where the thin films substrates is (glass) thickness of 1000 nm (CdTe) at room temperature where we note the efficiency of these junctions for the thickness of nm (500) where it was equal to (η=0.34%), and in the same way was obtained (η =1.12%). for the solar cell (Algrid / CdS / CdTe / Si / Al) where the films are silicon Si (1000 nm) for CdTe films at room temperature, where we observe the efficiency of these The differences for thickness nm (500) were equal to (η=0.58%). this as in Figure (4,5).

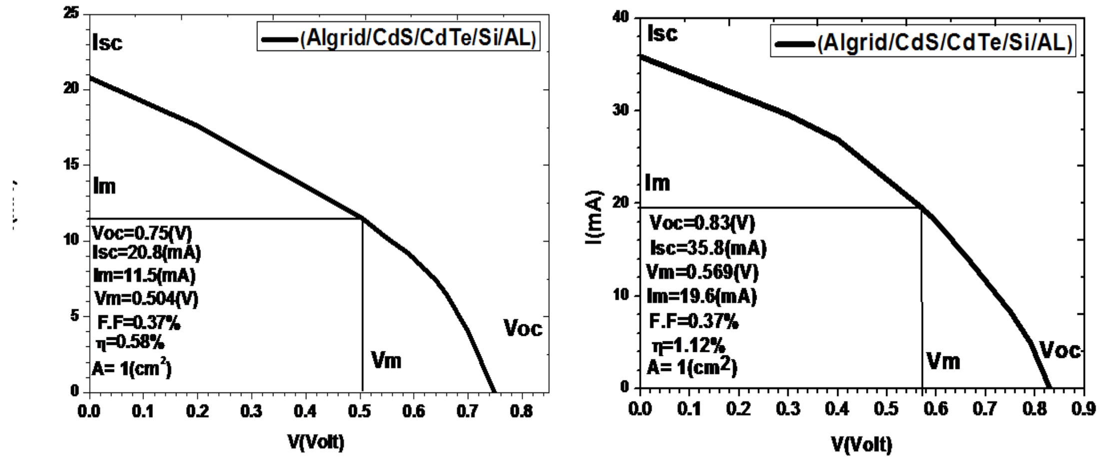


(a)



(b)

Figure 4. (I-V) Characteristics of in case of illumination of solar cells (Algrid / CdS / CdTe /glass/ Al) for thickness (a) (500) nm, and (b) (1000nm



(a) **(b)**

Figure 5. (I-V) Characteristics of in case of illumination of solar cells (Algrid / CdS / CdTe /Si/ Al) for thickness (a) (500) nm, and (b) (1000)nm

Conclusions:

1. Hall measurements showed that all the thin films are p-type and the adoption of both the dynamics and concentration of the charge factors on the thickness and the annealing temperature.
2. D.c conductivity measurements showed that CdTe thin films had two activation energies.
3. The results of I-V characteristics showed that CdTe thin films have the potential to be used to manufacture solar cells.
4. The possibility of manufacturing solar cells from CdTe thin films in thermal vacuum evaporation using the thin films (Al/ CdS / CdTe / Si/Al) on silicon substrates and using the thin films(Al/ CdS / CdTe /glass/ Al) on glass substrates at RT.
5. The best results that gave the best value for efficiency for the solar cell prepared on glass substrates (2.18%) and the silicon bases (η = 1.12%).

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Conflicts of Interest: None.

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تاثير السمك على الخواص الكهربائية وخواص (I-V) للاغشية (CdTe) الرقيقة وايجاد الكفاءة للخلية الشمسية (CdS/CdTe)

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الخلاصة:

حضرت اغشية CdTe عند السمك nm (500,1000) المرسبة على قواعد زجاجية بطريقة التبخير الحراري بالفراغ عند درجة حرارة الغرفة RT للقاعدة المرسبة عليها.وجرى تلدين النماذج عند درجة حرارة K(373,473,573) لمدة ساعة واحدة. وتم قياس ومعامل هول وتوصيلية كهربائية وخواص (I-V) في الظلام والضوء كدالة لدرجات حرارة التلدين والسمك مختلفة فتبين ان اغشية لها القابلية لتصنيع خلايا الشمسية وتم ايجاد كفاءة (η=2.18%) للخلايا الشمسية (Algrid/CdS/CdTe/glass/Al) و (η=1.12%) للخلايا الشمسية (Algrid/CdS/CdTe/Si/Al)بسمك (1000)nm لاغشية (CdTe) في درجة حرارة الغرفة RT.

الكلمات المفتاحية: أغشية الرقيقة CdTe، التبخير الحراري في الفراغ، خلية شمسية .