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MORPHOLOGICAL AND ELECTRICAL PROPERTIES OF CDSE THIN FILMS PREPARED BY THERMAL EVAPORATION TECHNIQUE

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Abstract

In this work , CdSe thin films with different thickness (100 and 200) nm have been prepared at RT by thermal evaporation technique on glass substrate under vacuum of 10-5 mbar. These films have been annealed to different annealing temperatures (423,473 and523) K. The morphology structure of the films has been examined using atomic force microscope (AFM) analysis. AFM measurements showed that the average grain size values of CdSe thin films decrease with increasing of annealing temperatures from (RT-523K). While the average grain size values increase with increasing thickness. The electrical properties of these films were studied with different thickness and annealing temperature. The d.c. conductivity for all deposited films decreases with increases of annealing temperatures. The electrical activation energies Ea1 and Ea2 found to decrease with increasing of thicknesses. While increase with increasing of annealing temperatures. From Hall effect result, it is found that the carriers concentration increase with increasing of annealing temperatures. While decrease with increasing of thickness. Hall mobility, drift velocity, carrier life time and mean free path decrease with increasing of thickness and annealing temperatures.

Keywords: Cdse Thin Films, Structural Properties, Electrical Properties, Thermal Evaporation Technique.

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Introduction

Cadmium selenide is an inorganic compound with the formula CdSe. It is a black to red-black solid that is classified as a II-VI semiconductor of the n-type[1]. Much of the current research on this salt is focused on its nanoparticles. Three crystalline forms of CdSe are known which follow the structures of: wurtzite (hexagonal), sphalerite (cubic) and rock-salt (cubic). The sphalerite CdSe structure is unstable and converts to the wurtzite form upon moderate heating[2].CdSe material is transparent to infrared (IR) light and has seen limited use in photo resistors and in windows for instruments utilizing IR light. The material is also highly luminescence [3]. Cadmium is a toxic heavy metal and appropriate precautions should be taken when handling it and its compounds. Selenide are toxic in large amounts. CdSe is a known carcinogen to humans and medical attention should be sought if swallowed, dust inhaled, or if contact with skin or eyes occurs[4]. In this paper, Thermal evaporation method is one of the most popular among the deposition methods. Simplicity of operation and proper speed are the notable strengths of this deposition method. Thermal evaporation is one of the Physical Vapor Deposition (PVD) methods during which a thin film is deposited on the substrate during a physical process[5,6].

Expermintal Part

CdSe films with different thickness (100 and 200) nm have been prepared at RT by thermal evaporation technique on glass substrate under vacuum of 10-5mbar. These films have been annealed to different annealing temperatures (423,473 and 523) K. The morphology structure of the thin films was determined by AFM (Scanning probe microscope type AA3000), supplied by the Angstrom Advanced Company to determine the grain size and roughness for CdSe deposit on the glass base has been recorded and their statistical distribution analysis. The measurements of DC conductivity have been done using sensitive digital electrometer type Keithley 616 and electrical oven. Hall Effect Measurements were done by Van der Pauw Hall Measurement Systems (Ecopia HMS-3000). Measurements required four Ohmic contacts on the sample; it has been placed in four-point probe into this device . The carrier concentration (nH) is related to the Hall coefficient (RH) which is determined (7):

$N=1/RH.q$……………………………………………………..(1)

Where q is the electron charge. The Hall mobility is determined from the equation :

$\mu H=RH.\sigma$…………………………………………...…………(2)

where σ is the conductivity .The drift velocity (υd) , carrier life time (τ)and mean free path (l) can be determined :

$\upsilon d = E.\ \sigma/N.q$ ………………………………………………………(3)

$\tau = m^*.\ \sigma/N.q2$ …………………………..…………………………(4)

$l = \upsilon d\ .\ \tau$

where E is the electric field and m* is the effective mass

Results and discussion

Morphological Properties

In order to examine the morphology of CdSe thin films deposited on glass are used atomic force microscope analysis which includes measured the roughness and average grain size of the films. . The roughness of the surface is an important parameter, where the surface roughness not only describes the light scattering but also gives an idea about the quality of the surface under investigation. Images of AFM analysis of CdSe film at thickness 100nm and 200 nm at different annealing temperatures a:RT , b:423K, c:473and d:523K is shown in Figure(1 and 2) respectively. These images reveal that the average grain size are in nano scale and the films have improving structure with a high homogeneity without voids , This means that the films are highly dense structure and are deposited very well . Average grain size , surface roughness are recorded in table (1) which illustrates that Roughness increases while Average grain size decreases with annealing temperature. Film prepared at thickness 100nm exhibits a slightly lower roughness, when compare with the thickness 200 nm which can be due to low aggregation of the nanoparticles comparing to thickness of 200 nm.

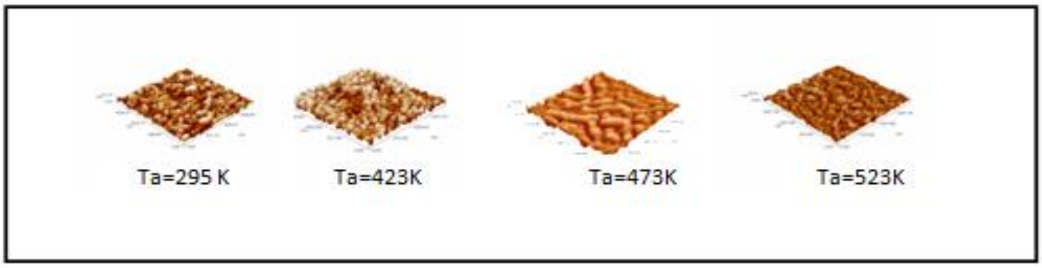

Figure (1) AFM image for cdse film at thickness 100nm and different annealing temperatures a:RT , b:423K, c:473and d:523K.

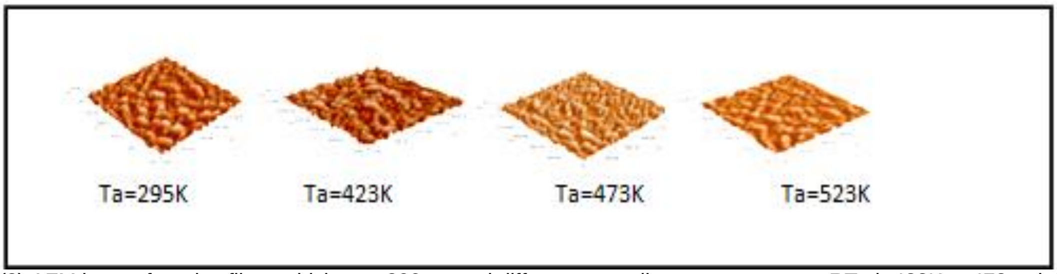

Figure (2) AFM image for cdse film at thickness 200nm and different annealing temperatures a:RT , b:423K, c:473and d:523K.

In general, we can notice from Table (1-1) that the average grain size values decrease with increasing of annealing temperatures while increase with increasing of thickness.

Table 1:Average grain size, average roughness and Peak- Peak for films with different thickness at RT and(423,473,523)K

X(nm)	Ta(K)	Ave. grain size (nm)	Ave. Roughness (nm)	Peak- Peak (nm)
100nm	295	63,28	2,44	20.5
	423	59.18	7.25	35,5
	473	58.08	9.25	42,7
	523	54.42	12.21	51.3
200nm	295	80.08	1.16	53.1
	423	88.,58	6.33	27.11
	473	91.7	2,54	38.2
	523	96.03	8.67	71.5

Electrical properties

Studying the electrical conductivity as a function of temperature to determine the behavior of electrical conductivity in thin films by defining the required energy values to make conducting. Figure (3 and 4) shows logarithmic change electrical conductivity ln (σ) with inverted degree of absolute temperature (1000/T) for CdSe thin films prepared by thermal evaporation method on glass substrate at RT and annealing to ((423,473,523)K and different thickness 100nm and 200 nm respectively. It is clear from these figures that there are two activation energy Ea1, Ea2 and hence two transport mechanism. The conduction mechanism of the activation energy (Ea2) at the higher temperatures range (413-475) K is due to carries excitation into the extended states beyond the mobility edge, and at the lower range of temperatures (293-403) K, the conduction mechanism of the activation energy (Ea1) is due to carriers excitation into localized states of the edge of the band. The values of Ea1 and Ea2 increase with increasing of annealing temperatures due to the elimination of some defects from the films and the improvement in crystallinity during annealing. We also observe that the values of Ea1and Ea2 decrease with increasing thickness and this may be attributed to the increasing of the absorption and decreasing of the energy gap[8,9].Table (2) illustrates obviously that the (σd.c) of the CdSe films increases with increasing of thickness. Also, it found that The (σd.c) decrease with increasing annealing temperatures for all films [10]. The observed lesser conductivity in thin films can be explained due to lower degree of crystallinity and the small grain size as mention in the previous results . This result is in agreement with Patida et al.[11].

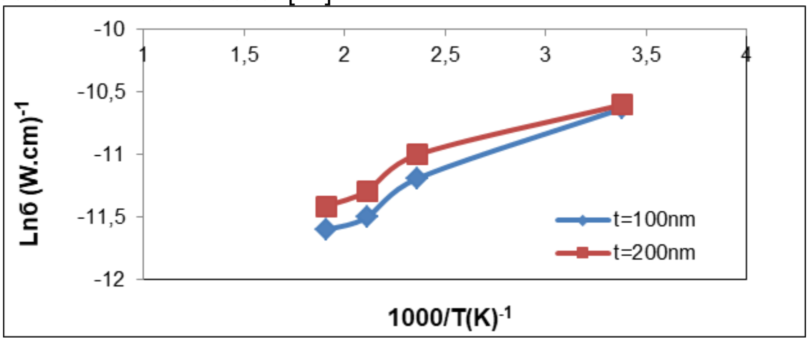

Fig. (3) Ln σd.c versus 1000/T for CdSe films at different thickness and annealing temperatures.

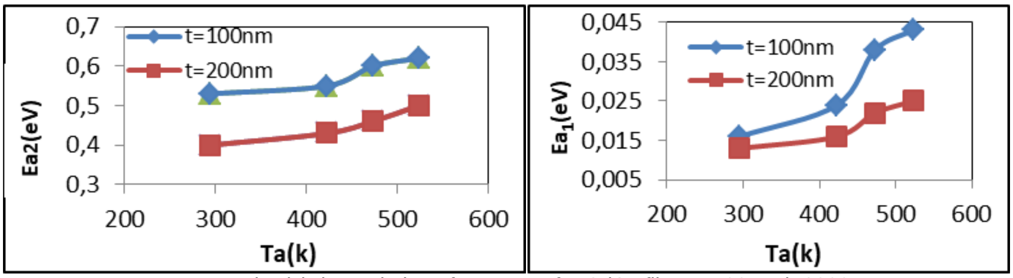

Fig. (4) the variation of Ea Vs Ta for CdSe films a:100nm-b:2000 nm

Table (2): D.C. conductivity parameters for cdse films at different thicknesses and annealing temperature.

Thickness (nm)	Ta (K)	σd.cR.TX10^ -5 (Ω.cm)-1	Ea1 (eV)	Temp. Range (K)	Ea2 (eV)	Temp. Range (K)
100	93(RT)	2.3	0.015	293-403	0.52	403-473
	423	1.81	0.021	293-403	0.54	413-473
	473	0.91	0.036	293-403	0.58	413-473
	523	0.89	0.041	293-403	0. 6	413-473
200	293(R.T)	2.39	0.01	293-403	0.38	413-473
	423	2	0.012	293-403	0.4	413-473

	473	1.23	0.02	293-403	0.44	413-473
	523	0.99	0.022	293-403	0.45	413-473

From Hall measurement it is found that the carriers concentration increases with increasing of annealing temperatures while decreases with increasing of thickness .The Hall mobility decreasing with increasing thickness and annealing temperatures of CdSe films . All these results are illustrated in Figure (3) and table (3) The decrease in the mobility with increasing thickness is due to the decreasing of the carrier concentration From the Hall mobility measurements,τ,Vd and ℓ of the carriers have been calculated at different thickness and annealing temperature, the results were shown in Fig.(5,c,d,e) and the values were listed in Table (3). We found that all these parameters approximately decrease with increasing thickness and annealing temperatures. The reason for this variation is mentioned previously[12,13].

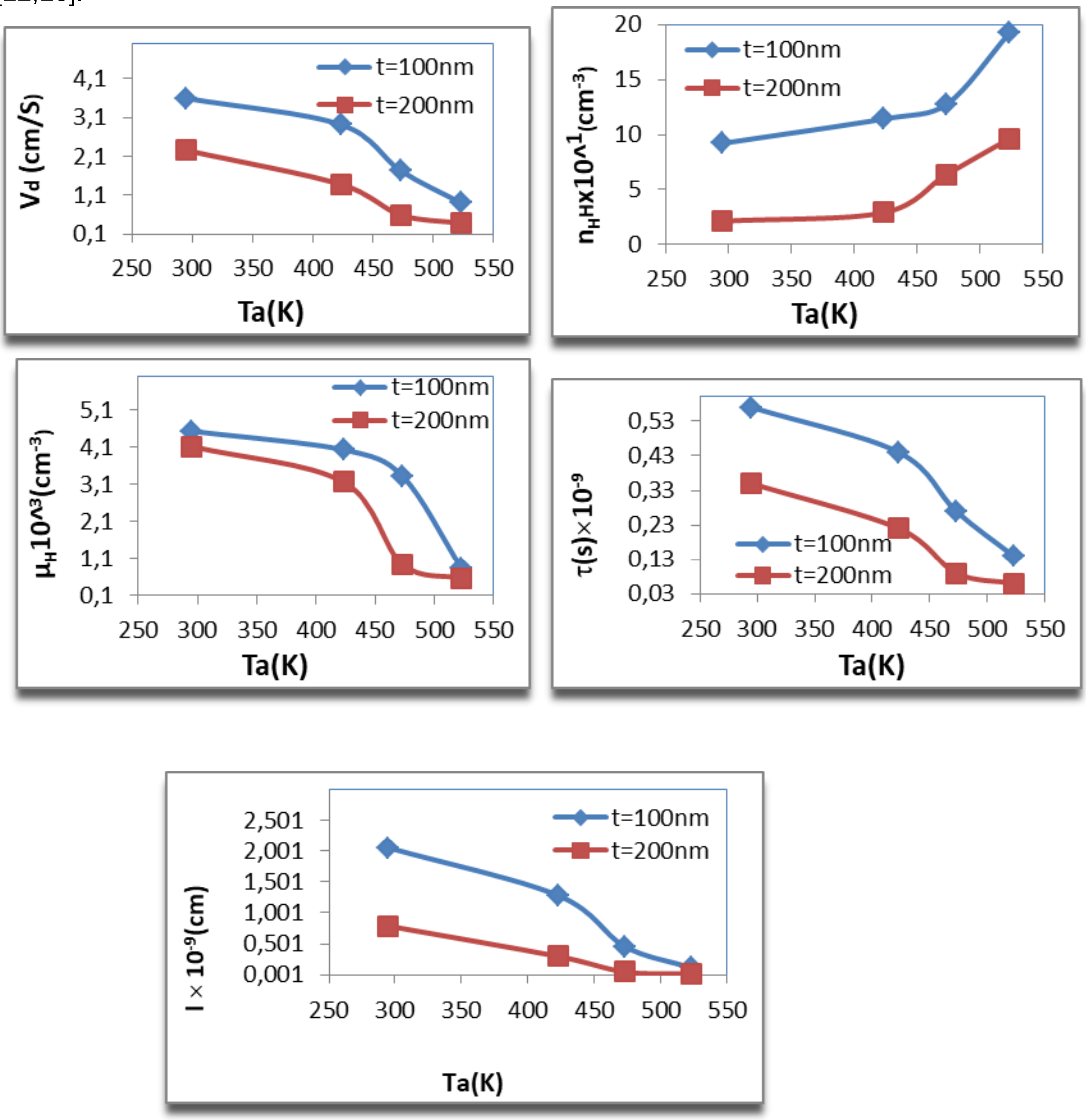

Fig.(3) Shows Hall parameters' of cdse thin films a-concentration (nH) b –Hall mobility(μH)
c-drift velocity (Vd) d- Lifetime (τ) e-mean free path (ℓ)

Table (3) Hall parameters for cdse films at different thickness and annealing temperatures

Thickness (nm)	Ta(K)	σR.T× 10-5 (Ω.cm)-1	nH×1011 (cm-3)	μH×103 (cm2/V.sec)	vd (cm/s)	τ(s)×10-9	l × 10-9 (cm)
100	2)	6.21	9.21	4.52	3.6	0.57	2.05
	423	6.02	11.42	4.02	2.92	0.44	1.28
	473	4.13	12.75	3.31	1.73	0.27	0.46
	523	3.24	19.22	0.82	0.9	0.14	0.12
200	2)	0.9	2.13	4.11	2.26	0.35	0.79
	423	0.75	2.91	3.15	1.38	0.22	0.3
	473	0.7	6.37	0.92	0.59	0.09	0.05
	523	0.68	9.62	0.55	0.38	0.06	0.02

Conclusions

CdSe thin films have been prepared successfully on glass substrate by thermal evaporation technique at RT and different annealing temperatures (423,473 and 523) K. AFM measurements showed that the average grain size values for CdSe thin films at RT and different annealing temperatures decrease with increasing annealing temperatures while increase with increasing of thicknesses. The electrical properties of these films were studied with different x content and annealing temperature. The D.C conductivity for all films increases as the thickness increases and decreases with increasing the annealing temperatures. Hall measurements showed that there are two types of conductance (n- type and p-type charge carriers). Also The charge carriers concentration increase with increasing annealing temperatures while decrease with increasing the thickness of CdSe films., whereas the mobility, drift velocity, carrier life time and mean free path decrease with increasing of thickness and annealing temperatures.

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