Study The Influence Of Sn Dopant On The Surface Topography And Some Physical Properties Of CdSe Films Prepared By Evaporation Technique

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***Abstract*—In the present paper , pure and doping cadmium selenide thin films have been deposited on to well cleaned glass substrates by thermal evaporation under vacuum method with a deposition Rate (0.7 nm/ sec) and at room substrate temperature (300 K) and (300 nm) thickness of the films.**

The effect of doping by (3%) Sn on the structural , optical , morphological and electrical properties of prepared films was carried out by using X-Ray diffraction (XRD), (UV/ VIS /NIR) spectrum, scanning Electron Microscopy (SEM) , Atomic force Microscopy (AFM) and Hall effect Measurements Respectively , the Results of this work has been discussion.

Keywords—AFM,XRD,CdSe,physical properties

1. INTRODUCTION

Cadmium selenide is one of the important compounds binary metal chalcogenide glassy semiconductors that which belonging to the II-VI group of periodic table , it has many essential electrical and optical properties that which allowed him to use in the optoelectronic application and produced photoelectric devices such as solar cells and light Emitting diode (LED) [1-4] .

Among of these properties , cadmium selenide have suitable direct optical band gap (1.74ev), and the electrons are majority charge carriers in this compound , so that it's classified as N-type electrical conductivity of semiconductor materials [5-7] , it has cubic zinc blende and hexago-nal wurtzite structures [8].

Cadmium selenide thin films can be prepar- ed by using various chemical and physical methods Such as spray pyrolysis [9] ,photo-electrochemical (PEC)[10] , chemical bath deposition [11,12] , spattering deposition [13] and thermal evaporation under vacuum method that which used to prepared all pure and doped films in this work [14].

In the present paper, we report the deposit -ion of CdSe thin films on glass substrates by thermal evaporation technique to study there structural ,morphological and optical properties and the effect of doping by (Sn) on these properties is also discussed.

2. EXPERIMENTAL DETALLS

CdSe fine powder of purity 99.99% was used as a source to prepare pure cadmium selenide thin films, glass micro slides with a size (2.5cm x 2.0cm) were used as a substra- tes and prepared to the deposition process by cleaning it in to the distilled water followed by acetone and then by ethyl alcohol , molybdenum boat was used to evaporated CdSe powder source.

Cdse thin films was evaporated in this research by using (Edwords306) coating unit with a deposition rate equal to (0.7 nm / sec) and vacuum pressure equal to (2.4×10^{-6} torr) and (300 nm) thickness.

The pure samples of CdSe films have been doped by (3%) Sn using the same coating unit, and then subjected to the diffusion heat at 200 C^o for one hour .

The X-Ray diffraction patterns of all prepar- ed films were recorded in the range of 2ϴ between (20-80) degree by using X-Ray diffractometer .

The transmission spectra of pure and doped CdSe thin films have been taken by using (UV-VIS-NIR 1800 Spectrophotometer) in the wave length range (400-1100) nm .

The particle shape and grain size of pure and doped CdSe thin films were investigated by using SEM and AFM (AA3000 Scanning prope Microscopy) Respectively .

The thickness of films was measured by using (TF prope spectroscopic reflectometer film thickness measurement system) .

3. RESULTS AND DISCUSSION

3.1 XRD ANALYSIS

The X-Ray diffraction pattern of therm- ally evaporated CdSe thin films (as-prepared with a thickness of 300 nm is shown in Fig.(1)a , this pattern shown that pure CdSe films are polycrystalline in nature and contain three main peaks at diffraction angl- es of (25.5008)^o, (35.2600)^o and (45.8503)^o which corresponding to the reflection of planes (002) , (102) and (103) respectively and with preferred orientation along (002) plane , these peaks are belonging to the hexagonal phase of CdSe structures , and good agree with the standards peaks (JCPDS – card No :008-0459)[15] , and with the results of the previous research [16 ,17].

Fig. (1)b shown the x-ray diffraction pattern of CdSe film that which doped by (3%) Sn , it is clearly from that figure the crystallinity of the film was increased by doping process and the intensity of preferred peak (002) was increased and shifting towards small diffraction angles as shown in the table (1) . while the intensity of the other two peaks have been decreased strongly ,this is due to the fact that increased the numbers of particles by doping process in the preferred orientation (002) much more than the other (102) and (103) (because have the lowest internal energy) which cause increment in nucleus size and leading to the large clusters and larger grains owing to the formation of continuous film in that preferred orientation.

From the other side , the increased in the intensity of the preferred peak can be attributed to the Sn dopant have been taken the substitutional lattice site of CdSe structure and have been processed some crystal defects such as point defects – that which absolutely conjugated with the structural of any film during it's fabrication process – by filling it and then produced the

Semi-perfect reflection plane such as [002]. this results are agreement with the results of research [18, 24].

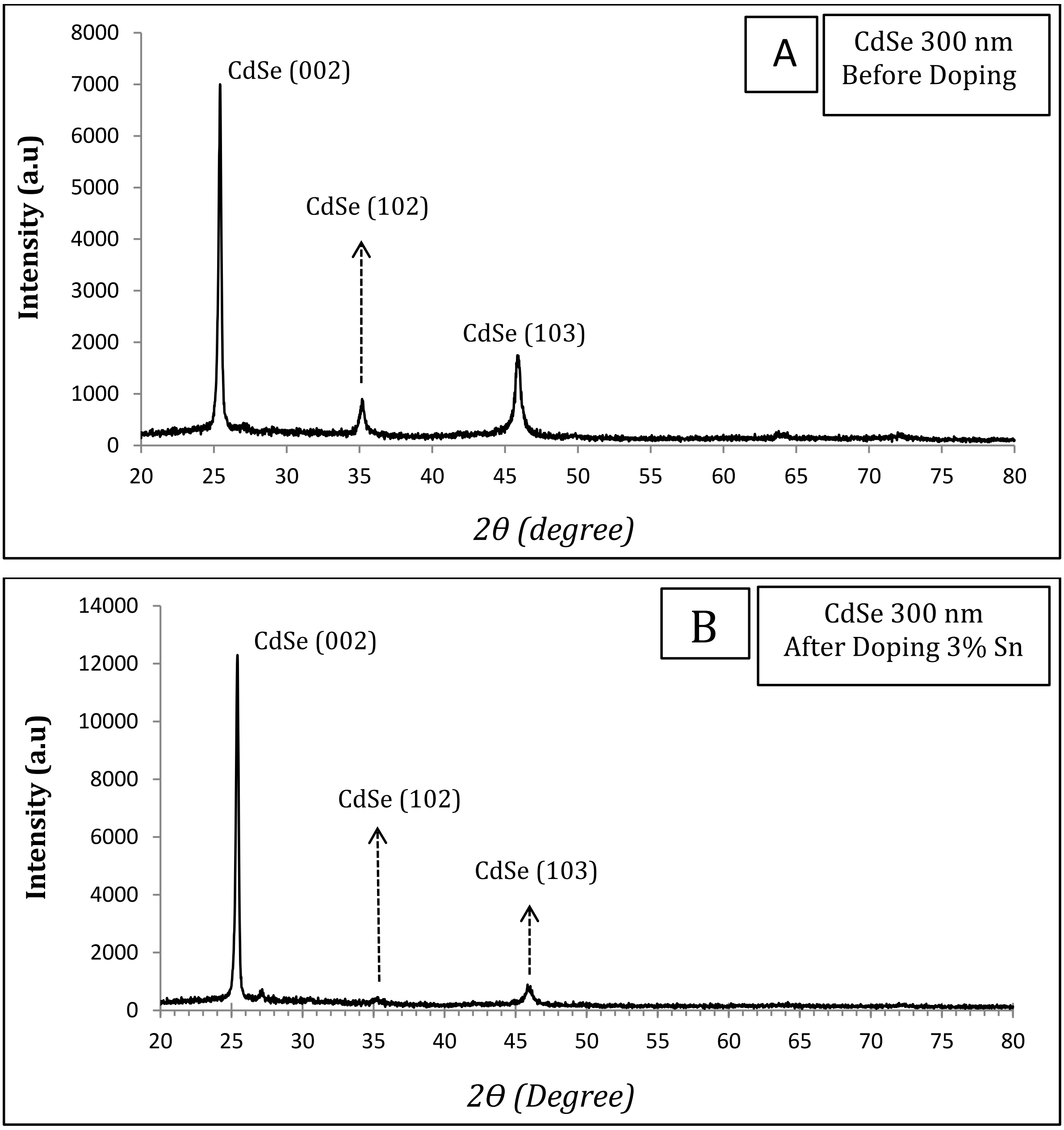

Figure (1): XRD pattern of pure (a) and 3% Sn doped (b) CdSe thin films at 300nm thickness

Table (1): XRD data of pure and 3% Sn doped CdSe thin films

300(nm)	hkl (ASTM)	2Θ(ASTM)	2Θ(Observed)	d(A°)ASTM	d(A°)Observed
As-Prepare	(002) (102) (103)	25.3538 35.1072 45.7884	25.5008 35.2600 45.8503	3.5100 2.5540 1.9800	3.4902 2.5435 1.9775
As-doping	(002) (102) (103)	25.3538 35.1072 45.7884	25.4379 35.2077 45.7703	3.5100 2.5540 1.9800	3.4987 2.5470 1.9787

3.2 AFM ANALYSIS RESULTS

The surface morphology of doped and undoped CdSe thin films was studies by atomic force microscopy , Figure. (2) shown the (3-dimensions) AFM images and distri- bution chart of both doped and undoped nanoparticles CdSe thin films , the AFM images proved that the grains in both two cases are uniformly distributed within the scanning area (2500 x 2000) nm with individual columnar grains extending upwards and there are no pin hole and cracks can be found in both two cases. It is clearly from the figure. (2)b and table (2) that doping process by (Sn) metal atoms was influenced significantly on the surface topography parameters such as colour , roughness , …ect.

The average grain size of CdSe films will be increased notably after doped films by (3%) , this is due to increased the number of particles that which joined within preferred grain's orientation especially after doping process which caused increased the agglomeration process of these particles and then consequently growth uniform and homogeneous continuous film with high crystallinity , this results are completely agree with XRD analysis results and with the results of research [18, 23] , the surface topography parameters such as grain size , roughness density and root mean square are listed in table (2) .

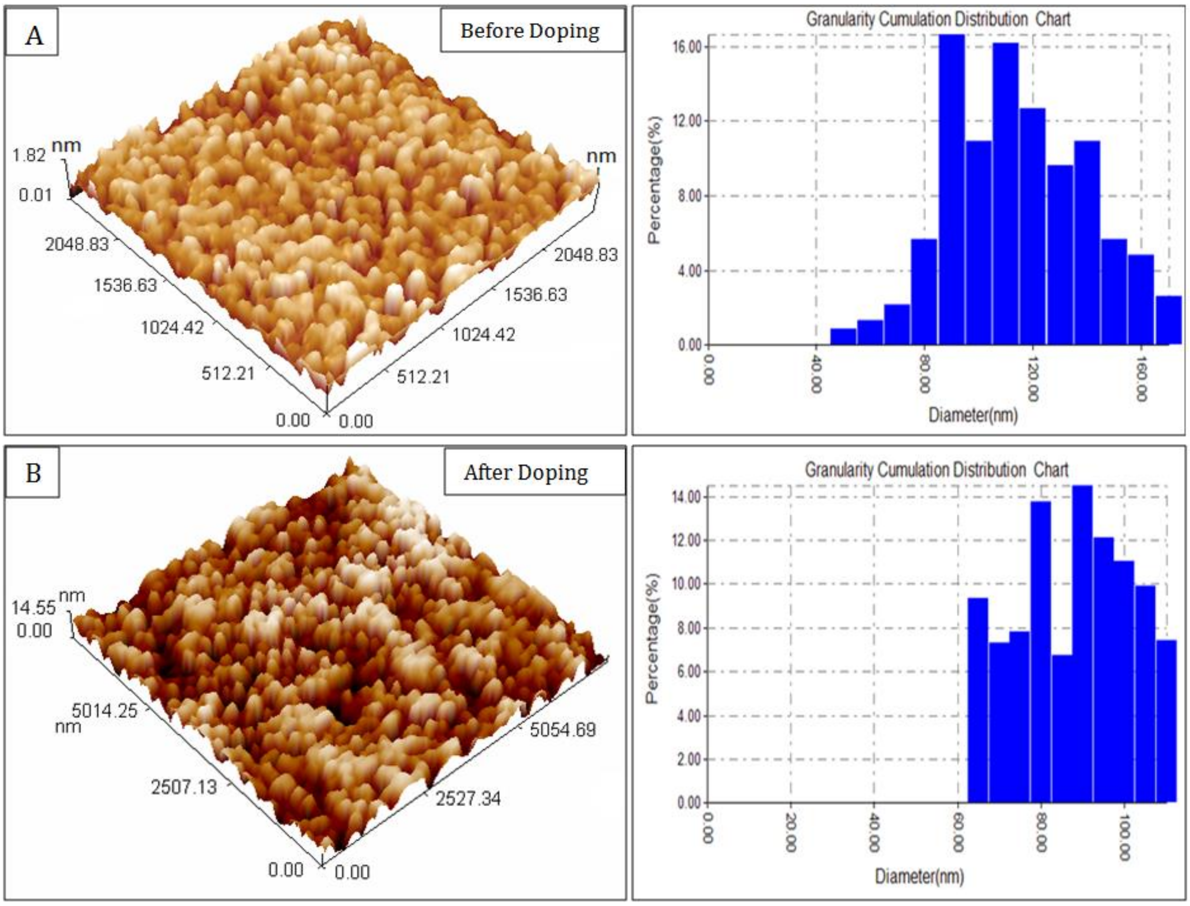

Figure (2): AFM images and distribution chart of pure (a) and 3% Sn doped (b) CdSe thin films at 300nm thickness

Table (2): AFM analysis results of p of pure and 3% Sn doped CdSe thin films

Thickness 300 (nm)	*Grain Size (nm)*	*Root mean square (nm)*	*Roughness density (nm)*
as- prepare	78. 80	0.25	0.198
Doped 3% Sn	85.58	3.52	2.990

3.3 SEM ANALYSIS RESULTS

In this research we are studied the micro structure of doped and undoped CdSe thin films by using scanning electron microscopy Figure. (3) reveals the SEM images of pure and (Sn) doped CdSe films with scanning magnification (50.0kx) and resolving power (1μm), it's observed from fig.(3)a , the films in the pure case consist of dense layer of small Nano size grains ,which have spherical shape and distributed uniformly over smooth homogeneous background and free from microscopy defect like cracks or peeling .

While when doped this films by (3%) Sn Metal, this grains had been converted in to continuous and homogeneous film with large grains as shown in fig.(3)b , this is due to the coalescence a large number of CdSe nanoparticles that which had been adhesion together and stacked especially in the diffus- ion heat treatment time (200C° for 1 hour) .

We can conclude from this behavior, that the doping process has been improved the surface morphology of pure CdSe films and then consequently increased the crystallinity of the films , this can be used and utilized it in the photovoltaic applications such as solar cells , and these result are completely agreement with both XRD and AFM analy -sis results and with the results of research [16 ,19].

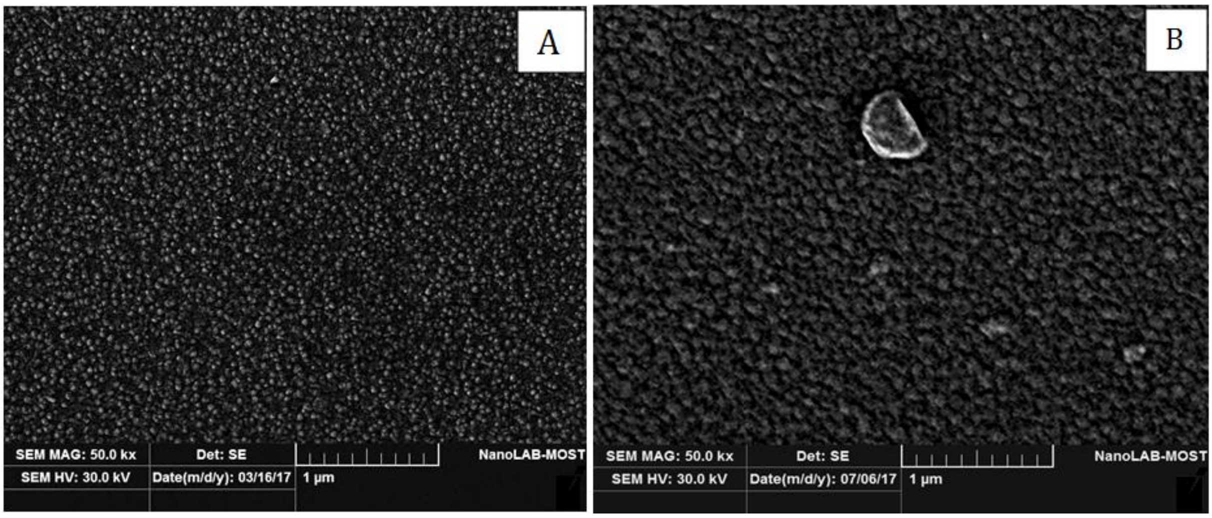

Figure (3): SEM images of pure (a) and 3% Sn doped (b) CdSe thin films at 300nm thickness

4. OPTICAL ENERGY GAP (Eg)

The optical energy gap of pure and doped cdse films was calculated from the transmit - ssion spectra by using (UV / VIS /NIR /1800 spectrophotometer) , Figure . (4) Shows the band gap of CdSe films in both doped and undoped cases , the optical energy gap was measured from the plote of square of $(\alpha h\nu)^2$ Versus photon energy (hv) where (α) is the absorption coefficient , and then by extrapo- lating the linear part of the curve toward the photon energy axis , the energy gap was found equal to (1.72ev) for pure CdSe films. this value was agreement with the research [19, 21] , while when doped this films by (3%) Sn, it was found that the value of energy gap has been decreased to become equal to (1.68ev) this can be attributed to the localization states of impurities atoms (Sn) that which created during the doping process and have been taken place within energy gap region , this states has been worked to turn –up the fermi level to become closer the conduction band and then consequently

Absorbed the photons that which has energy less than (1.72 ev) until the value (1.68 ev). this indicate that the doping process by (Sn) metal has been worked to increase the optical absorption region as well as absorption coefficient and leading the basic absorption edge to moved towards the lowest photon energies , this results are agreement with the results of research [18, 24].

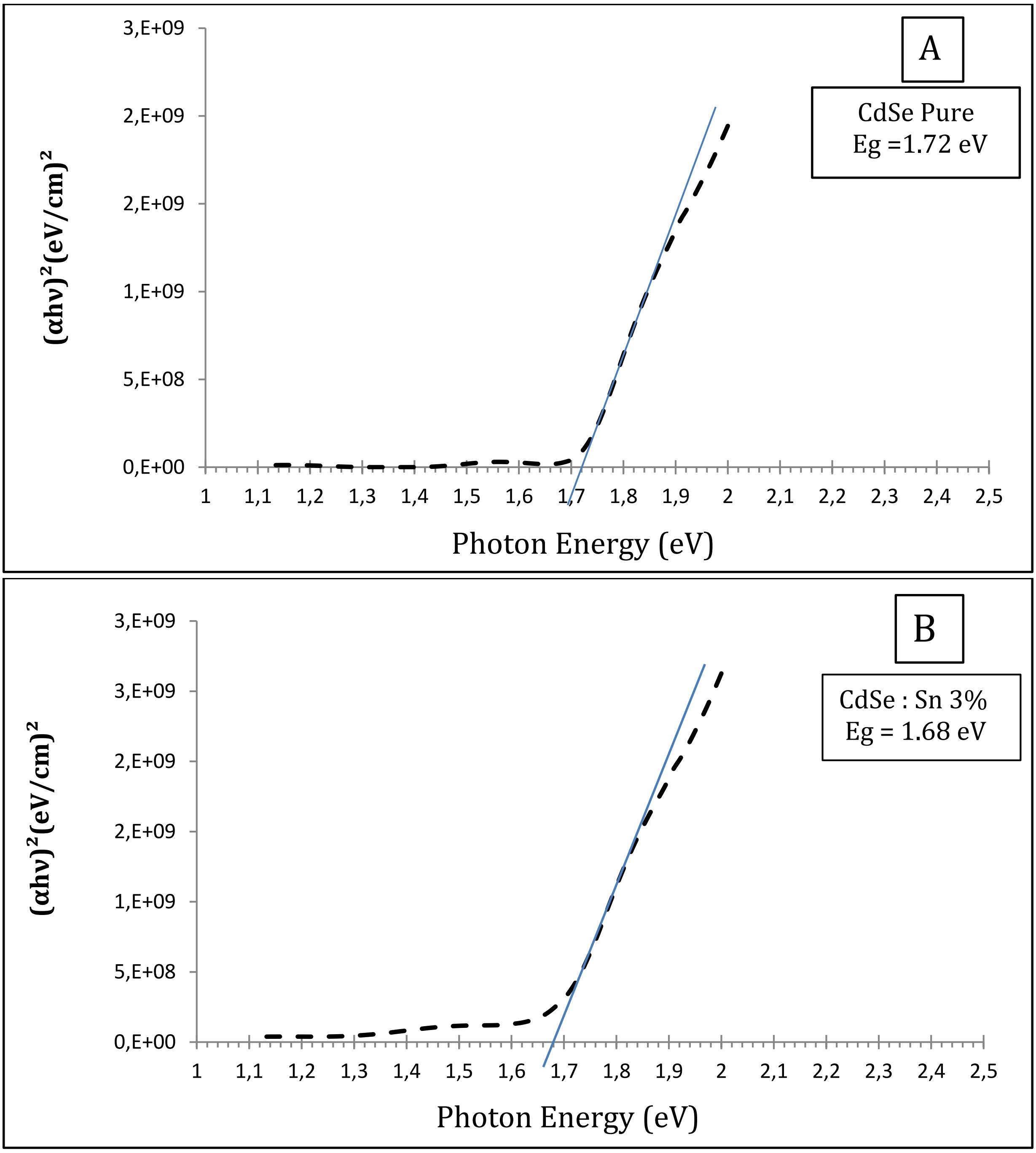

Figure (4): Energy optical gap of pure (a) and 3% sn doped (b) cdse thin films

5. HALL EFFECT MEASUREMENT

In this research , the electrical parameters such as carriers concentration , carriers mobility , majority carrier type , resistivity and electrical conductivity were measured by used (HMS-3000) hall effect measurement system that which produced from (Ecopia) company, the results of these measurements are listed in table (3) , it was clearly from this table the pure and doped CdSe films have negative type electrical conductivity through the negative sign of hall coefficient , also the hall mobility value was found to be increased by doping process , this can be attributed to increase the crystallinity of the films after doping process , (i.e increased the average grain size) that which leading to decreased grain boundaries scattering for the majority charge carriers , and then consequently increased the mobility value. This will be also influenced on the electrical conductivity and decreased the resistivity value , this results are completely agreement with XRD and SEM respectively and with the results of research [16, 20].

Table (3): Hall affect results of pure and 3% Sn doped CdSe thin films at 300 nm thickness

Thickness (nm)	*Carrier Concentration/ cm^3*	*Mobility (μ) cm^2 / V.sec*	*Resistivity (ρ) Ω.cm*	*Conductivity (σ) $(Ω.cm)^{-1}$*	*Hall Coefficient cm^3/c*
300	-3.907E+12	5.185E+0	3.085E+5	3.240E-06	-1.599E+6
300	-1.830E+11	2.996E+2	1.140E+5	8.772E-06	-3.412E+7

CONCLOSION

1- The X-Ray diffraction pattern shown that pure cadmium selenide thin films which prepared by thermal evaporation under vacuum technique and deposited at 300 nm thickness are poly crystalline in nature with preferred orientation along (002) plane , and the doping process has been increased the intensity of the beam that which reflected from preferred orientation along (002) plane .

2- The atomic force microscopy results shown that the doping process has been worked to increase the average grain size of the films from the value (78.80 nm) for pure case to become (85.58 nm) for the doped case , this indicate that the structural properties of pure fabrication CdSe thin films can be improvement by doping process .

3- The atomic force microscopy results are also shown that the roughness of the films has been improved by doped films and increased from the value (0.198 nm) for the pure condition to become (2.99 nm) at the distortion condition , this indicate that the surface morphology of pure fabrication CdSe films can be enhancement by doping process .

4- The scanning electron microscopy images shown that pure nanoparticles CdSe films has been transformed in to homogeneous and continuous films with a large grain diameter when doped these films by (Sn) metal, this indicate the surface morphology of pure CdSe films can be improved by this process .

5- The electrical measurement results shown that pure and doped CdSe films have n-type electrical conductivity and the doping process has been influenced positively on the electrical parameters of pure prepared films .

REFRENCES

[1] K.S. Ajaya, S.R. Deo, G.S. Thool, R.S. Singh, Y.R. Katre, A. Gupta, Synthesis and Characterization of Chemically Deposited Nano crystalline CdSe Thin Film, Synth. React. Inorg. Met. Org. Chem., 41 (2011) 1346 -1350.

[2] Y.R. Toda, K.S. Chaudhari, A. B. Jain, D. N. Gujarathi, Structural and Optical Properties of CdSe Thine Films Depósted by Chemical bath deposition Technique, Asian J. Chem. and Envi. Res., 4 (2011) 40-43.

[3] V.T. Patil, V.P. Joshi, D.A. Tayade, J.V. Dhanvij, D.N. Gujarathi, Surface morpholog ical and optical properties of CdSe thin films by closed space sublimation technique Chalcogenide Letters, 10 (2013) 239-247.

[4] H. L. Mansour, K.A. Mishjil, N.F. Habubi, S.S. Chiad, Structural and Optical Properties of (Cd 0.4 Se 0.6) Thin Films Prepared by CBD, Int. J. Thin Films Sci. Tec., 3 (2014) 57-60.

[5] M.A. Jafarov, E.F. Nasirov, E.A.Xanma mmadova. Preparation of Nano sized A2B6 Compound Multilayer Structures for Solar Cells. Universal Journal of Physics and Application 1(2): 125-129, 2013.

[6] S. Velumani, X. Mathew, P.J. Sebastian, S.K. Narayandass, D. Mangalaraj, Structural and optical properties of hot wall deposited CdSe thin films, Solar energy materials and solar cells, 76 (2003) 347-358.

[7] R.C. Kanithla, D.K. Pandya, K.L. Chopra, Photo-Electronic Properties of Solution - Grown CdSe Films, Solid - State Electronics, 25 (1982) 73- 76.

[8] O. Zakharov, A. Rubio, M.L. Cohen, Calculated structural and electronic propert- ies of CdSe under pressure, Physical Review B, 51 (1995) 4926-4930.

[9] Y. V. Melelera, N. A. Redy Chev, G.F. Nevikor, Inorg . Mater. 43(5), 455 (2007)

[10] S.S. Kale, H.M. Pathan, C.D. Lokhande, J. Mater. Sci. 40, 2635 (2005)

[11] P.P. Hankare, P. A. Chate, D. J. Sathe, B. V. Jadhav, J. Alloys Compd. 503, 220 (2010) .

[12] N. Gopakumar, P. S. Anjana, P. K. Vidyadharan Pillai, J. Mater. Sci. 45, 6653 (2010).

[13] R. W. Glew, Thin Solid Films 46, 59 (1977).

[14] D. P. Padiyam, A. Marikani and K. R. Murali, Mater. Chem. Phys. 78, 51 (2002).

[15] JCPDS card No (000-008-0459).

[16] S. R. Vishwakarma, A. Kumar and S.Prasad, Synthesis and Characterization of n-CdSe thin films Deposited at Different Substrate temperatures , Vol . 10, No . 10, (2013),P.393-402.

[17] Yunus . Akaltun , M. Ali . Yıldırım, Aytunç . Ates and Muhammet Yıldırım, The relationship between refractive index-energy gap and the film thickness effect on the characteristic parameters of CdSe thin films, Opt. Commun. 284 (2011) 2307-2311.

[18] M . Ali, W . A . A . Syed, M. Zubair, N . A . Shah and A. Mahmoud, physical properties of Sb-doped CdSe thin films by thermal evaporation method , Journal of Applied Surface Science, 284(2013) 482-488 .

[19] A.A.Yadav , M.A.Barote and E.U.Mas-umdar, studies on cadmium selenide (CdSe) thin films deposited by spray pyrolysis, Journal of Materials Chemistry and physics 121 (2010) 53-57 .

[20] V . S . Kumar and C . C . Bijumon , Raman, PL and Hall effect Studies of CdSe Thin Film Deposited by Chemical Bath Deposition , International Journal of Scientific and Technology Research ,5(5)2016.

[21] S . M . Hus and P. Parlak, J. Phys. D, Applied Phys. 41, 035405 (2008).

[22] H. M. Ali and H. A. Abd EI-Ghanny, Phys. Condensed Matter 20, 155205 (2008).

[23] M . K. Khalaf, A.I.Khudiar and Anwar abd- Alzahra , " influence of nanocrystalline size on optical band gap in cdse thin films prepared by DC sputtering, Journal of science Direct, 527(201) p1-8 .

[24] V. M. Bhuse , chemical bath deposition Of Hg doped CdSe thin films and their characterization, Journal of materials Chemistry and physics, 91 (2005) 60-66 .