Enhancement efficiency of cadmium selenium solar cell by doping within silver

M. H. Mustafa, H. M. Ali*, G. S. Ahmed, B. H. Hussein
Department of Physics, College of Education for Pure Science / Ibn Al-Haitham, University of Baghdad, Baghdad, Iraq

We studied at the morphology, structural setup, and optical characteristics of thin cadmium (CdSe) films a thickness of 250 nm that were created by thermal evaporation over glass, The films exhibited a hexagonal shape were crystalline, and tended to form grains in the (111) crystallographic direction, according to the X-ray diffraction examinations. These characteristics were established using the investigation's findings. Through the use of thin films of CdSe doped with Ag at a concentration of 1.5%, the crystal structure orientations for pure CdSe (25.32, 41.84) and CdSe:Ag (25.39, 41.01) that were both pure as well as those that were doped with silver were both determined. The band gap of the optical spectrum decreased by 1.93–1.81 eV (300–700 nm). This reduced the rate of absorption measuring the current-voltage properties of heterojunctions made from a range of clean and doped materials with an incident electrical power density of (100 mW/cm^2). The films' hexagonal structure was revealed by the X-ray investigation, and grain development was driven by the (220,111) crystallographic direction.

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Keywords: Structural properties, Optical properties, I-V, Hall effect, FE-SEM, Conversion efficiency

1. Introduction

Cadmium selenide (CdSe) one of the AB^{VI} semiconductor materials that has received the most research.This type of chemical is very well suited for several applications because of its unique physical properties, including solar cells and high-efficiency thin-film transistors [1,2].For a fuller comprehension of this association and to enhance the performance of these films for technological applications, additional research into the relationship between the physical characteristics of CdSe films and their annealing time is still required. Several CdSe film manufacturing techniques have recently been described in several kinds of literatures [3,4]. A very practical way for obtaining homogeneous adhesion films is thermal evaporation under vacuum, one of several preparation procedures. For the use of CdSe in the manufacture of devices, a detailed examination of the film's different properties is essential. This study examines how the optical properties and structural of thin films CdSe are affected by the tempering period. There are several applications for the atomic compound cadmium selenide (CdSe), which is found in groups II through VI of the periodic table of elements. The spectacular expansion of CdSe films' use in scientific, technological, and industrial applications has been greatly aided by our growing understanding of their many features. The applications of CdSe, which is typically an n-type material, in this study include photoconductors [5], solar cells [6], thin film transistors [7,8], gas sensors [9], acousto optic devices [10], vidicones [11], photographic photoreceptors [12], etc. a glass substrate with thin layers. In the study Doping's effects on CdSe films' optical properties and solar cell performance have been studied.

* Corresponding author: hiba.m.a@ihcoedu.uobaghdad.edu.iq
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2. Experimental

The CdSe films created by thermally evaporating on substrates made of glass in an atmosphere of high vacuum are around 250 nm thick. Substrates consisting of P-type single-crystal (111) Si wafers were also used. The films on glass substrates (300K) were made by thermal evaporation [18]. The thin films were created using molybdenum boat technology from Edwards-Unit 306 and thermal evaporation procedures. The glass slides were separated from the base holder and cut into 1.5 by 1.5 cm pieces using a sharp blade. Glass slides' colored and protein-containing residue was removed using a conveniently accessible chemical detergent solution.technique X-ray was used to study the crystallographic structure of both pure and doped CdSe thin films when an X-ray diffractometer (Japan SHIMADZU XRD 600) with (Cu K_{α}) = 1.5418740 was used with ($\lambda_{Cu\ K\alpha}$ =1.5418740 Å(XRD) technology (SHIMADZU Japan XRD 600) was used to analyze the crystalline structure of thin films employing radiation of wavelength for 2 values between 20° and 80° to compute the crystalline size. [12]. A UV/VIS spectrophotometer was used to measure the transmittance (T) and absorbance (A). After analyzing the spectrum of coated materials, the energy gap was calculated using the equation Tauc [13–14]. The Shockley equation is applied to the I-V graph of an atomic force microscope using a UV-Vis spectrophotometer [15]. For Hall measurements, Van der Pauw Ecopia-HMS-3000 measured the qualities of electricity.using the Shockley equation to look at I-V The n-CdSe:Ag/p-Si heterojunction's current voltage characteristics are different from those of n-CdSe/p-Si. The effectiveness determined was of the solar cell [16].

3. Results and discussion

3.1. Structural Properties

Fig. 1 The hexagonal, wurtzite-like structure seen in (JCPDS files No. 19-0191) may have originated from cadmium selenide. The graph, which displays the X-ray diffraction patterns of electron beam evaporated CdSe films on glass substrates at room temperature, illustrates the X-ray diffraction patterns of each thin film applied to glass as a testimony to the samples' conformity with set criteria. According to the graph [17], the samples exhibit an orthorhombic polycrystalline structure with peaks for CdSe and CdSe:Ag (111), and the results meet established standards. After doping, the films become more crystalline, which sharpens the peaks. This illustrates how the Ag is dispersed uniformly over the CdSe structure. The structure of these films was carefully examined using X-ray diffraction at 0.05° intervals between 20° and 80°. Using Bragg's rule and Scherer's Formula, which were also used to calculate the crystalline size of the films (hkl), the miller index interplanar spacing d (hkl) was calculated. Table 1 includes the lattice constants (a), (d), (hkl), and average dimensions of the crystallite. This could be The expanding film has a hexagonal structure, thus "a" and "c" may be determined from an equation. [18–19]

$$"\frac{1}{d^2} = \frac{4}{3}\frac{(h^2+hk+k^2)}{a^2} + \frac{l^2}{c^2} \quad (1)$$

The diffraction peak's width at half maximum intensity is designated as B (FWHM). The following equation can be used to determine the microstrain (ε) for manufactured thin films:

$$\varepsilon = \frac{\mathrm{BCOS}}{4} \quad (2)$$

These results are in line with The Scherrer's formulation (D) can be used to determine the crystallite size. [20-21]

$$D = \frac{0.94\,\lambda}{(FWHM)\cos\theta} \quad (3)$$

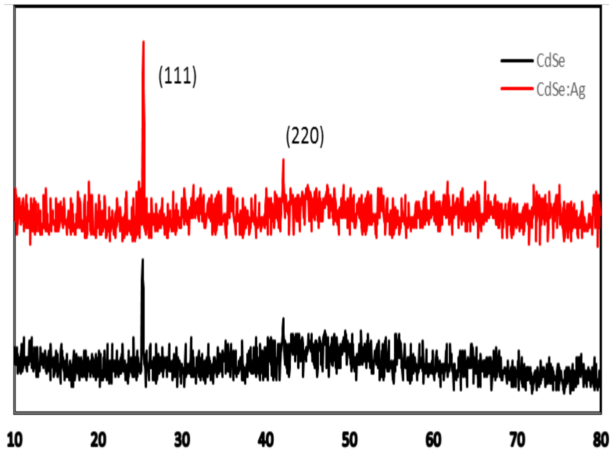
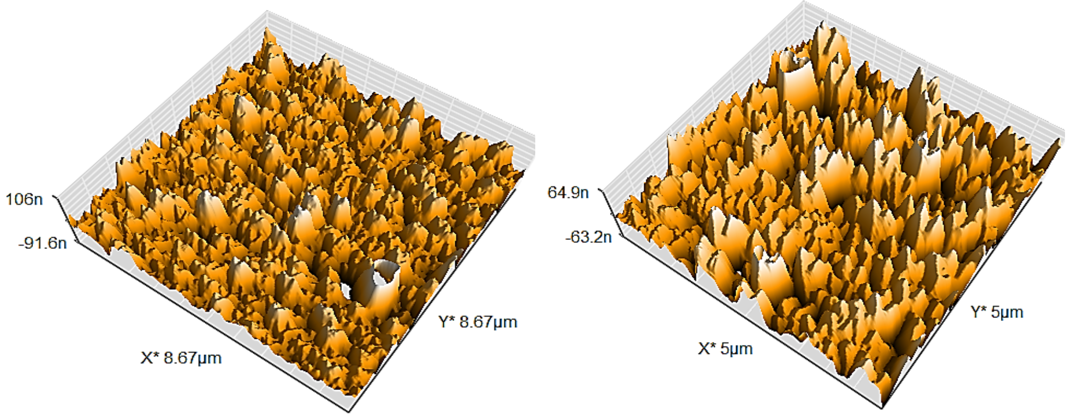


Fig. 1. thin film XRD pattern CdSe and CdSe:Ag.

Table 1. X-ray Diffraction Indexing thin films CdSe and CdSe: Ag.

samples	2theta(°dag)	d(A⁰)	C.S	DIS (lines.m^{-2}) *10^{-15}	(hkl)	N*10^{16}
CdSe	25.32	3.47	24.64	1.645	111	2.337
	41.84	2.03	30.96	1.168	220	1.178
CdSe:Ag	25.39	3.49	23.82	1.761	111	2.588
	42.10	2.1	29.45	1.152	220	1.369

Fig 2 The AFM picture representative of the samples under investigation is shown. CdSe and CdSe:Ag films utilized in AFM testing have low surface roughnesses (2). Table 2 presents data for the result that occurred (R.M.S), diameter mean, and surface roughness of the The findings demonstrated that grains are closely clustered to produce ridges and dopant. On the surface of CdSe, there exist films made of CdSe:Ag. As atoms move around, depart, A thin layer has a greater root mean square, is rougher on the surface, and develops crystal grains in low stress orientations. Because CdSe accelerates grain recrystallization, the ratio of CdSe to Ag rises faster than dopant Ag.

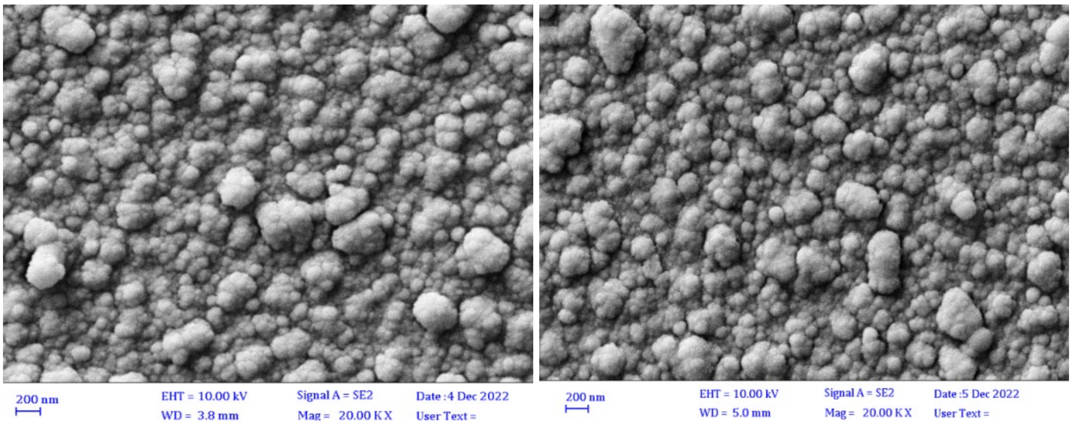


(a) *(b)*

Fig. 2. The 3D AFM images Thin Flims A- pure CdSe ,B- CdSe Doping with silver.
Table 2. R MS, Roughness grain size.

Thin Film	G.S (nm)	Average) Roughness (nm)	(RMS) (nm)
CdSe	86.08	21.13	25.71
CdSe:Ag	54.08	23.66	28.26

Figure 3 FE-SEM Due to its excellent nanoscale resolution, FE-SEM was the method that was most frequently employed for characterizing nanomaterials and nanostructures. CdSe and CdSe FE-SEM images: On a glass substrate, 1.5% Ag thin films were created in order to examine the sample surfaces' surface characteristics. Figure 3 illustrates the incredibly tiny nanostructures present in all samples. The picture depicting the SEM cross-sectional image of a film that has been deposited in an asymmetrical pattern gives the impression that the surface of a nanostructure is heavily covered with tiny nano grains. On the other hand, The morphologies of the nanostructures in the CdSe films, on the other hand, remained mostly unchanged when Ag-doping was applied, and the picture demonstrates that the particles fused after annealing. These films also showed outstanding adhesion.



(a) *(b)*

Fig. 3. FE-SEM images of thin films, a)CdSe pure ,b)CdSe:Ag.

3.2. Optical Properties

Fig. 4 displays the transmittance optical and spectral absorbance and Reflection of films that are pure CdSe and Ag doped at a ratio of 1.5% Ag. It has been demonstrated that when the Ag ratio increases, the absorbance increases in the 300–700 nm wavelength region. This could be because the average crystallite size and Ag ions in the CdSe lattice work together to enhance crystallinity. The optical constant's calculated values at a wavelength of 700 nm are listed in Table 3. This judgment is supported by [3, 12]. The values of in drop with dopant when the corresponding reflection is reduced. As the ratio of Ag increases for all samples, the transmittance decreases; this might this could be due to higher absorption, which may be connected to the CdSe deformation brought on by Ag ions. The data for these films' enormous crystallite sizes (86.08–54.08 nm) are displayed in Table2.

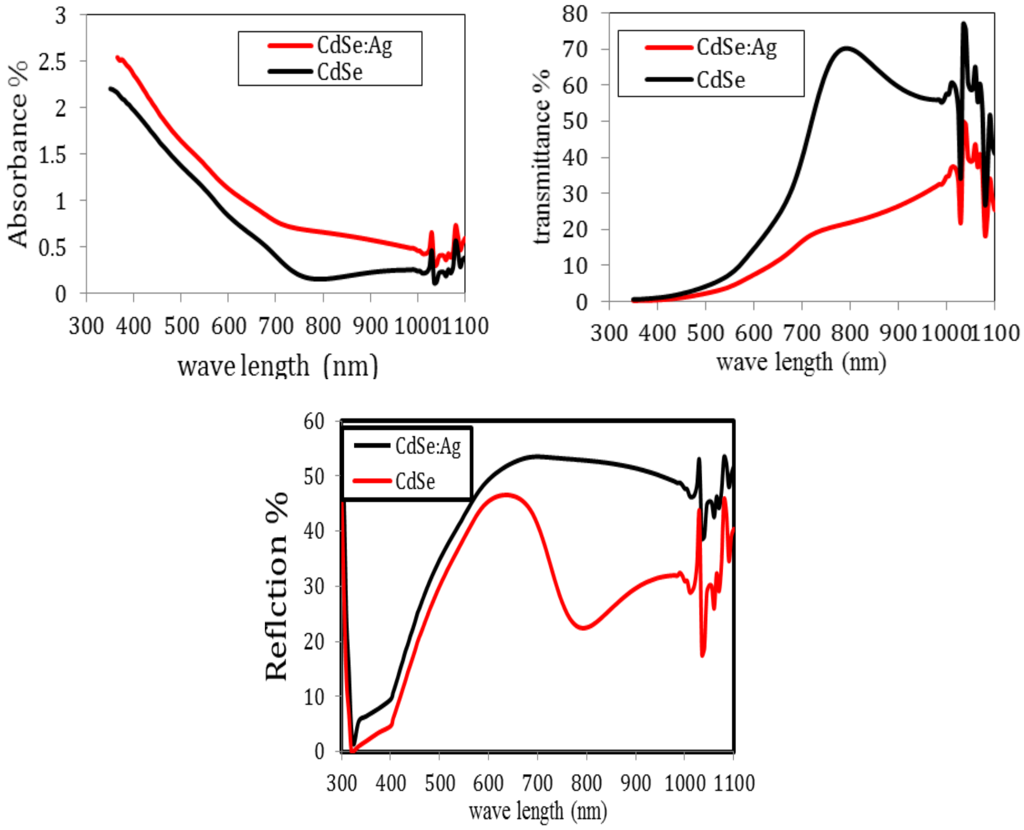


Fig. 4. Transmittance, absorbance, Reflection CdSe and CdSe: Ag made of thin films.

Fig 5 the shows optical energy gap as a consequence of applying the Tauc equation [22, 23] in the high absorption area. Energy band gaps for pure CdSe and Ag-doped thin films with the Ag ratios shown in Table 3 were 1.93 and 1.81, respectively. Because of the reduced defect count in films and the reported lower energy-gap values, the density of localized states in the Eg after doping reduces. Near the longer-wavelength red area, there is optical energy gap motion. [5]. Due to the observed decreased energy-gap values, the density of localized states, and the high absorbance, the sample CdSe thin films with Ag doping are effective optical energy-gaps in the high absorption area To comprehend the relationship between surface form and growing absorbance, this pattern may be combined with Diffraction and AFM data. Because of their high absorbance, samples of CdSe thin films doped with Ag have value as an optical component for solar cells.

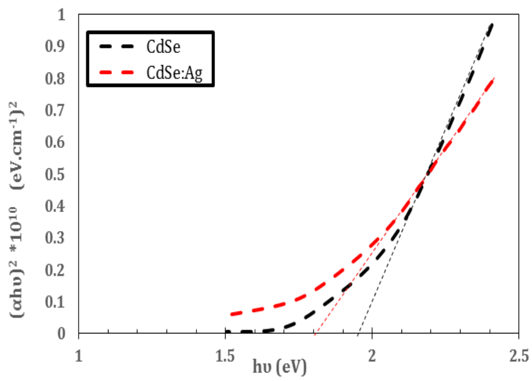


Fig. 5. Thin film CdSe and CdSe:Ag optical energy-gap on substrates glass.

Table 3. For CdSe, CdSe added Ag thin films are given E_{gap}^{opt} and coefficient absorption thin film.

Wavelenght=550nm		
Thin films	E_g^{opt} (eV)	$\alpha \times 10^4$ cm^{-1}
CdSe	1.93	3.52
CdSe:Ag	1.81	3.40

3.3. Electrical Properties

Represents the relationship between the ratios of Ag in CdSe films and the carrier concentration (ND), resistivity (ρ), and carrier mobility (μ). Ag ratios had an impact on the electrical characteristics; Table 4 shows the values of all the variables.

Table 4. Hall effect For CdSe and CdSe:Ag thin films.

Thin film	RH(cm^3/C)	NA× 10^{18} (cm^{-3})	μ(cm^2/V.S)	σ (Ω.cm)$^{-1}$ × 10^2
CdSe	-2.168	2.882	3.0751	1.418
CdSe:Ag	-1.825	3.423	2.8757	1.575

Electrical measurements demonstrated an improvement in the electrical properties of the CdSe films due to the addition of Ag.[23,24]The produced samples' n-type conductivity was validated by the negative signs of Hall coefficients for both pure CdSe and Ag doped films; this finding is consistent with references. The substitution of Ag with Cd might be the cause of the improved electrical characteristics demonstrated by higher carrier mobility and conductivity values for all samples of CdSe thin films [1,17]. The current and voltage density of the n-CdSe:Ag/p-Si solar cell PV under illumination circumstances in Fig. (6) are depicted, with a voltage range of 0 to 1.2 mV for a solar-powered device with an Isc of 2.12 mA/cm^2 and a Voc of 0.967 mV. The expected improvement in solar cell efficiency to 1.363% occurs with an Ag ratio of 1.5%, as indicated in Table 5. When the sample's doping ratios climb as a result of its expanding surface area, the quantity of Ag molecules that may be absorbed might also increase.[25,26]. While promoting faster electron transit and lowering the possibility of electron-hole pair recombination might be helpful, sunlight also serves to boost the efficiency of solar cell production [22]

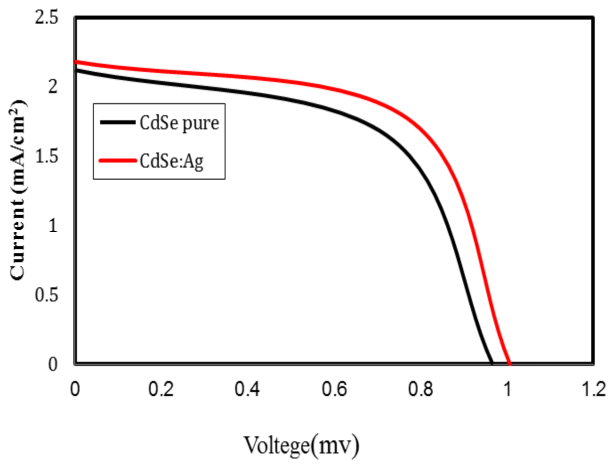


Fig. 6. Current-Voltege characteristic for added thin film and efficiency of conversion Solar cell factors.CdSe:Ag /Si and CdSe:Ag

Table 5. CdSe:Ag /Si for pure and CdSe: Ag /Si factors Solar cell of thin films.

Thin films	Voc(mV)	Isc (mA/cm^2)	Vmax (mV)	Imax (mA/cm^2)	F.F%	η %
CdSe	0.967	2.12	0.721	1.65	58.03	1.189
CdSe:Ag/Si	1.007	2.18	0.768	1.77	61.92	1.363

4. Conclusion

Thermal evaporation was used to cover the thin Ag-doped and CdSe sheets. The degree of Ag doping has an impact on the structural, optical, and electrical properties of CdSe thin films. The XRD patterns show that all of the deposited components are polycrystalline and have a cubic structure. The grain size increased from 86.08 to 54.8 nm as a result of modifications in the Ag ratios. Using a solar cell factor based on incoming power density of 100 mW/cm^2 and maximum efficiency of 1.363%, together with superior absorption coefficient values and excellent crystallite size, heterojunction (n-CdSe:Ag/p-Si) exhibits the following I-V characteristics, and fill factor of 61.92%, are best when dopant is used.

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