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Influence Annealing on the Physical Properties of Silver Selenide Thin Film at Different Temperatures by Thermal Evaporation

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Abstract

This survey investigates the thermal evaporation of Ag_2Se on glass substrates at various thermal annealing temperatures (300, 348, 398, and 448) °K. To ascertain the effect of annealing temperature on the structural, surface morphology, and optical properties of Ag_2Se films, investigations and research were carried out. The crystal structure of the film was described by X-ray diffraction and other methods.The physical structure and characteristics of the Ag_2Se thin films were examined using X-ray and atomic force microscopy (AFM) based techniques. The Ag_2Se films surface morphology was examined by AFM techniques; the investigation gave average diameter, surface roughness, and grain size mutation values with increasing annealing temperature (75.74 nm–96.36 nm). Additionally, With various variations to the nominal values, the absorbance and transmittance spectra are further studied and reported in accordance with the wavelength range of (400-1100) nm. The findings indicate that the sample highest absorbance value was attained at a temperature treatment of 448 K, whereas the sample highest transmittance was at a temperature treatment of 300 K. According to the results, direct transitions were permitted in the under-review thin films at optical energies of (2.15, 1.85, 1.75, and 1.7) eV, respectively

Keyword: Ag_2Se, different thermal, morphology surface, optical properties.

1.Introduction

The binary chalcogenide I-VI semiconductor compound known as silver selenide (Ag_2Se) has received a lot of attention recently because of its optical characteristics [1]. The manufacture of silver selenide thin films can be accomplished using a variety of methods, such as chemical vapor deposition, adsorption, electro-deposition, flash evaporation, solvothermal, vacuum evaporation, and explosive vaporization [2]. Thin AgSe films with different compositions and thicknesses were created using the three-temperature methods on pre-cleaned glass substrates. This material was thought to belong to the family of superionic conductors. Ag_2Se was used in a variety of practical applications, such as photovoltaic cells and light-emitting diodes [3]. Photoconductors, thin-film transistors [4], These technologies include but are not limited to, thermochromic materials for non-linear optical devices, infrared detectors, multipurpose ion-selective electrodes, electrochemical storage cells, infrared sensors, electrochemical potential memory devices, and magnetic field sensing apparatus [5]

Semiconductor optical devices were employed for electrochemical potential memory devices and visible region devices [6-7]. Silver selenide (Ag_2Se) with a narrow band gap was thought to be a fundamental n-type semiconductor [8] One of the potential physical materials that can be used in magnetic field detecting equipment with low field sensors is Ag_2Se. This is caused by the Ag_2Se significant agnetoresistance feature, which it possesses at room temperature together with a linear dependence on the magnetic field. [9]

There are several different methods for preparing Ag_2Se thin films. An example was the chemical where

the chemical bath deposition technique was used to green the thin films of Ag_2Se, as - the thermal evaporation technique was used in this work (rapid evaporation in this research [10]. A pulsed laser deposition technique was considered for thin-film deposition. In addition, Sol-Gel, Thermal Water and Sonochemical [12-11] are methods widely used to prepare Ag_2Se nanoparticles [13-14].

The aim of this study is to create an Ag_2Se thin film and analyze how different annealing temperatures impact the structural and optical construction of solar cells.

2.Experimental Details

The silver selenide alloy was made from pure silver and selenide powder (99.99 percent, 99.5 percent). The alloy was created in a quartz tube that was evacuated. The alloy was used to fabricate thin Ag_2Se films with a thickness of about 350 nm of substrate glass slides. The thin films produced in a vacuum using thermal evaporation techniques were prepared using the (Edwards-Unit 306) system. The base holder was removed using a steel blade, and the glass slides were then cut into pieces measuring (1.5*1.5) cm. A straightforward chemical cleaning solution was employed to clean the glass slides in order to remove the stain and the material protein on their surface. An X-ray diffracted meter system (Shimadzu Japan XRD 600), a Cu K radiation source with a wavelength of 1.5405 A, a current of 20 mA, and a voltage of 40 KV were used to assess the structural properties of all films. The surface morphology of Ag_2Se thin films was investigated using an atomic force microscope (AFM) type AA3000, contact mode spectrometer, provided by Angstrom Advanced Inc. Company, USA. The optical characteristics were measured using a UV-Visible 1800 spectra photometer that was built in England. An appropriate monochrometer system (SPEX-minimate) in the (4-8.5) m range, a Cary100 ConcplusUV-Vis spectrophotometer, and a Philips CM10 pw 6020 transmission electron microscope were utilized to evaluate the spectrum responsiveness of all materials.

3.Results

3-1 Optics and Structural Investigation

The four high-temperature annealings of the Ag_2Se thin films created on glass substrates (300, 348, 398, and 448)^o k are shown in **Figure (1)**. Similes and metaphors All thin films have polycrystalline orthorhombic phases, and an Ag_2Se sample strong peak in the XRD pattern shows peaks at [(031),(042),(204), and (032)], which is consistent with published standard card no.

[24.1041]. The 2theta angle is varied from 20 to 80 degrees. It would seem from this that increasing the annealing temperature would improve the crystallinity of the thin films under consideration. **Table (1)** provides the traditional Scherre's Equation, which is used to calculate the crystallinity size of Ag_2Se thin films. [15-16]

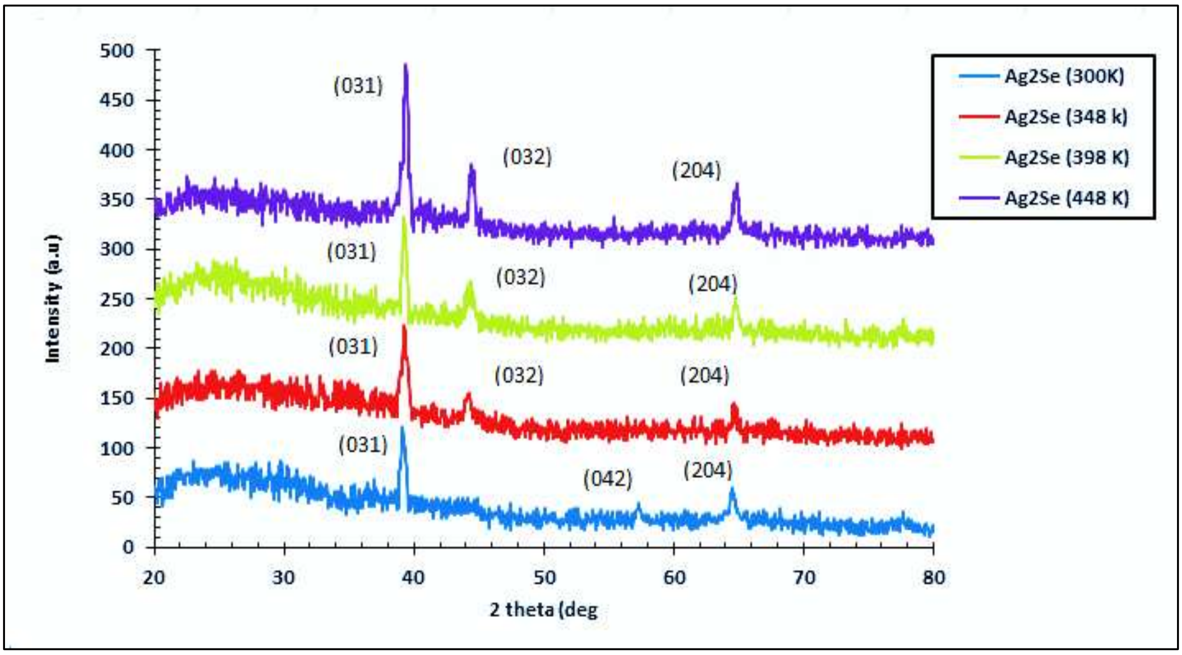

Figure 1. XRD pattern for Ag_2Se thin film in different temperature annealing (300, 348, 398, and 448) °K

The G. S (D) can calculate with Scherrer's Equation [17].

$$D = \frac{0.94\,\lambda}{(FWHM)\,cos\,\theta} \quad (1)$$

(θ) the Bragg's angle,(λ) was the wavelength X-ray equal (1.54056 Å) and (FWHM) the full width half maxima of the main peak .

The **Figure (2)** shows that after thermal annealing, the major improvement in the crystal structure is cleared and no new peak is seen [18]. Additionally, crystallite size increases when Ta rises. Thus, it can be seen that the higher annealing temperatures result in greater crystallization of the film from other studies [19].

Table 1. X-ray Ag_2Se Diffraction at varying annealing temperatures (348, 348, 398, and 448) k

Temperature (k)	2 Ө	2 Ө ASTM	FWHM	D	d (Å) Observed	d (A) ASTM	planes(hkl)
Ag_2Se(300)	39.421	39.999	0.125	70.53	2.283	2.254	031
	57.491	57.794	0.163	58.12	1.607	1.601	042
	64.452	64.476	0.175	56.13	1.440	1.444	204
Ag_2Se(348)	39.084	39.999	0.122	72.19	2.241	2.254	031
	44.447	44.973	0.1333	67.27	2.012	2.014	032
	64.489	64.476	0.172	57.12	1.443	1.444	204
Ag_2Se(398)	39.7	39.999	0.12	73.53	2.268	2.254	031
	44.54	44.973	0.131	68.47	2.032	2.014	032
	64.489	64.476	0.1667	58.94	1.443	1.444	204
Ag2Se(448)	39.296	39.999	0.115	76.63	2.290	2.254	031
	44.98	44.973	0.124	72.46	2.013	2.014	032
	64.572	64.476	0.155	63.418	1.442	1.444	204

Figure (2) shows a three-dimensional AFM image of an Ag_2Se thin at four distinct annealing temperatures (300, 348, 398, and 448) º k A homogeneous distribution with a columnar structure in all photos. **Table(2)** includes information on average surface roughness, (r.m.s) values, and average surface particle size. It can be inferred that these parameters increase with increasing the annealing temperature (300, 348, 398, and 448) °K as a result of thermal annealing-induced crystallization of the Ag_2Se films. Increasing the temperature can cause grains to recrystallize.[17-18]

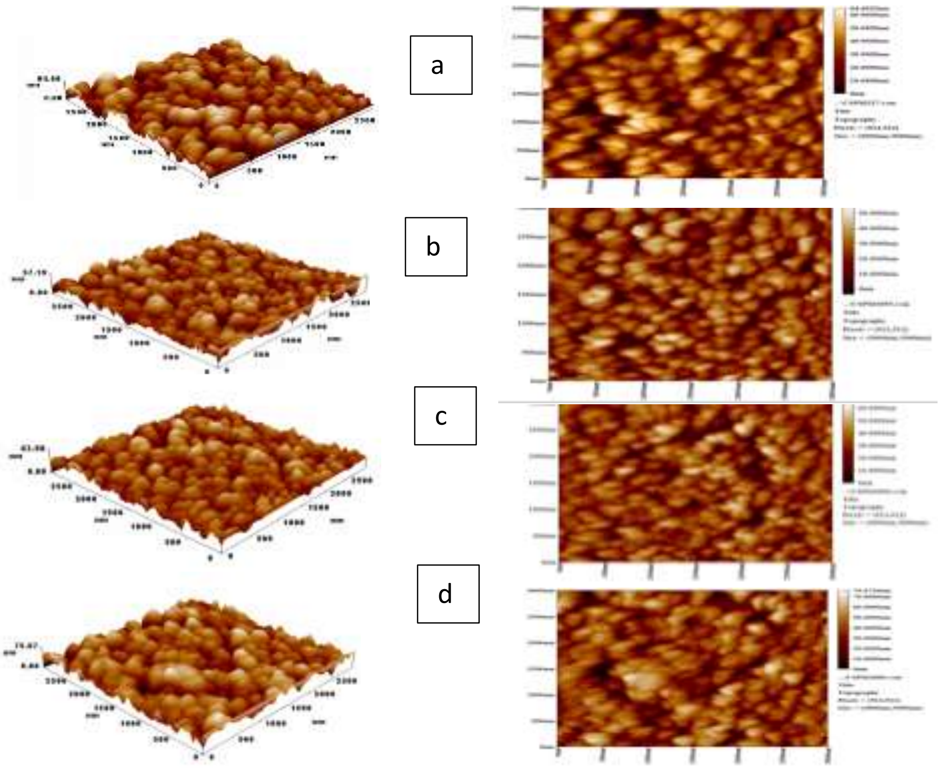

Figure 2. Three-dimensional images of Ag_2Se at various annealing temperatures (a)300, (b)348,(c) 398, (d) 448) °K

Table 2. Root Mean,**G.S** Average grain, Averge Roughness at various annealing temperatures (300, 348, 398, and 448) °K

Ag_2Se different annealing temperature (300, 348, 398, and 448) °K	G.S(Averge nm)	Averge Roughness (nm)	R.M.S (nm)
300	75.74	8.16	12.5
348	86.35	8.22	10.2
398	94.68	9.93	10.4
448	96.36	10	12.7

Figure (3) Ag_2Se thin films optical transmittance (T) curves are measured before and after annealing. The spectrophotometer that has a wavelength range of (400-1000) nm is used to make this determination **Figure (3)**. Results show that the heat treatment, which in turn causes an alteration in the atomic structure, causes the transmittance to drop as the annealing temperature rises. The absorption coefficient is a unit used to describe how well a material can absorb light. The rate of absorption is significantly influenced by the band gap and photon energy. Figure. 3 shows how the optical absorption coefficient (α) for the Ag_2Se annealing sheets fluctuates with photon energy while keeping in mind the equations [20]. This can be written:

$$\alpha = (2.303)(A)/(t) \quad (2)$$

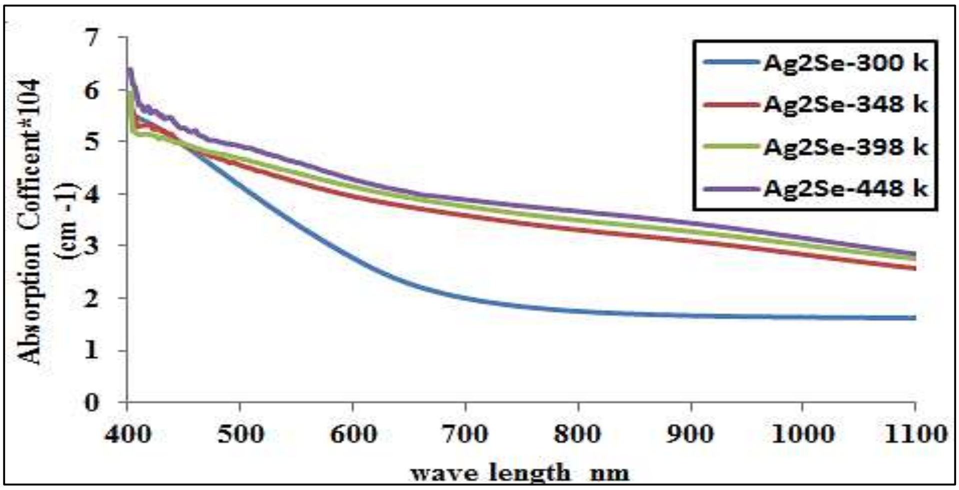

Figure 3. The (Ag_2Se) thin films' absorption coefficient as a function of photon energy at various annealing temperatures (300,348,393,448) k

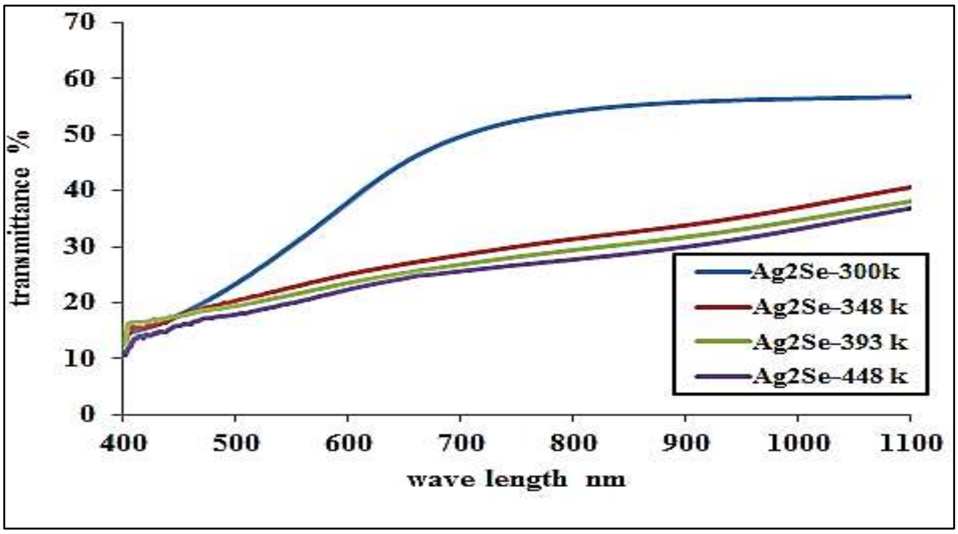

Figure 4. The (Ag2Se) thin film transmittance spectra as a function of wavelength at different annealing temperatures (300,348,393,448) k

where (A) is the film's absorbance, and (t) is the thickness of the film. The absorption coefficient is in the order of 10^4 cm^1**. Figure (4)** shows that it reaches a high value at higher photon energies (shorter wavelengths), indicating a high probability that the allowed direct transition will occur. As a result, the absorption coefficient (α) decreases as the wavelength increases. Additionally, the results show that the absorbance rises as the Ag_2Se annealing temperature rises. Again, the crystallite variety is the reason for this.

Using the Tauc relation, the Ag_2Se energy gaps are assessed [15].

$$\alpha h\nu = (h\nu - Eg)^{\frac{1}{2}} \qquad (3)$$

The curves of $(\alpha h\nu)^2$ ev are plotted, and **Figure (5)** displays them. The deposited Ag_2Sethin films are found to have optical energy gaps of (2.15, 1.85, 1.75, and 1.7) eV for temperatures of (300, 348, 398, and 448) °K, respectively. This can be justified by the fact that the annealing process alters the internal structure of the atoms in addition to its influence on specific faults. These defects show up as a deep and shallow level in the band gap of the complicated semiconductor material. The results of past research [15–19], the band gap of annealed films change as a result of the increase in grain size caused by temperature[21]

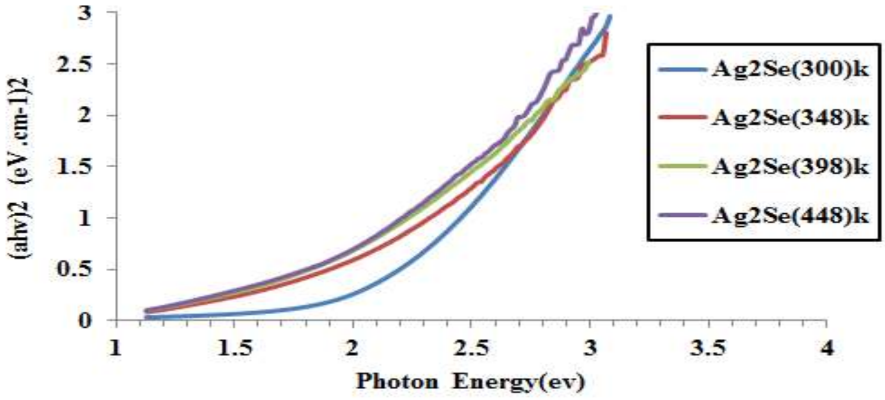

Figure 5. Ag_2Se films' (hv) photon energy at 300, 348, 398, and 448 °K are annealed at different temperatures.

Table 3. The (Ag_2Se) thin film optical energy band gap at different annealing temperatures (300, 348, 398, and 448) °K

Ta.(k)	Eg (eV)
300	2.15
348	1.85
398	1.75
448	1.7

4.Conclusion

The Ag_2Se deposited using the thermal evaporation method on glass substrates variations in annealing temperatures (300, 348, 398, and 448) °k are used to deposit Ag_2Se on glass substrates using the thermal evaporation process. The films are polycrystalline with an orthorhombic phase, according to the X-ray diffraction data. The results of the AFM technique show that the grain size increases as the annealing temperature rises, reducing the grain boundary. Ag_2Se optical transitions are direct and (Eg) reduces with rising films annealing temperatures. We are able to create a layer for photocells that is well-absorbing.

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