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Study the Effect of heat treatment on $AgInTe_2$ the optical properties thin films

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ABSTRACT

$AgInTe_2$ (AIT) thin films had been prepared by the used technique of vacuum thermal evaporation, with thickness 300 nm, the deposition rate 1.7 ±0.1 nm/sec on a glass substrate at room temperature and pressure (10^{-5}) mbar Heat treatment was performed in the range (473-673) K for samples. The AIT thin films optical properties (absorption coefficient, index of refractive, extinction coefficient, real and imaginary dielectric constant) were studied by determination using measurement absorption and transmission spectra. The results showed they are wide applications such as photovoltaic electronic applications and photovoltaic applications.

Introduction

Semiconductor thin films are particularly attractive in applications of solar cells due to have high optical absorption factor so their varied both optical and electrical properties. AIT have direct band gap material , good stability, high absorption coefficient and largest efficiency[1]. So it has been used in several applications like optoelectronic devices and photovoltaic applications [2,3].

AIT thin film have the high coefficient of absorption (10^4 cm^{-1}), a direct band gap and the largest efficiency[1, 2], so these properties create $AgInTe_2$ a probable substance for many photovoltaic applications [3].It is recognized that the optical, electrical, and structural. The properties of this substance are highly influenced via the mechanism used for the production

Experimental details

Using (Edwards – Unit 306) system with $2.5x10^{-5}$ mbar at room temperature from (AIT) alloy thin films have been deposited on glass substrate by the mechanism of thermal vacuum evaporation. The film's thickness was specified with (Precisa-Swiss) microbalance by using the weighing method and found about (300∓10)nm and deposition rate of (1.7∓0.1) nm/sec.

From equation (1) can be calculated the coefficient of absorption (α) from the transmittance spectrum[4]:

$$\alpha = \frac{2.303A}{t} \quad \ldots\ldots\ldots (1)$$

Where: t film thickness, A is the absorbance can be calculated by the relation[4]:

$$A=\log(1/T) \ldots\ldots\ldots (2)$$

Where: (T) is the transparence.

Both the type and value of the optical gap are determined by the equation (3) which represent electron excitation from the valence band to conduction band[5]:

$$\alpha h\nu = B(h\nu - Eg)^n \ldots\ldots\ldots (3)$$

Where: B is constant and depending on the semiconductor type, α(cm^{-1}) is the coefficient of absorption, hν(eV) is the energy of the photon, Eg (eV) is the optical band gap. The (n) is an index attached to the material nature which is specified via the optical transition involved in the absorption process, it appoints the allowed direct transition (n = 1/2) and allowed indirect transition (n = 2) in the electronic band structure.

optical constants completely characterize the optical materials manner so they are important main properties of matter [6,7]. The optical properties of the film depend completely on the evaporation technique. The index of refractive (n), the coefficient of extinction (k), both real(ε_1) and imaginary parts (ε_2) of dielectric constant represent the optical constants. Using the equation(4) to calculate the refractive index (n) [5]:

$$n=[\frac{4R}{(R-1)^2} - k_0^2]^{1/2} - \frac{1+R}{1-R} \ldots\ldots\ldots (4)$$

Where: R is the reflectance and shown in the equation(5), [4]:

R + A + T = 1 ……………………..(5)

The refractive index dispersion functions an significant part for optical materials because it is an important factor in designing devices from the spectral dispersion [6].

The coefficient of extinction (k), (imaginary part of the refractive index), which is attached to the exponential decay of the wave as it passes into the medium can be specified by equation[7]:

$$k = \frac{\alpha\lambda}{4\pi} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Where: λ is the incident wavelength radiation.

The complex electronic dielectric constant(ε) defined as [6,8]:

$$\varepsilon = \varepsilon_1 - i\varepsilon_2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Where: ε_1 the real dielectric constant, ε_2 the imaginary dielectric constant, ε_1 and ε_2 can be determined by the equations[5,8]:

$$\varepsilon_1 = n^2 - k_0^2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

$$\varepsilon_2 = 2nk_0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

Results and Discussion

The spectra of optical transmittance as a wavelength function for AIT thin film are showed in fig.1 from 350nm to 1090 nm with annealing at (473-673) K . Usually the transmittance of optical increases when the wavelength increases ,there was when the temperature of annealing increase lead to shift in the wavelength for the region where the transmittance are increases. So for all the temperature annealing the transmittance is very high at wavelength longer than (850 nm). The transmittance values are reduced by increasing the temperature of annealing due to an increase in absorbance. It is also noted that the higher permeability values are shifted towards the larger wavelength when the thickness increases ,this is consistent with the sources [9,10,11].

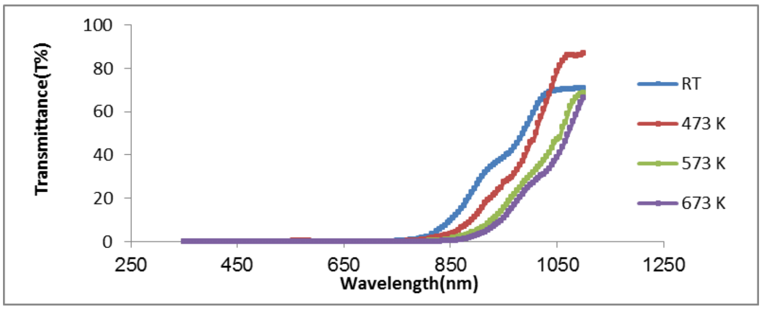

Figure (1):Variation the transmittance spectra as a function wavelength of AIT thin films .

Fig.2 is shown the spectra of absorption for all films .When Increase temperature of annealing refer to increase the absorption value and all peaks of high absorption shifts to lower wavelength, because Increase temperature lead to the atoms rearrangement for position in the structure [9] .

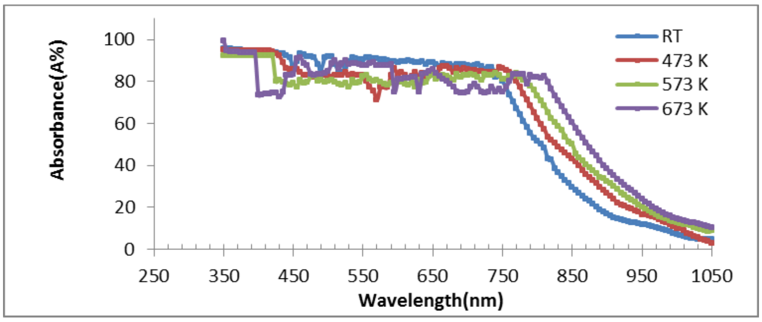

Figure (2): Variation the absorbance spectra as a function wavelength of AIT thin films .

Fig.3 is shown the spectra of reflectance for AIT thin films. In the range of (550 - 650) nm the reflectance of $AgInTe_2$ the reflection decreases with the temperature and increases with the wavelength [10,11] ,but at (T=473K) refers to the susceptibility of this different material to change its reflection by wavelength, due to the correlation of reflectivity to the change of absorbance and permeability within these wavelengths The shift of transmittance and reflectance refer to that regard to the change in the crystalline properties of the film and decrease with wavelength from the range of (800 to 1100) nm [9].

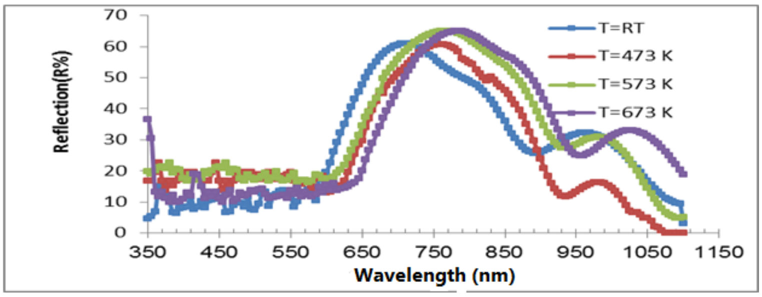

Figure (3): Variation of reflectance spectra as a function wavelength of AIT thin films

Fig. 4 is shown the absorption coefficient (α) change with wavelength. Absorption coefficient (α) decreases with increase of wavelength which main a large probability of the allowed direct transition, By increasing the annealing temperature absorption coefficient increase, because of the improved crystalline structure and rearrange the atoms of their sites within the crystal lattice to be more regular access to the crystalline state[11]. As well, table No.(1) it is shown in that absorbance increases with increase the annealing temperature of the $AgInTe_2$.

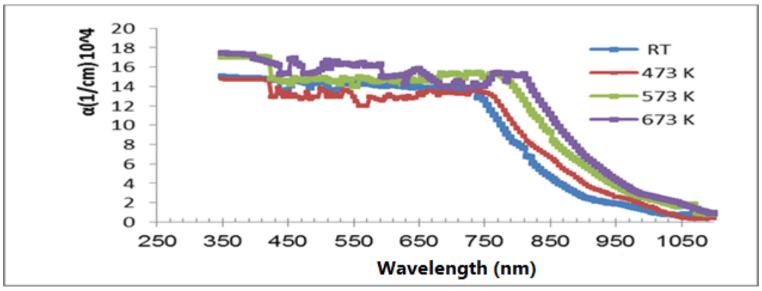

Figure (4): absorption coefficient change with wavelength of AIT thin films.

Fig.5. is shown the films have direct band transitions. The shift towards higher or to lower energies depends on the method of film preparation [11]. table No.(1) showed the energy gap is decrease with increase annealing temperature because rearrange the atoms in crystalline structure and hide some crystalline defects and add additional levels between the valence band and conduction band [10]. The value of the energy gap was similar to previous studies[10,11].

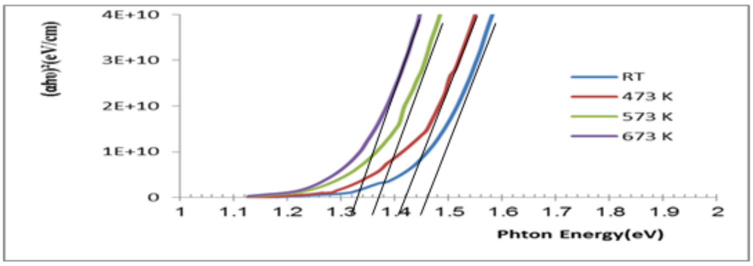

Figure (5): $(\alpha h\upsilon)^2$ change with photon energy (hυ)of AIT thin films

The manner of refractive index shown in fig.6. The refractive index increases with the increasing of photon energy point out that all the films show a normal dispersion manner in the range (1.3 - 2) eV identical to the wavelength in the range (650-900) nm due to improved crystalline structure and increased absorption coefficient [12]. From table No.(1) we show the annealing films decrease the refractive index .

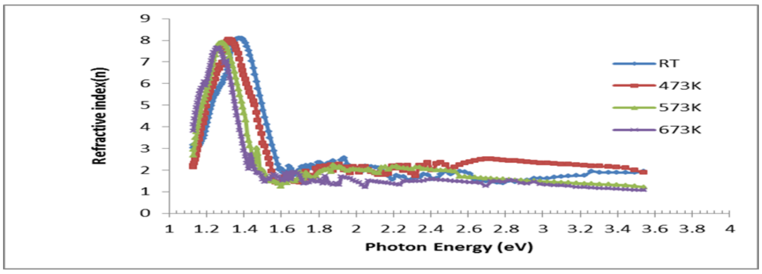

Figure6: refractive index change with photon energy of AIT thin films.

Eq.(6) show the manner of (k_0) is roughly like to the identical absorption coefficient (α) because of the extinction coefficient depends on (α), so increase of extinction coefficient with the increase of absorption coefficient due to the increase of photon energy and from table No.(1) extinction coefficient (k) increase with increase annealing temperature due to change the properties of the film to crystalline structure[10]. Fig.7 exhibit the change of extinction coefficient (k_0) with photon energy.

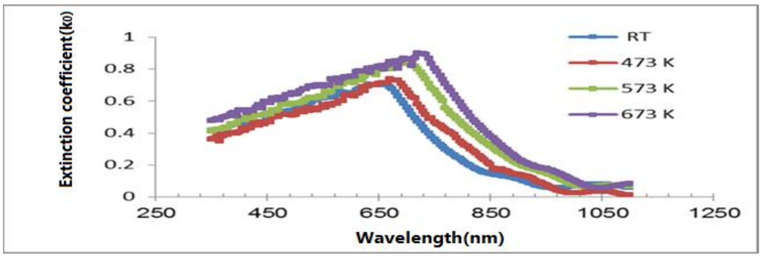

Figure (7): change extinction coefficient with photon energy of AIT thin films

Table No.(1) : Variation the optical properties with annealing temperature

T(K)	$\alpha x10^4$ (cm^{-1})	Eg (eV)	*K*	n	ε_1	ε_2
RT	6.033	1.44	0.398	7.023	49.164	5.590
473	7.830	1.41	0.576	5.412	28.987	6.234
573	11.146	1.34	0.775	4.198	17.022	6.506
673	13.490	1.3	0.892	1.663	1.969	2.966

Conclusion

The annealing process affected on the optical properties of the AIT films .The absorbance in the visible region high. when increase the annealing temperature the absorbance increase. The optical band gap has an allowed direct transition types, so the values were found to decrease from (1.44 to 1.3) eV with increasing of annealing temperature. The optical constants like (coefficient of absorption, refractive index, coefficient of extinction, imaginary and real part) of the films depend on the annealing temperature.

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دراسة تأثير التلدين على الخصائص البصرية للغشاء الرقيق $AgInTe_2$

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الملخص

تم تحضير أغشية (AgInTe2) بواسطة تقنية التبخير الحراري في الفراغ , بسمك 300nm وبمعدل ترسيب 1.7±0.1 nm/sec. تم الترسيب على شرائح من الزجاج بضغط mbar (10^{-5}) وبدرجة حرارة الغرفة. تم معاملة جميع العينات حراريا (تلدين) بمدى من درجات الحرارة K (673-473). تم حساب جميع الخصائص البصرية للغشاء الرقيق (فجوة الطاقة ,معامل امتصاص ,معامل الانكسار , معامل التوهين وثابت العزل الحقيقي والخيالي) بواسطة كل من طيف الامتصاص وطيف النفوذية . بينت النتائج انه يمكن استخدام المادة في الكثير من التطبيقات مثل التطبيقات الكهروضوئية والتطبيقات الفوتوفولطائية.