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Effect of Annealing On Some structure Properties and Hall effect of ($ZnS_{0.1}Se_{0.9}$) Films.

تأثير التلدين على بعض الخصائص التركيبةوتأثير هول لأغشية $ZnS_{0.1}Se_{0.9}$

R.M.S.AL-Haddad, Bushra A.Hasan and M.H.Dwech*

University of Baghdad, College of Science, Department of Physics,

*University of Karbala, College of Science, Department of Physics.

د. رعد محمد صالح الحداد   د. بشرى عباس حسن   م.م.ماجد حسين دويج

جامعة بغداد   جامعة بغداد   جامعة كربلاء

Abstract:

The effect of annealing (Ta=300,373,423) K on some structural properties and hall effect has been studied (concentration (n_H), Hall mobility (μ_H),and drift velocity (v_d)) had been measured for $ZnS_{0.1}Se_{0.9}$ films with different thickness (t=0.3,0.5, and 0.7 µm) which were prepared at room temperature using thermal evaporation under vacuum . We notice from this study that the films at all thicknesses and tempertures have a negative Hall coefficient (n–type charge carriers).

الخلاصة:

تمت دراسة تأثير التلدين K (Ta=300,373,423) على بعض الخصائص التركيبية و تأثير هول (تركيز حاملات الشحنة(n_H)وتحركية هول (μ_H) وسرعة الأنجراف (v_d))والتي تم قياسها للغشاء الرقيق($ZnS_{0.1}Se_{0.9}$) والتي حضرت عند درجة حرارة الغرفة بطريقة التبخير الحراري تحت الفراغ وبأسماك مختلفة µm (t=0.3,0.5,0.7). أظهرت النتائج أن تلك الأغشية عند جميع درجات حرارةالتلدين والأسماك هي من نوعn–type.

Introduction

II – VI compound semiconductors, such as, ZnSe and ZnS, are well known for application in a wide range of optoelectronic devices . ZnSe is an important semiconductor material for the development of various modern technologies of solid – state devices (blue light emitting diodes, laser diodes, solar cells) [1].

ZnS is a potentially important material to be used as antireflection coating for heterojunction solar cells. It is an important device material for the detection, emission, and modulation of visible and near ultraviolet light [2] .

II-VI compound semiconductors are considered for applications in fast-particle detectors and can cover the whole wavelength range from the far infrared to the near ultraviolet in optoelectronic devices. The width of the band gap can be adjusted in pseudo-ternary compounds such as $ZnS_{0.1}Se_{0.9}$ by varying the composition x. II-VI semiconductors appeared promising for emitter or detector devices due to their excellent optical features together with predicted favorable transport properties [3].

Experimental Part

The structure of the $ZnS_{0.1}Se_{0.9}$films grown on glass substrates and treated at different annealing temperature have been examined by x-ray diffractions using a Philips x-ray diffractometer system which records the intensity as a function of Bragg's angle. The source of radiation was $Cu(k_\alpha)$ with wavelength λ=1.5406°A, the current was 30mA and the voltage was 40 Kv. The scanning angle 2θ was varied in the range of (20 – 60) degree with speed of (4) deg/min. The interplaner distance d_{hkl} for different planes was determined by using Bragg's law [4]**:**

$$n\lambda = 2d\sin\theta \quad \text{……………………………………………………………….(1)}$$

Where n is the reflection order.

The lattice constants are estimated from the relation:

$$d = a \;/\; (h^2 + k^2 + l^2)^{1/2} \quad \text{………………………….…………….}\textbf{(2)}$$

where d is the interplanar spacing and (hkl) are Miller indices.

Alloy of $ZnS_{0.1}Se_{0.9}$ were prepared by quenching technique. Materials of (99.999) pure of Zn ,Se and S elements were weighted according to their atomic percentage and sealed in quartz ampoules in vacuum $2x10^{-5}$ mbar The sealed ampoules were kept inside a furnace where the temperature was increased up to 1100K .The ampoule was left for 12 hours at the highest temperature. The quenching was done in air .Films of different thickness (0.3,0.5, and 0.7 µm)were prepared from the alloy using vacuum evaporation method keeping the substrate at room temperature and base pressure of $2x10^{-5}$ mbar using molybdenum boat .The samples were annealed at different temperatures (373 and 423K).The structures of the alloys and samples were examined by x- ray diffraction (XRD).

Hall measurements are widely used in the initial characterization of semiconductors to measure the carrier concentration and mobility,
and it is used to distinguish whether a semiconductor is n or p – type.

When a constant current (I) follows along the x–axis from left to right in the presence of a z– directional magnetic field (B). Electrons are subjected to the Lorentz force initially and they drift toward the negative y–axis, resulting an excess surface electrical charge on the side of the sample and causing a transverse voltage, this transverse voltage is known the Hall voltage (V_H).The Hall coefficient (R_H) is determined by measuring the Hall voltage that generates the Hall field across the sample of thickness (t), by [5]:

$$R_H = \frac{V_H}{I} \cdot \frac{t}{B} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

From the Hall coefficient equation we can determine the carrier's concentration of the semiconductor, and the carrier type, since R_H is negative and positive for n– and p– type, respectively:

$$R_H = \frac{-1}{n.e} \qquad \text{For} \qquad \text{n-type} \ldots\ldots\ldots(4)$$

$$R_H = \frac{1}{p.e} \qquad \text{For} \qquad \text{p-type} \ldots\ldots\ldots(5)$$

Where e is the electron charge. If the conduction is due to one carriers type e.g. electrons, then from equation (6), we can measure the mobility as:

$$\mu_n = \frac{\sigma}{n.e} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(6)$$

$$\mu_n = \sigma |R_H| \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(7)$$

i.e., by knowing σ , the mobility can be determined.

The drift velocity could be calculated from the equation:

$$\nu_d = \mu_H \cdot E_n \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(8)$$

where E_n is the applied electric field
the relation between Hall voltage and the current for $ZnS_{0.1}Se_{0.9}$ films for various thicknesses . From the slope of the figure and by using equation (3) , Hall coefficient (R_H) can be calculated .
using equation (4,5) the Carrier concentration (n) is calculated for all film thicknesses and it is of n- type.

Results and Discussion

The XRD patterns of the deposited $ZnS_{0.1}Se_{0.9}$films on glass at substrate temperature equal to R.T with thickness equal to 0.3 μm at R.T and different annealing temperatures (373 and 423) K are illustrated in Fig.(1)to(4) .This figure shows polycrystalline structure of all the annealed samples. Similar result has been emphasized by ***SHEN -Ke et al***.***[6]***, ***and AL-HAMED*** **[7]**. which indicates that these films have stoichiometric structure. The variation of X–ray diffraction parameters with annealing temperature is listed in Table (1).

Peaks appeared at 2θ equal to(27.8^o, 45.6^o and 53.8^o) at composition (X=0.1) are correspond to reflection from (111), (220) and (311) planes respectively at R.T and annealing temperatures equal to (373 and 423) K. A point of interest is that the preferential orientation is the [111] direction of the films, this may be due to the layer stability of the [111] planes which reflects the more relaxed bonds with minimum energy. Another interpretation is that this stability originates in the larger density of bonds [8]. The lattice constant of the films was estimated from equation (1),(2) and it is nearly equal to the standard value (5.67Å) and it has been found to be constant with variation of annealing temperature for each plane as given in Table (1).

The type of charge carriers, concentration (n_H), Hall mobility (μ_H),and drift velocity (v_d)of charge carriers have been estimated from Hall measurements. Fig.(5) shows the variation of Hall voltage as a function of current for $ZnS_{0.1}Se_{0.9}$ films deposited at substrate temperature equal to 433 K for different thicknesses and annealing temperatures. We can notice from this figure that the films of all thicknesses have a negative Hall coefficient (n–type charge carriers), i.e. Hall voltage decrease with increasing the current. Similar results were obtained by ***Al-Haddad*** [9] and ***El-Wahhab*** [10]. This result is in contrast with the result of ***Islam and Mitra*** [11]. The variation of carriers concentration and Hall mobility with annealing temperatures of $ZnS_{0.1}Se_{0.9}$ films at different thickness are shown in Figs.(6 and 7) respectively. We can notice from these figures that both the carrier's concentration and mobility decrease with increasing of annealing temperatures. This result is in agreement with the result of Al-Haddad [9] and El-Wahhab [10], and this may be due to either increasing the trapping centers or the films have a large amount of adsorbed oxygen which reduces both the number of charge carriers and their mobility essentially because of the higher grain boundary barrier height [10]. Mobility increases with increasing of thickness is due to the decreasing of the carrier's concentration as shown in Fig.(6 and 7) and Table (2). From the Hall mobility measurements, v_d and n_H of the carriers have been calculated by using the equations (3),(4) and (5) respectively, for $ZnS_{0.1}Se_{0.9}$ films at different thicknesses and annealing temperatures. The results are listed in Table (2). We found that all these parameters approximately increase with increasing of thickness and decrease with increasing of annealing temperatures. The reasons for this variation are mentioned previously.

Table(1)XRD data for $ZnS_{0.1}Se_{0.9}$ powder and films at different annealing temperatuers.

$ZnS_{0.1}Se_{0.9}$	**Ө2 (degree)**	**d (stand.) (ºA)**	**d (exp.) (ºA)**	**(hkl)**
powder	27.5	3.273	3.241	111
	45.2	2.004	2.013	220
	53.5	1.709	1.711	311
Films	27.8	_	3.207	111
	45.6	_	1.988	220
	53.8	_	1.703	311

Table (2) Hall parameters for $ZnS_{0.1}Se_{0.9}$ films at different thicknesses and annealing temperatures.

Thickness (μm)	**T_a (K)**	**n_H (cm^{-3}) $\times10^{15}$**	**μ_H (cm^2/V.s)**	**v_d (cm/s)**
0.3	R.T	1.45	0.5603	1.107
	373	1.31	0.429	0.701
	423	1.24	0.202	0.463
0.5	R.T	0.86	63.560	97.247
	373	0.71	54.616	95.305
	423	0.64	39.264	83.632
0.7	R.T	0.78	74.330	219.274
	373	0.73	64.915	205.456
	423	0.69	38.430	111.831

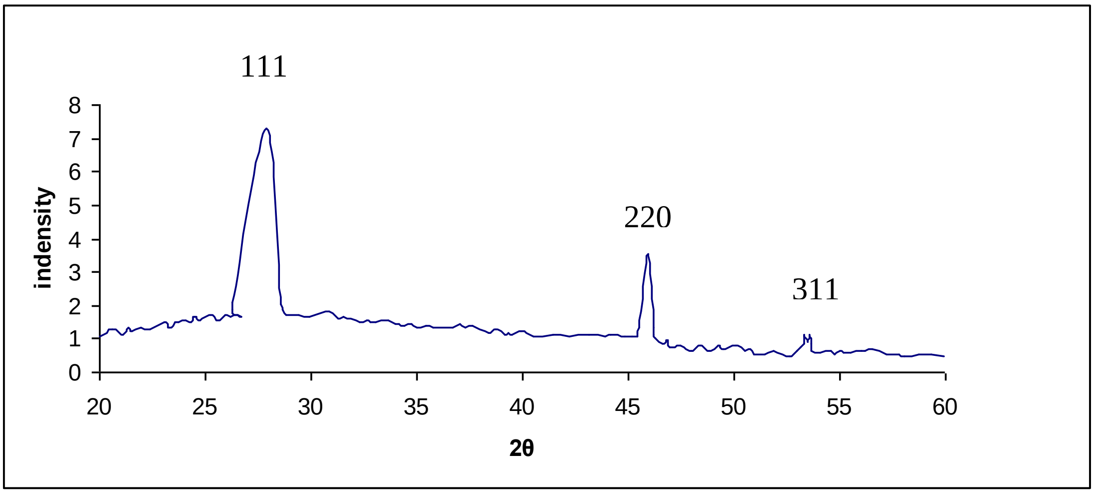

Fig. (1) X-Ray Diff. for $ZnS_{0.1}Se_{0.9}$ powder .

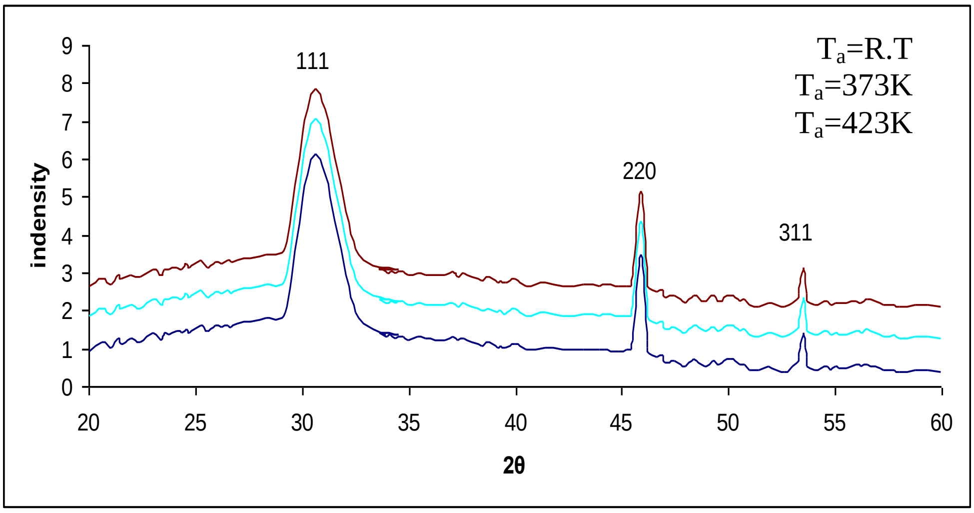

Fig. (2) X-Ray Diff. for $ZnS_{0.1}Se_{0.9}$ to thickness 0.3µm .

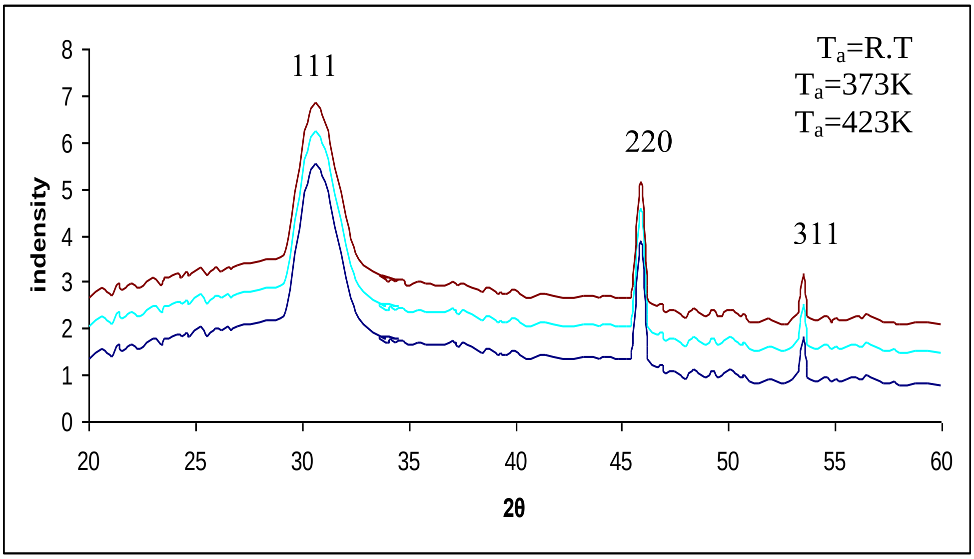

Fig. (3) X-Ray Diff. for $ZnS_{0.1}Se_{0.9}$ to thickness 0.5 µm .

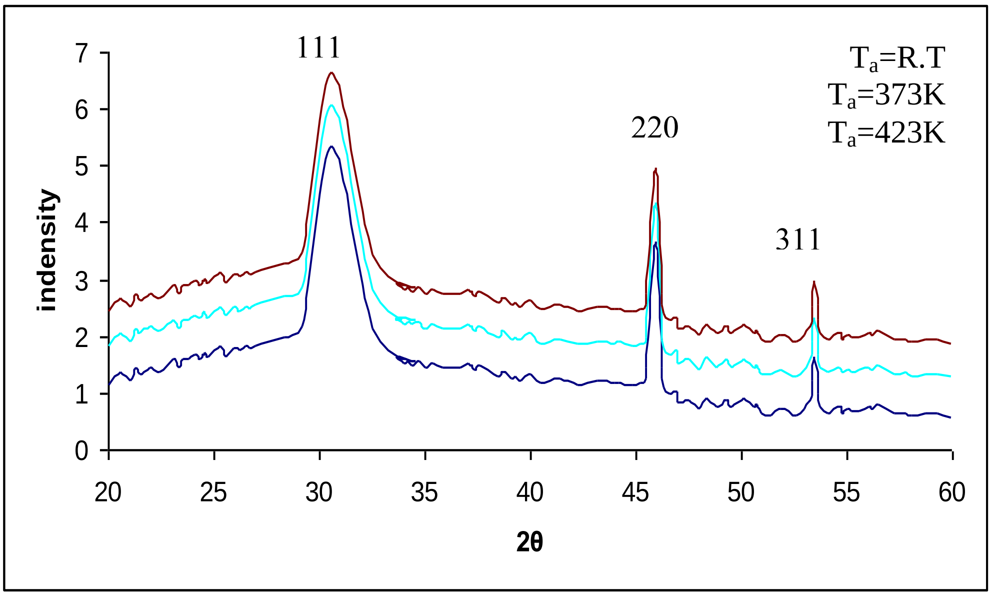

Fig. (4) X-Ray Diff. for $ZnS_{0.1}Se_{0.9}$ to thickness 0.7 µm .

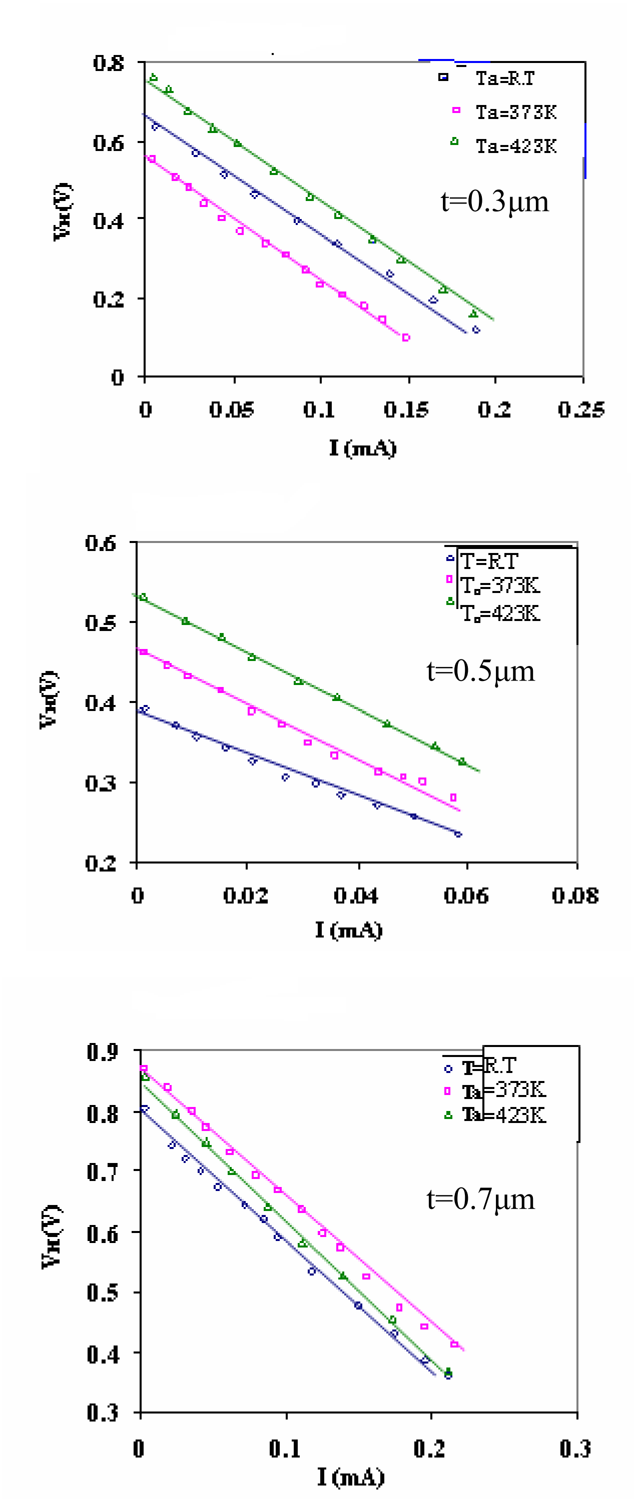

Fig.(5) Variation of Hall voltage as a function of current for $ZnS_{0.1}Se_{0.9}$ films at different thicknesses and annealing temperatures.

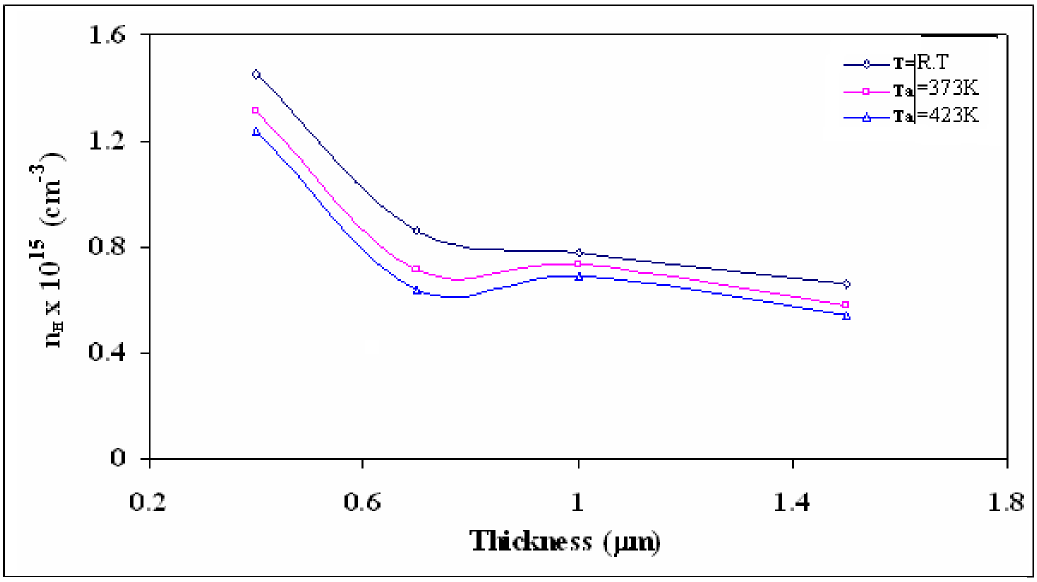

Fig.(6)Variation of concentration as afunction of thickness for $ZnS_{0.1}Se_{0.9}$ films at different thicknesses and annealing temperatures.

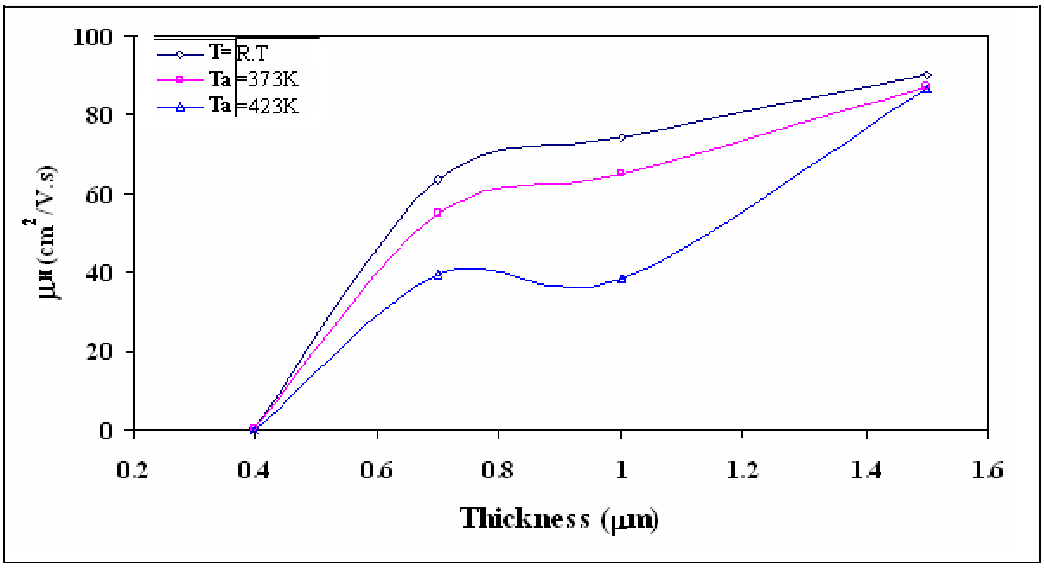

Fig.(7)Variation of mobility as afunction of thickness for $ZnS_{0.1}Se_{0.9}$ films at different thicknesses and annealing temperatures.

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