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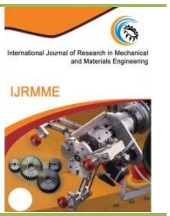

EFFECT OF ANNEALING TEMPERATURE ON STRUCTURAL AND ELECTRICAL PROPERTIES OF A-GAAS:SE FILMS

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ABSTRACT

GaAs:Se films with thickness 0.25,0.5,0.75 and1 μm have been prepared by flash evaporation technique on glass substrate and silicon under vacuum of 10^{-5}mbar. These films have been annealed at different temperatures T_a (373 , 473)K. The structural characteristic of GaAs:Se have been studied by using x-ray diffraction which show that the film have amorphous structure up to 473K, after that the crystallinity is improved. The d.c conductivity for all deposited films decreases with increases of annealing temperatures while the electrical activation energies (E_{a1} and E_{a2}) increase with increasing of annealing temperature. Carrier concentration and Hall mobility have been determined from Hall measurements a-GaAs:Se thin films Hall measurements show that all these films have a negative Hall coefficient (n-type charge carriers).

INTRODUCTION

III-V semiconductors are commonly used in the fabrication of optoelectronic devices, e.g. the laser and light emitting diode in the visible spectrum (AlGaAs) and in the infrared spectrum (GaAs) as used for CD and DVD drives. GaAs is also of interest for high frequency applications [1]. III–V compounds provide the basis materials for a number of well-established commercial technologies, as well as new cutting – edge classes of electronic and optoelectronic devices, which include high electron mobility and hetrostructure bipolar transistor, diode laser, light emitting diodes, photo detector electro-optic modulators, and frequency mixing components. One of the big attractions of III–V compounds is that, generally, they crystallize with a high degree of stoichiometry and crystals may be grown in variety ways. An interesting feature of III–V compounds is the relationship between band gap and composition which helps the designer to use them in the different device requirements.

The valence and conduction bands in amorphous semiconductor have tails of localized states. They also assume that the tails can overlap, so that the density of state at the Fermi level is finite. Also preparation condition play an important role in determining the electrical properties of a-GaAs The affected of the preparation conditions, in particular the annealing temperature, necessary for the deposition of amorphous III-V materials. The conductivity of the amorphous materials is rather intensive to the presence of impurities because of the valence requirements of the impurity atoms are locally satisfied in non-crystalline material [2].

A systematic study of the effect of thermal annealing on the structure properties of As-rich a-GaAs film deposited on to Si and glass substrate, the structure and local bonding configuration in a-GaAs film have been investigate systematically as a function of composition from extended x-Ray absorption fins structure (EXAFS) measurement and also from electron diffraction experiments [3-5].

` In this study a GaAs:Se films with different thickness have been prepared by flash evaporation technique and annealed at different temperatures T_a (373 , 473) K and study by using x-ray diffraction . The d.c conductivity, Carrier concentration and Hall mobility have been also determined from Hall measurements

Experimental work

Thin films of GaAs were prepared from GaAs powder (99.999%) doped with 1% Se using an Edwards high vacuum coating unit model E 306A with an arrangement for flash evaporation method under vacuum (10^{-6}) mbar. The substrate was glass which was cleaned with chromic acid, alcohol and in ultrasonic cleaner The substrate was placed at a distance (15cm) from the boat, Molybdenum was used as a boat source. The mean film deposition rate was3.3A/sec and the film thickness was measured by interference method. These film was annealed at different temperature (373,473)K . The XRD analyses have been done by using a Philips XRD with Cu(K_{α}) at wavelength λ=1.5406Å. The electrical resistance has been measured as a function of temperature for GaAs:Se films in the range (298-473) K ,the measurement have been done using sensitive digital electrometer type keithley 616 and electrical oven . The conductivity was measured at different film thickness with different annealing temperature

RESULT AND DISCUSSIONS

Structural Characterization of GaAs:Se Thin Films

The XRD results of GaAs doped with 1%Se films prepared on glass substrate at room temperature with thickness 1µm at different annealing temperatures (373and 473)K are shown in figure 1.

This figure show amorphous structure of these-deposited films upto annealing at temperatures of 373 K, the films appear almost in an amorphous form. Further raise of the annealing temperature up to 473K, the crystallinity is improved and peak located at 2θ=27.3692, 45.2411 and 53.8913 and the oriented in (111),(220),(311) at T_a 473K. These peaks correspond to the face-centered cubic structure and fully transformed into a crystalline phase of GaAs . The increase of degree of crystalline which increases with increasing annealing temperature may be interpreted in terms of filling the vacancy and in terms of the structure becoming more regular and completed in 3-D in lattice. The amorphous phase partially disappears at 473K . The FWHM value was calculated by using Schrrer's and shown in table (1) as well as the corresponding values of the interplanar spacing $d_{(hkl)}$ and compared with the standard values of JEPDR data. The trend of FWHM values implied that the crystallinity of the GaAs:Se thin film was improved as the annealing temperature was increased .

3-2 D.C Electrical conductivity of GaAs:Se/c-Si thin film

It is known that the study of the temperature dependence of the electrical conductivity of thin films may offer much information about the correlation between the structure and the electrical properties of the films. The d.c conductivity for a-GaAs:Se thin films has been studied as a function of temperature with the range of (298 - 473) K for different thicknesses (0.25, 0.5, 0.75, 1.0) µm at RT and annealing temperatures (373and 473) K.

Figure 2 shows the relation between the $\sigma_{R.T}$ and film thickness with difference annealing temperature. From this figure, we observe that the d.c. conductivity increases with increasing thickness due to the concentration of vacancies defect in amorphous film that increased with the increase of thickness.

Figure 3 shows the relationship of the logarithm of the d.c conductivity (ln σ_{dc}) as a function of 1000/T . It is found from these figures that there are two mechanisms of activation energy (E_{a1} and E_{a2}). At higher temperature range (403 - 473) K, the conduction mechanism is due to carrier excited into the extended states beyond the mobility edge and at lower temperature range (298-403) K, the conduction mechanism is due to carrier excited 3-3 Hall Effect of a- GaAs:Se

Carrier concentration and Hall mobility have been determined by Hall measurements of a-GaAs:Se thin films on glass substrate at room temperature R.T for different thicknesses and different annealing temperatures. Hall measurements show that all these films have a negative Hall coefficient (n-type charge carriers). Figure (5) & (6) show the variation of Hall mobility and carrier's concentration as a function of thickness with different annealing temperatures, respectively. It's observed from these figures that the carrier's concentration decreases with increase of annealing temperature while Hall mobility increases, this behavior due to the re-arrangement process, which leads to the decrease of defects in the film during the film growth, and consequently a decrease of the carriers scattering at the defect. For that reason the mobility increasing. There is increasing in the carrier's concentration with increases of thickness due to concentration of the defect in the film increasing with increase thickness led to increase the charge carrier and for higher value of thickness may lead to create the loop of dislocation. This result is in agreement with H. Kobayashi et al. while decreasing in the Hall mobility with increases of thickness .There is a direct proportion between the carrier's concentration and the conductivity and this proved in the d.c. conductivity and Hall effect, where the carrier's concentration decrease with the increasing of annealing temperature and increase with the increasing thickness and thus increasing conductivity in the thin film.

Table 1. X-ray diffraction data for GaAs:Se compound as thin film

TA	2θ (Deg.)	FWHM (Deg.)	d_{hkl} Exp.(Å)	G.S (nm)	d_{hkl} Std. (Å)	hkl	phase
473	27.3692	1.1151	3.2560	7.3	3.2642	(111)	Cub. Ga As:Se
	45.2411	0.9338	2.0027	9.2	1.9989	(220)	Cub. Ga As:Se
	53.8913	0.7842	1.6999	11.4	1.7047	(311)	Cub. Ga As:Se

Table 2. Values of Carrier Concentration and Hall mobility for a-GaAs:Se Thin Films

Thickness (μm)	μ_H(cm^2/V)	n_H(cm^3)×10^{16}	T_a (K)
0.25	2.455	0.14	RT
	3.121	0.02	373
	3.404	0.01	473
0.5	0.748	2.84	RT
	0.839	0.45	373
	0.989	0.13	473
0.75	0.269	20.83	RT
	0.344	0.82	373
	0.360	0.78	473
1	0.114	104.17	RT
	0.116	16.89	373
	0.120	5.21	473

Figure 1. XRD patterns of GaAs:Se films prepared at different annealing

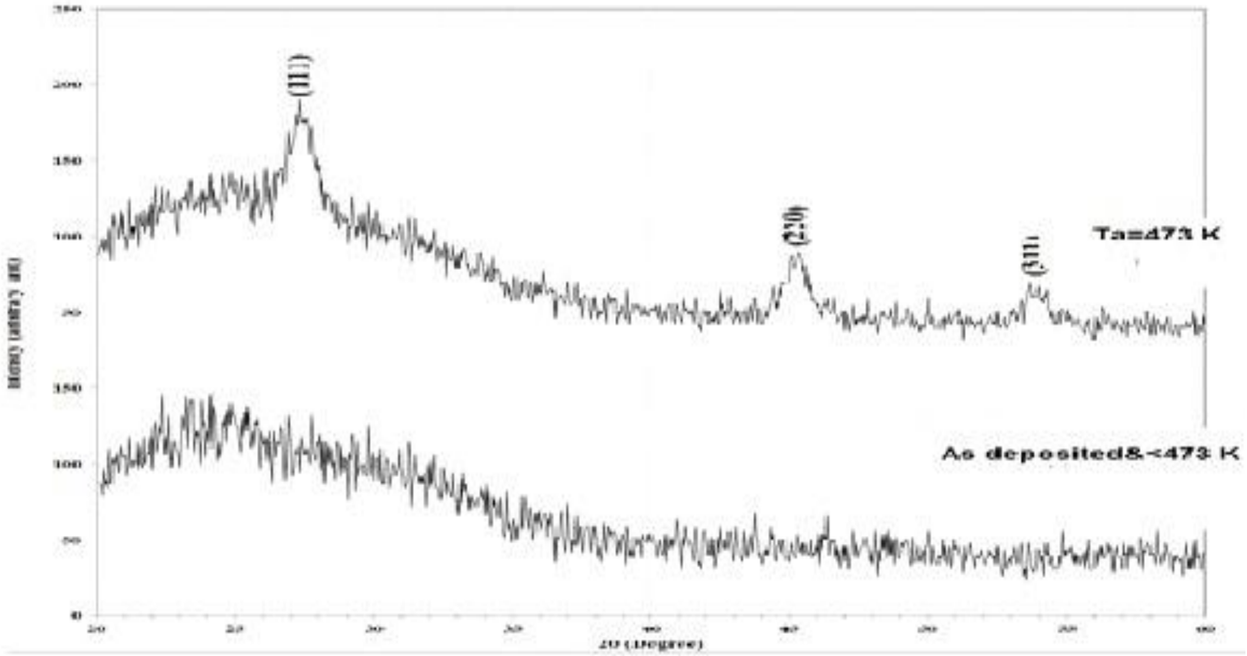


Figure 2. Variation of $\sigma_{R.T}$ versus thickness for a-GaAs:Se films at different annealing temperatures.

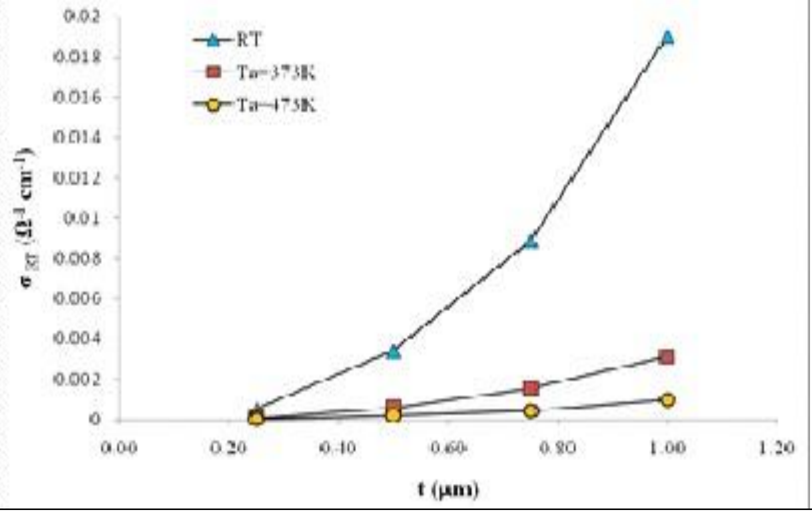


Figure 3. Lnσ versus 1000/ T for a-GaAs:Se films with different thicknesses (a) 0.25µm,(b) 0.5 µm,(c) 0.75 µm ,(d) 1.0 µm and annealing temperatures (RT,373,473)K

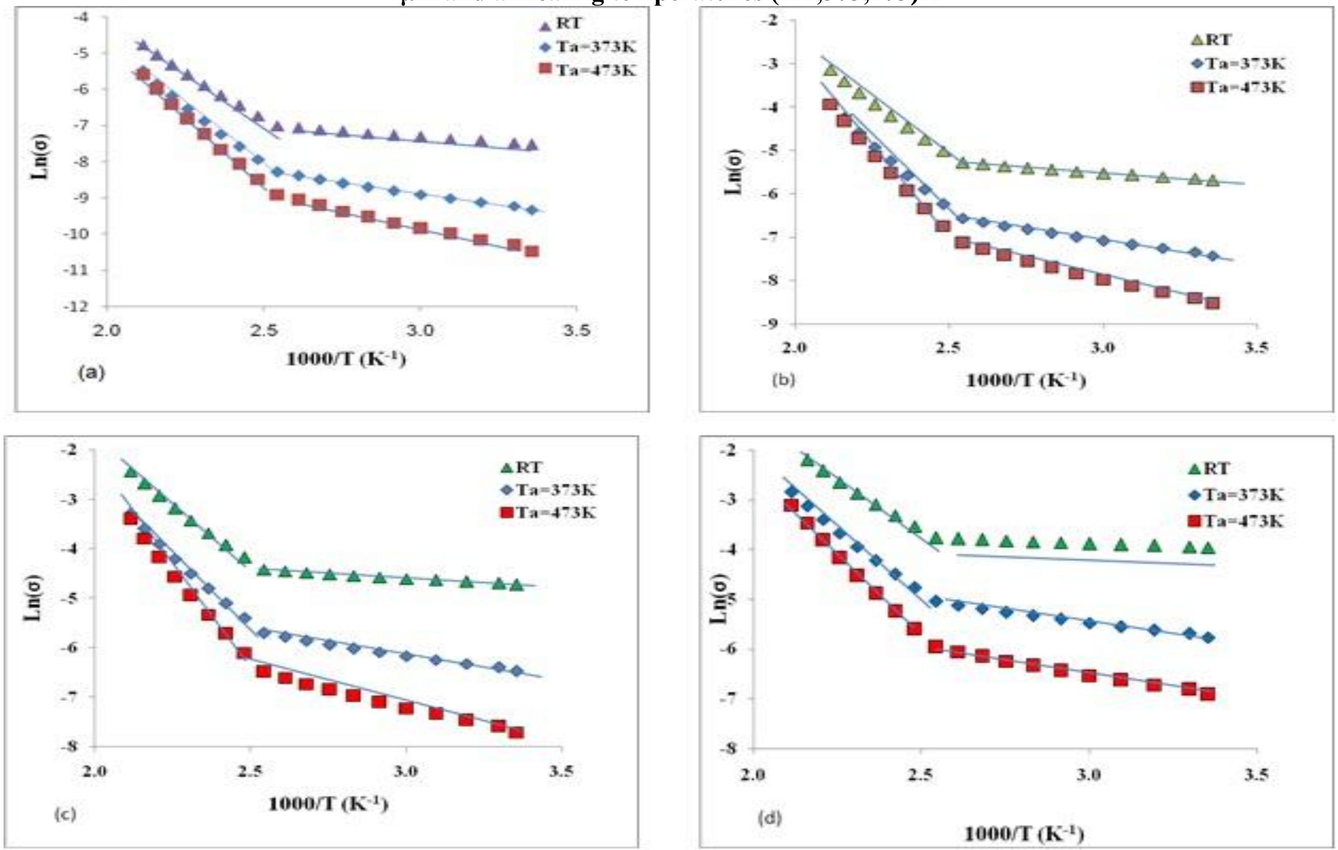


Figure 4. E_{a1} and E_{a2} as a function of annealing temperatures for a- GaAs:Se films at different thicknesses.

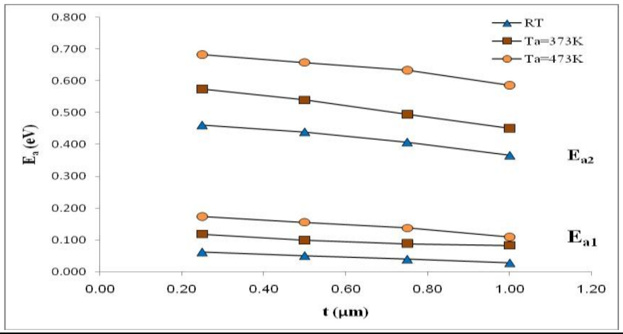


Figure 5. Variation of Hall mobility versus thickness for a-GaAs:Se films at different annealing temperatures

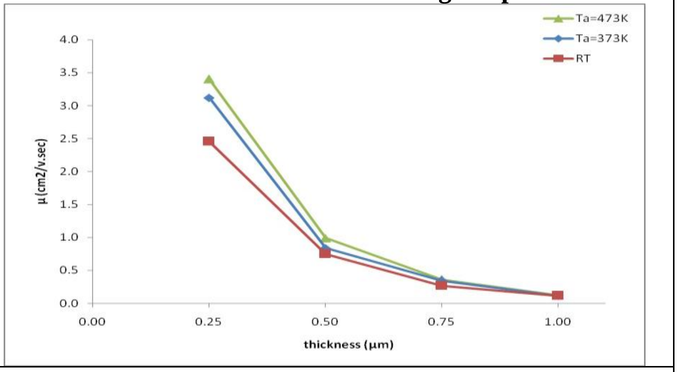
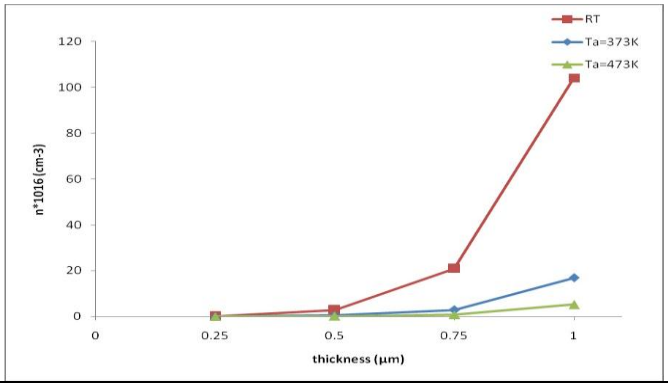


Figure 6. Variation of Hall concentration versus thickness for a-GaAs:Sefilms at different annealing temperatures



CONCLUSION

The structure of GaAs:Se films prepared by flash evaporation at different annealing is amorphous and became a Polycrystalline after annealing process at high temperature. The d.c conductivity for all sample decreases with increasing of annealing temperatures .There are two transport mechanism of the charge carrier in the range of temperature (298-473). The activation energies increasing for annealing temperature increasing . Hall measurements showed that all the films are of n-type. The carrier concentration decreases with increasing of annealing temperatures while it increases with increasing of thickness. Also we observe that the mobility increasing with increasing of annealing temperatures but decreases with thicknesses

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