

Study The Structural Properties of Flashed GaAs Films

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Abstract:

A polycrystalline GaAs thin films have been prepared by flash evaporation technique on glass substrate with Thickness $\sim 1 \mu\text{m}$ and substrate temperature (T_s) of about 423 K under vacuum of about 10^{-5} mbar. The thin films were treated at different annealing temperatures 423, 473, 523, 573 K for 2 hours. The structural tests showed that GaAs have The main planes of the GaAs alloy (111), (220) and (311) as reflections at Bragg angles 27.24° , 45° and 53.3° respectively, and coincide exactly with that of ASTM cards.

Aim of Research

The solid state devices which are made from thin films (as a sandwich) need to improve the structure of their layers, in this search we are trying to find the optimum preparation conditions which lead to the polycrystalline layer of GaAs thin film serves as a layer in the detectors, transistors, LED, ...etc.

1- Introductions

The Semiconductors which made of elements from group III and V in the periodic table are among the technologically most important compound semiconductor materials for microelectronic applications. The gallium arsenide (GaAs) has found the widest use, owing to their highly developed technology, which is the material of the future and will always remain so reflects the current status of GaAs among semiconductors.

III-V semiconductors are commonly used in the fabrication of optoelectronic devices, e.g. red 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].

Nearly all III-V compounds crystallize in an arrangement where each atom is at the center of a regular tetrahedron, at the four corners of which lie atoms of the other kind. These tetrahedron can be arranged into two forms of crystals structure "zincblend" which is cubic, and "wurzite" which is hexagonal [3]. One of the big attractions of III-V compounds is that generally, they crystallize with a high degree of stoichiometry and crystals may now be grown in variety ways [4]

2- The Experimental Work

2-1 Substrate Preparation

Corning glass slides substrates were used as substrate and were cleaned by water, pure alcohol and cleaned it in ultrasonic vessel [5].

2-2 The Thickness Measurement

The weighting method is one of many methods that used for measuring the thickness of prepared films. This method gives an approximate deposited film thickness (t), which determined by the relation:

$$t = \frac{m}{2 \pi \rho R^2} \quad \text{----- (1)}$$

Where m and ρ are the material mass and density respectively, R is the distance between the substrate and the boat.

2-3 X-Ray Diffraction (XRD)

The structure of GaAs alloy and films with $1 \mu\text{m}$ thickness was studied. All Prepared films annealed in 2 hr in the range of 423-573 K. The samples have been examined by XRD with target CuK_α wavelength $1.5405 \text{ \AA}$, the scanning angle has varied in the range (10-70) with speed 2 cm/min , current 20 mA and voltage 40 KV . When X-Ray beam incident on the sample under study, it's reflected. When the angle of incident has certain value depending on the wavelength and lattice constant of the sample because of the Braggs reflection from parallel planes which occur constructive interference, this interference is obey Braggs law .

$$2 d_{(hkl)} \sin \theta = n \lambda \quad \text{----- (2)}$$

Where $d_{(hkl)}$ is the interplaner distance for different planes, θ is the angle between X-ray beam and reflecting planes, $n\lambda$ is path difference. By comparing this d value with ASTM card for GaAs we have examined the structure of their alloys and films. The lattice constant (a) is estimated from the relations:-

$$a = \frac{\lambda}{2} \cdot \frac{\sqrt{h^2 + k^2 + l^2}}{\sin \theta} \quad \text{----- (3)}$$

2-4 Flash Evaporation of GaAs Films

Flash evaporation technique is generally used for the evaporation and deposition of the compound GaAs, since the material is evaporated quickly, the decomposition of the compound is minimized [6]. In this method the components of the compound in spite of the difference between their vapor pressures but the material do not separate through the evaporation process

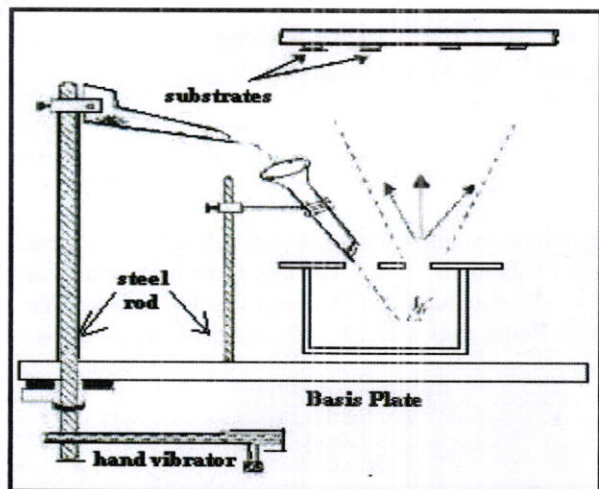


Fig.1 schematic representation of flash evaporation

The Preparation of GaAs films by flash evaporation technique is shown in Fig.1 the alloy crushed into very small grains (powder), this powder is dropped into a heated boat from the *feed through* passing through a guide funnel by manual vibrating handmade system. The substrate temperature obtained by a tungsten heater and measured by a thermocouple Type K.

The structure of alloy of GaAs has been investigated by using XRD to ensure the structure of our material. Fig.2 shows the XRD pattern of the alloy and Table 1 gives all the calculated parameters which we are need them to illustrate the structure and the effect of annealing process on the alloy and films.

From Fig.2 we can observe the main of planes the GaAs alloy (111), (220) and (311) were reflection at Bragg angles (27.24°), (45°) and (53.3°) respectively, and coincide exactly with that of the ASTM and from Table 1 we can observe that there are two phases in this zincblend alloy (cubic and orthorhombic). From Fig.3 we can observe the effect of the annealing process on the films, the first observation that all the films were polycrystalline and the orthorhombic phase disappear through the annealing process and a new characteristics diffraction peaks (was not found in the alloy XRD pattern) will appear in the structure of films corresponding to the (200), and (222) reflections at Bragg angles 31.7° and 56.5° respectively, also we can recognize some peaks of Ga. because of Ga more activity than As to interact with O_2 , Aguir et al (1989) deposited the GaAs films by R.F glow discharge, and they found that a-GaAs films contain a gallium oxide (Ga_2O_3) and gallium clusters[7], this may due to the influence of the substrate temperature because it was not systematic[8]

Table 1 the structure parameters of XRD pattern of 1 μ m GaAs films prepared by flash evaporation at $T_s=423$ °K for different T_a

Sample	2 θ	hkl	(I/I ₀) _{exp.}	$d_{\text{stan.}}^{\circ}(\text{\AA})$	(I/I ₀) _{stan.}	$d_{\text{exp.}}^{\circ}(\text{\AA})$	structure	Material
GaAs	27.2	111	93.0919	3.26297	100	3.2756	Cub.	GaAs
Powder	39	011	25.3481	2.30495	21	2.30747	Orth.	GaAs
	45	220	100	1.991	50	2.01276	Cub.	GaAs
	53.3	311	72.8913	1.70456	38	1.71724	Cub.	GaAs
	65.5	400	33.1337	1.41354	8	1.42382	Cub.	GaAs
	72.5	331	45.2325	1.29715	10	1.30262	Cub.	GaAs
	83.6	422	46.7632	1.15396	9	1.1556	Cub.	GaAs
Film	27.2	111	100	3.26297	100	3.34782	Cub.	GaAs
Sample	2 θ	Hkl	(I/I ₀) _{exp.}	$d_{\text{stan.}}^{\circ}(\text{\AA})$	(I/I ₀) _{stan.}	$d_{\text{exp.}}^{\circ}(\text{\AA})$	structure	Material
At R.T	31.8	200	89.564	2.80316	1	2.81124	Cub.	GaAs
	38.9	011	60.790	2.30495	21	2.31300	Orth.	GaAs
	40.9	-	-	-	-	-	-	Ga
	43.2	-	-	-	-	-	-	Ga
	45.3	220	47.315	1.991	50	1.99948	Cub.	GaAs
	48.9	-	-	-	-	1.86080	-	Ga
	51.1	022	38.297	1.7713	5	1.7853	Orth.	GaAs
	53.4	311	32.016	1.7039	38	1.71377	Cub.	GaAs
	56.4	222	30.699	1.6313	1	1.62963	Cub.	GaAs
	57.4	-	-	-	-	1.60349	-	Ga
film at	22.6	-	-	-	-	-	-	Ga
$T_a=423$ °K	27.2	111	100	3.26297	100	3.3495	Cub.	GaAs
	31.8	200	75.99	2.80316	1	2.811	Cub.	GaAs
	40.9	-	-	-	-	-	-	Ga
	43.2	-	-	-	-	-	-	Ga
	45.5	220	4.18	1.991	50	2	Cub.	GaAs
	53.6	311	46.4	1.7039	38	1.746	Cub.	GaAs
	56.5	222	33.118	1.6313	1	1.629	Cub.	GaAs
film at	22.6	-	-	-	-	-	-	-
$T_a=473$ °K	27.3	111	100	3.26297	100	3.262	Cub.	GaAs
	31.7	200	71.63	2.80316	1	2.81	Cub.	GaAs
	40.9	-	-	-	-	-	-	Ga
	43.2	-	-	-	-	-	-	Ga
	45.3	220	54.499	1.991	50	1.9993	Cub.	GaAs
	48.9	-	-	-	-	-	-	Ga
	53.4	311	36.73	1.7039	38	1.71377	Cub.	GaAs
	56.4	222	34.54	1.6313	1	1.629	Cub.	GaAs
	57.4	-	-	-	-	-	-	Ga
film at	22.6	-	-	-	-	-	-	Ga
$T_a=523$ °K	27.3	111	100	3.26297	100	3.25699	Cub.	GaAs
	31.6	200	75.86	2.80316	1	2.82	Cub.	GaAs
	40.7	-	-	-	-	-	-	Ga
	45.4	220	51.724	1.991	50	1.9999	Cub.	GaAs
	49	-	-	-	-	-	-	Ga
	53.5	311	36.206	1.7039	38	1.709	Cub.	GaAs
	56.5	222	36.206	1.6313	1	1.626	Cub.	GaAs
	57.4	-	-	-	-	-	-	Ga
film at	22.7	-	-	-	-	-	-	Ga
$T_a=573$ °K	27.4	111	100	3.26297	100	3.2511	Cub.	GaAs
	31.6	200	74.3	2.80316	1	2.82	Cub.	GaAs
	40.7	-	-	-	-	-	-	Ga
	45.5	220	53.846	1.991	50	2	Cub.	GaAs
	48.9	-	-	-	-	-	-	Ga
	53.5	311	35.38	1.7039	38	1.71	Cub.	GaAs
	56.5	222	38.46	1.6313	1	1.626	Cub.	GaAs

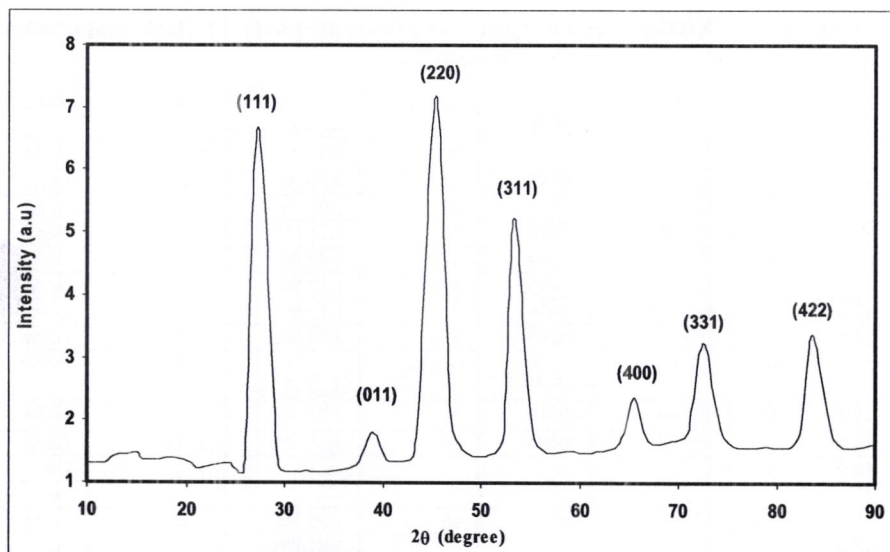


Fig. 2 XRD patterns of GaAs powder

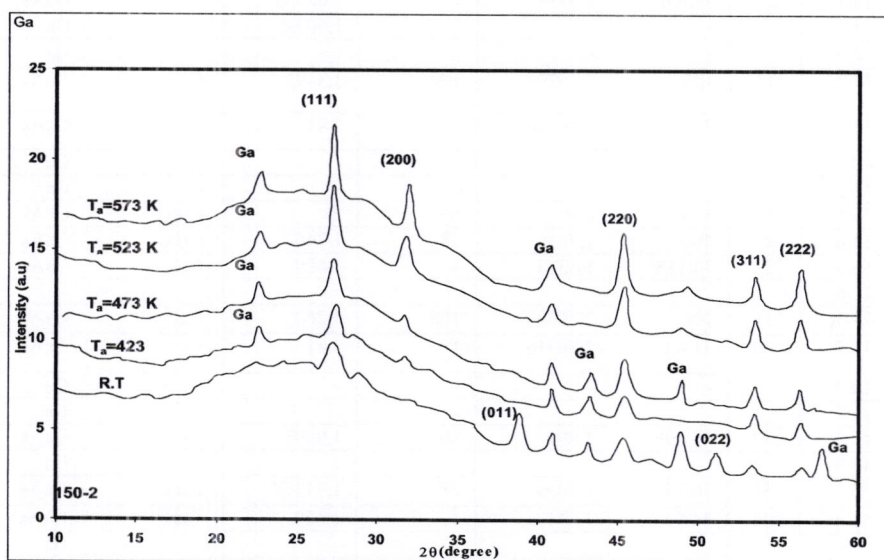


Fig. 3 XRD patterns of 1 μm GaAs films at $T_s = 423^\circ\text{K}$ and different annealing temperature

The diffraction diagrams look remarkably similar; there is only a slight increase in contrast after annealing. Gheorghiu et al (1984) found that the structure of polycrystalline GaAs films annealed at 580°K consist the (222) planes and the films annealed at high temperature consist the (111) planes [8]. Al Haddad et al (1991) found similar observation in flash evaporated when annealed at 598°K for 30 min.[9].

4- Conclusions

The increase in the annealing temperature will lead to improve the structure, and these improvements are important to fabricate solid state devices.

The main planes of the GaAs powder are (111), (220) and (311) as reflections at Bragg angles 27.24° , 45° and 53.3° respectively, and coincide exactly with that of ASTM cards.

5- References

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دراسة الخواص التركيبية لأغشية زرنيخات الكالسيوم المحضرة بتقنية التبخير الوميضي

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الملخص

تم في هذا البحث تحضير أغشية زرنيخات الكالسيوم الرقيقة متعددة البلور بواسطة تقنية التبخير الحراري الوميضي وبسمك $1 \sim$ مايكرومتر ودرجة حرارة الأرضية كانت 423 مطلقاً تحت ضغط 10^{-5} ملي بار. تم معالجة الأغشية الرقيقة حرارياً بدرجات حرارة تليدين مختلفة، 423 ، 473 ، 523 ، 573 كلفن. وقد أظهرت النتائج تحسناً في التركيب البلوري مع زيادة درجة حرارة التليدين حيث تم مقارنتها مع نتائج مسحوق سبيكة جاهزة لنفس المادة.