D.C. Conductivity of a-InAs Films Prepared at Different Thickness

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Abstract

The behaviour of the electrical conductivity (σ) and the activation energies (Ea_1, Ea_2) have been investigated on a-InAs thin films as a function of thickness (250,350,450,550,650) nm, before and after heat treatment. The films were annealed at (373, 423, 473) K for one hour.

The films contain two types of transport mechanisms, and the electrical conductivity (σ) increases whereas the activation energy (Ea) would decrease as the films thickness increases.

Introduction

The method of preparation plays an important role in preparing InAs films [1] because of the tendency of the material to dissociate at its melting point, which makes it difficult to obtain stoichiometric films
[2-7].

Several authors have used co-evaporation [3], sputtering [4, 5], electro deposition [6], flash evaporation [2, 8], chemical deposition and heating with a vacuum deposited [9] etc.

In the present paper, thermal evaporation technique for a-InAs films formation as it ensures stoichiometric was used.

Detailed measurements are made on electrical conductivity and activation energies of this material , by varying thickness for both as deposited and annealed films at (373, 423, 473) K for one hour. We have already reported [10] on the Hall effect measurements on a-InAs films prepared at different thickness.

Experiment

Amorphous InAs films were prepared onto a glass slide substrate (using a suitable mask) in a vacuum of ($3*10^{-6}$) torr by using Edward coating unit model E 306 A.

The alloy was obtained by fusing the mixture of the appropriate quantities of the elements in evacuated fused quartz ampoules at (1273) K. The ampoules quenched rapidly in cold water.

Film thickness varied from 250 nm to 650 nm. The distance from molybdenum boat to substrate was about 15 cm. The deposition rate was about 1nm/s for all the films. Al electrodes were used as contact material for making the electrical connections.

For D.C. measurement Keithly model 616 was used to measure the variation of electric resistance (R) with temperature range (298-503) K, then calculated the resistivity (ρ) by the formula [11]:-

$$\rho = \frac{R \cdot b \cdot t}{L} \qquad (1)$$

Where t is film thickness, b is electrodes width; L is the distance between two Al electrodes.

The conductivity (σ) is related to the resistivity by equation [11]:-

$$\sigma_{d.c} = \frac{1}{\rho} \qquad (2)$$

Results and Discussion

Fig.1 shows the lnσ of a- InAs film versus $10^3/T$ results obtained for different thickness on a various samples for as-deposited films. This figure also shows two mechanisms for electrical conductivity at lower and higher temperatures with two values of activation energy (Ea_1, Ea_2) for all films, which means that there is two mechanism of transport, at a higher temperature range (383-503) K the conduction mechanism of this stage is due to carriers excited into extended states beyond the mobility edge .Atother range of temperature (298-383) K the conduction mechanism due to carriers excited into the localized states at the edge of the bands and hopping.

Fig.2 (a, b) shows the variation of the electrical conductivity (σ) of an InAs film, as a function of thickness and annealing temperature.

In conclusion, it is seen that the films with lower thickness had lower conductivities than those with higher thickness. We should point out that the electrical conductivity (σ) increased dramatically with increasing (t) and reached the maximum value ($1.6 * 10^{-3}$) $ohm^{-1}.cm^{-1}$ at t=650 nm for film Ta=298 K.

The increasing trend in σ upon increasing thickness is due to the decreasing scattering at grain boundaries in thicker films [12]. We believe that the increase in film thickness (t) decreases the trapping centers of charge carriers, this is, perhaps, duo of the decreases of the grain boundary scattering, moreover it yields more packing density, this result is in an agreement with Sharma and Reddy [2], who prepared InAs films by the different method and different deposition parameters.

Fig.3 (a, b) shows the activation energies (Ea_1, Ea_2) of an InAs film, as a function of thickness for different films, before and after heat treatment. It is clear from these figures that both Ea_1 and Ea_2 decrease with increasing thickness (t).

It is clear from figures (2, 3) that σ decreases after heat treatment, while the activation energies showed opposite trend for all films prepared because of the decreased number of carriers available for transport, this behaviour can be attributed to the decrease of the density of states in the gap, the reduce of the dangling bonds, and defects like vacancy sites in the films structure with the increasing Ta.

Conclusions

The electrical conductivity and activation energies of thin a-InAs films, prepared by thermal evaporation, are seen to be dependent on the film thickness.

The electrical conductivity shows an increasing behaviour with an increasing thickness before and after heat treatment, whereas the activation energies decrease as the thickness increases.

The films contain two types of transport mechanisms, and the electrical conductivity decreases with the increasing Ta while the activation energies decrease.

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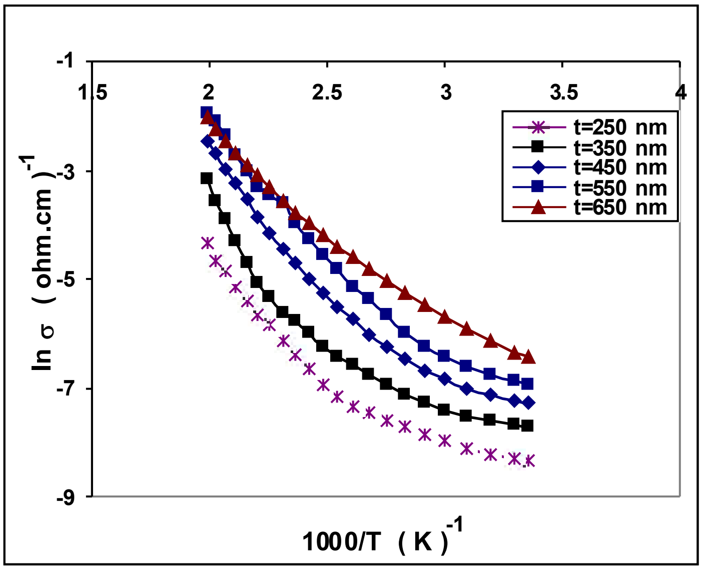
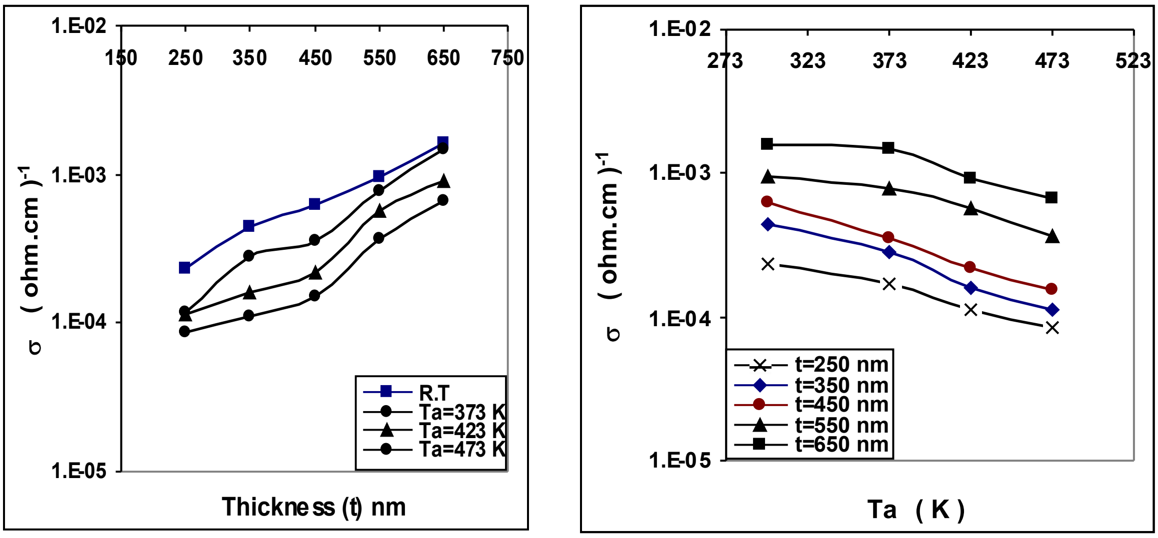


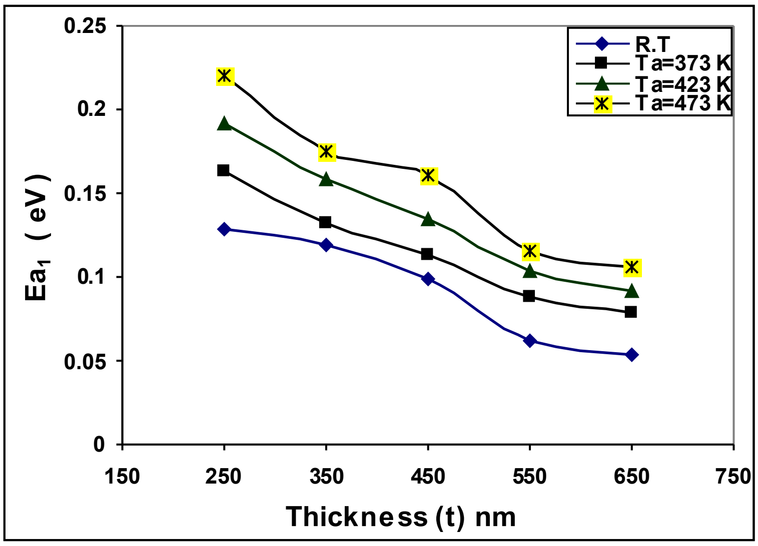
Fig.(1): Electrical conductivity behaviour as a function of temperature for a-InAs thin films as-deposited at different thicknesses.



(a) (b)

Fig.(2): Electrical conductivity of a-InAs thin films as a function of:-
(a) thickness at different annealing temperature.
(b) annealing temperature formed at different thicknesses.

(a)



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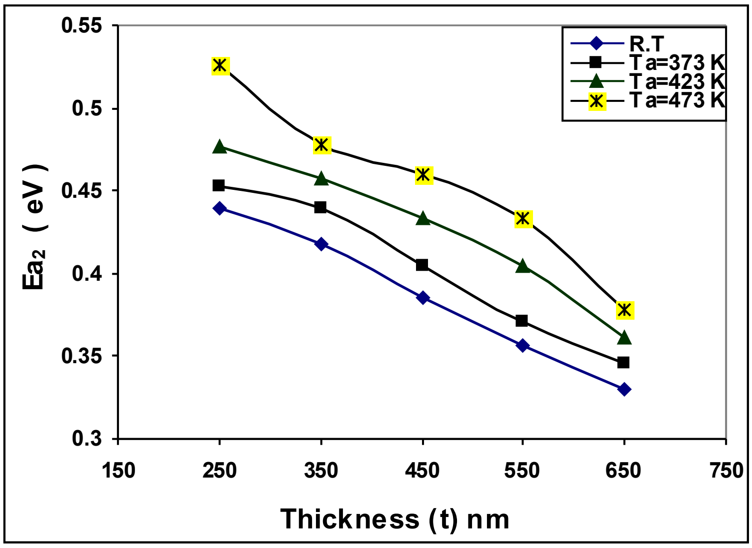

Fig.(3):Activation energies versus thickness of a-InAs thin films at different annealing temperatures

التوصيلية المستمرة لأغشية InAs العشوائية المحضرة عند أسماك مختلفة

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الخلاصة

يهدف هذا البحث الى دراسة سلوك التوصيلية الكهربائية وحساب طاقات التنشيط لاغشية InAs العشوائية دالة لتغير السمك ، وقد حضرت الاغشية بأسماك مختلفة nm (250,350,450,550,650) ، ولدنت بدرجات حرارة تلدين K (373, 423, 473) ومدة ساعة واحدة.

وقد أظهرت الاغشية آليتين للانتقال الالكتروني، ولوحظ زيادة التوصيلية الكهربائية مع نقصان طاقات التنشيط بزيادة سمك الاغشية المحضرة.