Dependence of the Hall Mobility and Carrier Concentration on Thickness and Annealing Temperature of a-As_2Te_3 Thin Films

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Abstract:

Hall effect measurements have been made on a-As_2Te_3 thin films for different thickness film in the range (200-350) nm. The Hall mobility in a-As_2Te_3 thin films decreases with increasing annealing temperature but the carrier concentration increases. When increasing the film thickness increases the Hall mobility decreases, while the carrier concentration increases.

الخلاصة:

تم اجراء قياسات تأثير هول لأغشية a-As_2Te_3 العشوائية في مختلف درجات حرارة التلدين بمدى (303-473)K واسماك مختلفة بمدى (200-350)nm. لوحظ تناقص تحركية هول مع زيادة درجة حرارة التلد ن ولوحظ زيادة في حاملات الشحنة مع زيادة درجة حرارة التلدين .كذلك وجد تناقص تحركية هول للأغشية مع زيادة السمك بينما تزداد حاملات الشحنة مع السمك.

Introduction:

The Hall effect in amorphous semiconductors exhibits remarkable difference from that in crystalline materials. Not only is the sign of Hall coefficient (R_H) almost opposite to that of the thermoelectric power, but its magnitude is approximately 100 times smaller than might be expected from the carrier concentration (n_H) determined by other means[1]. The phenomena of Hall effect was discovered in (1879)[1], its standard tool to investigate the type of charge carriers and carrier concentration (n_H) .The Hall mobility (μ_H) is basically given [4,5]

$$\mu_H = \sigma R_H \qquad (1)$$

Where: σ is the dc conductivity

The Hall coefficient is given by:

$$R_H = \frac{V_H}{I} \cdot \frac{t}{B_0} \qquad (2)$$

Where: V_H is Hall voltage, t is the film thickness, and Bo is the magnetic field.

Also the concentration of carriers of charge is given [1] by:

$$n_H = \frac{1}{R_H q} \qquad (3)$$

Where: q = - e for electrons, q = + e for holes.

Much experimental and theoretical work exists concerning the electrical properties especially Hall effect measurement on chalcogenide glasses containing group VI for example As_2Te_3[2-4].

Mytilineou and Roilos (1987)[5], reported that Hall mobility has higher values for stoichiometric composition, As_2Te_3 than for intermediate composition, they also showed that the Hall effect experimental data on chalcogenide glasses give values for Hall mobility at room temperature between 0.02 and 0.12 cm^2/V. sec.

Grant et al [3], showed that the sign of the Hall voltage in As_xTe_{1-x} film was negative with Hall mobility 0.07 cm^2/V. sec at room temperature.

Weiser and Brodsky (1972) [6] found the average of Hall mobility in the range (0.3 – 5) cm^2/V. sec for As_2Te_3 films prepared by electron – beam heating.

Seager et al (1973) [2] found the value of Hall mobility for bulk As_2Te_3 is equal to 0.05 cm^2/V. sec.

The above reviewed studies on a-As_2Te_3 semiconductors films lack reproducibility of the Hall effect measurements as a function of thickness and annealing temperature. In order to obtain more detailed picture of the relationship between Hall mobility and thickness and annealing temperature in a-As_2Te_3 , thin films. Hal effect measurement within thickness range (200 – 350)nm and annealing temperature within the range (303 – 473)K are reported.

Experimental Details:

As_2Te_3 alloys were made by heating and mixing the appropriate constituents in an evacuated quartz tube at 800 K for 4 hours. After heating for 4 hours the tube was taken from furnace and quenched into a cool water. a-As_2Te_3 thin films prepared by thermal evaporation with thickness about (200 - 350) nm by using coating unit (BAE 370).

The shape of a-As_2Te_3 sample film is square, four Al electrode were positional at its side. When the magnetic field (B_o = 0.257 Tesla) is applied perpendicular to the electric field it yields a current (I), then the transverse e.m.f. which is called Hall voltage (V_H) is set up across the sample, so that the Hall coefficient is given by eq.(2) and the carrier are connected to the Hall coefficient according to relation(3). Hall experiment may also imply the Hall mobility (μ_H) according to relation (1).

Results and Discussion:

The value of μ_H for a-As_2Te_3 thin films were in the range (0.003 – 0.392) cm^2/V. sec, it is a good agreement with [3] and [5]. It is clear from Fig.(1) that μ_H decrease with increasing annealing temperature . Also from Fig.(2) the values of (n_H) increased with increasing (T_a). We showed point out that the Hall carrier concentration increased with increasing T_a means the increase in carrier energy at Fermi level. Such results are in agreement with refs[4,8]. Fig.(3) shows the variation of μ_H with increasing thickness at different annealing temperature . It is observed that μ_H decreases with increasing thickness. Our interpretation is that the increasing thickness caused to reduce the trapping centers of charge carriers need lower energy to transit Fermi level to conduction band which lead to increase the charge carrier density while the carriers concentration increases with increasing thickness as shown in Fig. (4). From this Fig. We can see the value of μ_H decreases from 0.392 cm^2/V.sec for film thickness 200 nm to 0.042 cm^2/V.sec for film thickness 350 nm for as-deposited film. While the value of n_H decreases from 0.087 cm^2/V.sec to 3.4 x 10-3 cm^2/V. sec for same thickness at T_a = 473K. This variation may be associated with ionized impurity scattering becomes less effective for higher energy electrons.

Conclusion:

Hall effect measurements have been investigated. Hall mobility and carrier concentration were found to be more sensitive to thickness and annealing temperature. The Hall mobility decreases with increasing T_a and thickness while carrier concentration increases with increasing T_a and thickness.

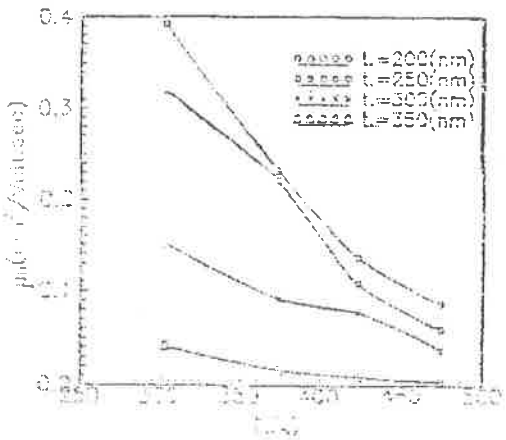

Fig.(1): Hall mobility Vs annealing temperature T_a of a-As_2Te_3 films.

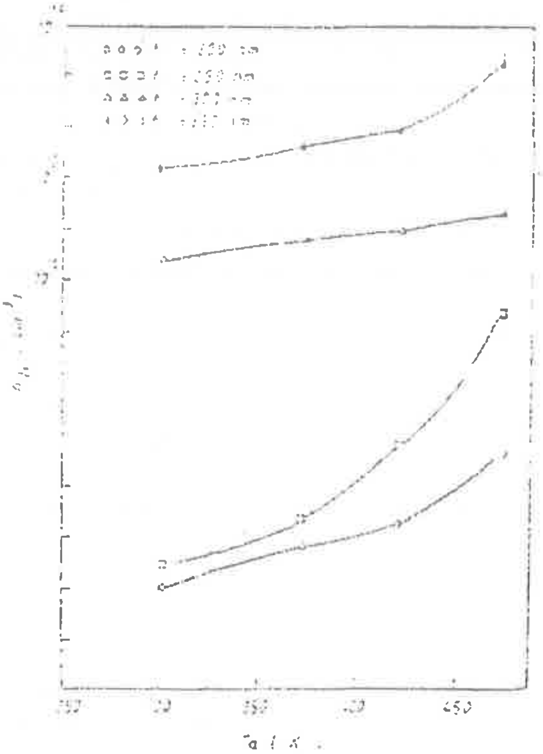

Fig.(2): Hall carrier concentration Vs T_a of a-As_2Te_3 films.

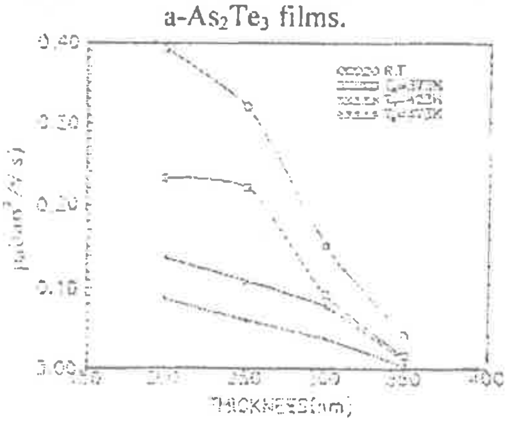

Fig.(3): Hall mobility Vs annealing temperature T_a of a-As_2Te_3 films.

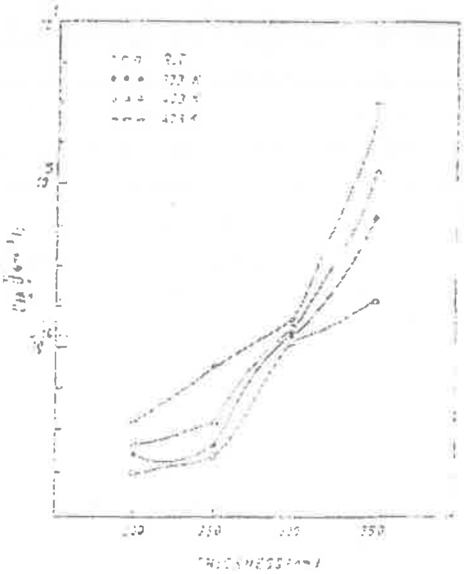

Fig.(2): Hall carrier concentration Vs T_a of a-As_2Te_3 films.

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