Journal of Al-Nahrain University **Vol.13 (1), March, 2010, pp.69-72** **Science**

INVESTIGATION OF STRUCTURAL AND OPTICAL PROPERTIES OF Sb_2S_3 THIN FILMS

Salma M. Shaban
Department of Physics, College of Science, University of Baghdad.

Abstract

Sb_2S_3 thin films were obtained by evaporating the powder of Sb_2S_3 compound onto glass substrates maintained at room temperature and at substrate temperature 423 K under vacuum pressure of (2×10^{-5}) torr. The composition of Sb_2S_3 powder was determined by atomic absorption spectroscopy .The deposited films at room temperature were amorphous but the deposited films at 423K were polycrystalline structure. Optical parameters like absorption coefficient, energy gap, and refractive index were measured by the analysis of the experimental transmission spectrum over the wavelength range (200-1100) nm.

Introduction

Antimony trisulphide (Sb_2S_3) is considered as an interesting optical material in various optoelectronic device like television cameras [1]. The structure of thin films can be changed by preparation condition and preparation method [2] .Many researchers studied the characteristics of Sb_2S_3 compound like Liker[3] who investigated the relation between rate of deposition and the structure of Sb_2S_3 compound. In the present work, we studied the XRD patterns of Sb_2S_3 thin films and transmission spectrum by swanepoel method [4,5]. Swanepoel showed that the optical properties of a uniform thin film of thickness d, refractive index n, and absorption coefficient α, which were deposited on a substrate with refractive index n_s, can be obtained from the transmission spectra by constructing two envelopes for the interference maxima T_M , and minima T_m in the transmittance spectra. The observed transmittance spectra were corrected relative to optically identical uncoated glass substrate . The optical energy gap and refractive index were measured by the transmission spectrum.

Experimental

Sb_2S_3 thin films have been prepared onto glass substrates by thermal evaporation under vacuum (2×10^{-5}) torr of Sb_2S_3 high purity polycrystalline powder (99.999%purity) .The glass substrates were cleaned and were kept at room temperature and another at 423 K during the film deposition. The distance between the molybdenum boat and the substrate was 10 cm. The deposition rate for all films was 0.5 nm/s. The thickness of the thin films was determined by fizeau fringes method with equal thickness [2,6], which was about (150) nm. The optical transmission spectrum of the deposited films was recorded using a shimadzu and UV-visible recorder spectrometer UV-160. An Edward E306 A coating unit was used to prepare thin films.

Results and Discussion

The composition of Sb and S of Sb_2S_3 powder was measured by atomic absorption spectroscopy.It was nearby stoichiometric (44% Sb and 56 % S).

Fig.(1) showed that the X-ray diffraction patterns of Sb_2S_3 powder and for thin films at R.T and at 423 K. It was clear that the prepared film at room temperature is amorphous and becomes polycrystalline with orthorhombic structure at 423 K which is due to the larger mobility of atoms to arrange themselves in large crystalline grains at higher substrate temperature with preferential orientation of crystallites along the (310) plane.

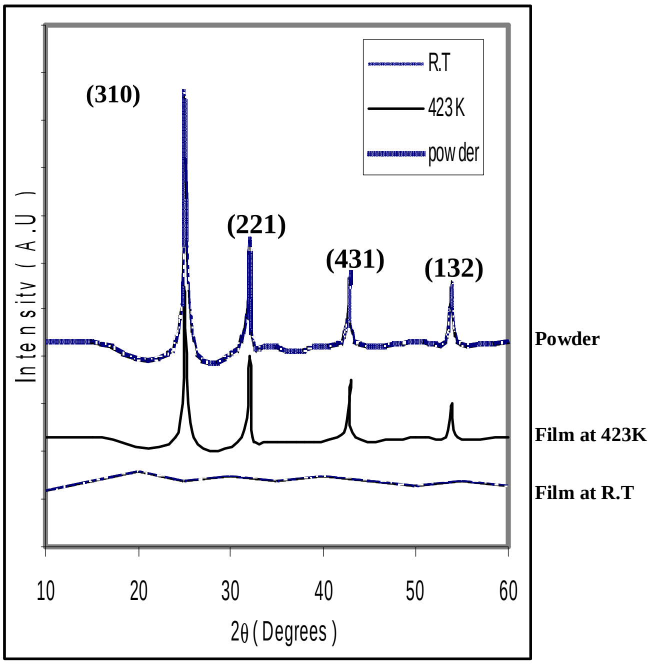

Fig. (1): XRD patterns of Sb_2S_3.

As shown in Fig. (1) the interplanar spacing $d_{(hkl)}$ was calculated using the Bragg's equation.

$$d_{hkl} = n\lambda / (2 \sin\theta)$$

where λ is the X-ray wavelength , n is the spectrum order , and θ is the diffraction angle. The calculated values of d_{hkl} for Sb_2S_3 thin films at 423 K, are in good agreement with the standard values as shown in Table (1). The calculated lattice parameters were :
a = 11.4 A°, b = 11.22 A°, and c = 4 A°.

Table (1)
Comparison of experimental d_{hkl} with standard values for Sb_2S_3 thin film.

(hkl)	2θ(deg.)	d_{hkl} (A°)		(I %)
		Exper.	Standard	
(310)	25.41	3.593	3.558	85.50
(221)	32.86	2.716	2.764	28.40
(431)	47.31	1.960	1.940	20.50
(132)	54.50	1.690	1.691	15.02

Fig.(2) shows the spectral behavior of the transmittance spectra for Sb_2S_3 thin films deposited at room temperature and at substrate temperature (423)K at film thickness (150) nm. The value of substrate transmittance was found to be 93%. The dashed curves indicated the interference maxima, T_M , and minima , T_m. As shown from Fig. (2) the films have an average transmittance of 64 % over (750-1100) nm range .

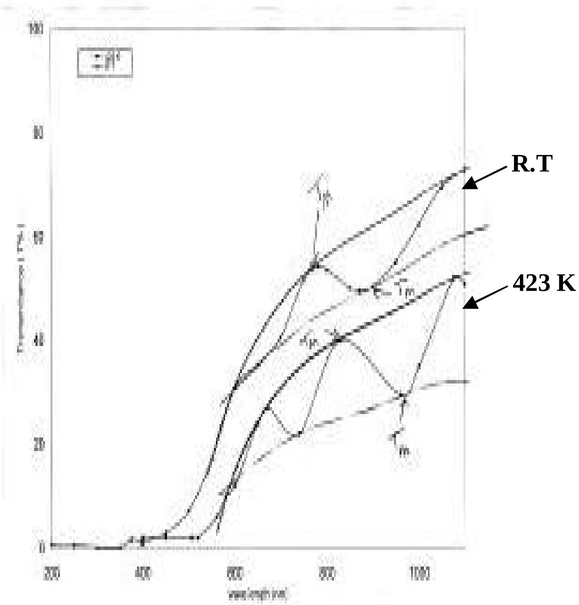

Fig.(2): Transmittance spectra of Sb_2S_3 thin films as a function of wavelength.

The refractive index (n) of a uniform thin film, for a determined wavelength, is given by

$$n = \left[N + (N^2 - n_s^2)^{1/2} \right]^{1/2}$$

Where $$N = \left[\frac{(1+n_s^2)}{2} \right] + 2n_s \frac{(T_M - T_m)}{T_M * T_m}$$

Where n_s is the refractive index of the substrate and T_M , T_m represents the maxima and minima peaks as shown in Fig. (2) respectively. From Fig. (2), the extrapolated envelope method has been employed to extract the refractive index, n, of the Sb_2S_3 films by taking many points which locate on the extrapolated envelope. The reflective index was found to decrease with the increase of wavelength as shown in Fig. (3).

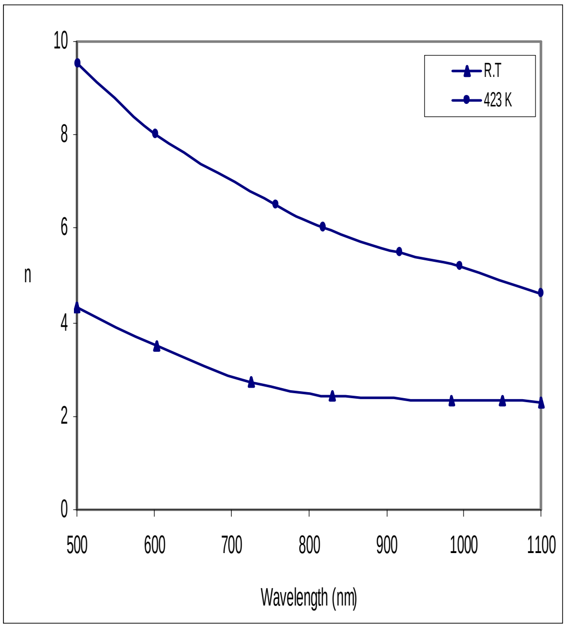

Fig.(3): The refractive index of Sb_2S_3 thin films.

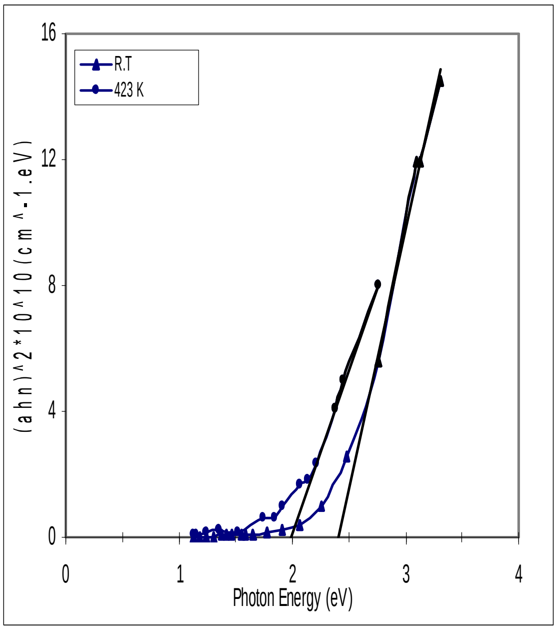

Fig. (4) : Plot of $(\alpha h\upsilon)^2$ against $h\upsilon$.

Also, the optical energy gap was measured in the fundamental absorption edge by using the expression for the absorption coefficient, for allowed direct energy gap[7,8] , as

$$(\alpha h\nu) = A(h\nu - Eg)^{1/2} \text{ .... (1)}$$

Where $h\upsilon$ is the photon energy , E_g represents the energy gap , and A is constant .

Fig.(4) shows the relation between $(\alpha h\upsilon)^2$ against $h\upsilon$, from the figure ,the energy gap was determined by the intercept of the linear part of the curve with X-axis and was found to be (2.4 and 2.0) eV at room temperature and at 423 K respectively with allowed direct transition . The decrease in energy gap at higher substrate temperature is due to the improved crystalline structure.

Conclusion

Sb_2S_3 powder exhibited good stoichiometry as analyzed by atomic absorption spectroscopy. It was clear that the film prepared at room temperature is amorphous and became polycrystalline with orthorhombic structure at 423 K. A lower transmittance is observed for such films with condition of substrate temperature (423)K at film thickness (150) nm. The optical energy gap was found to be (2.4 and 2.0) eV at room temperature and at 423 K respectively. The refractive index for thin films deposited at 423 K was higher than thin films deposited at R.T.

Reference

[1] Ghosh ,G. ; 1979 ;" thin solid films " , 69 ; 61.
[2] K. L. Chopra , " Thin Film Phenomena " , MCGraw–Hill, New York, (1969).
[3] A. Y. Liker and Huseyin Tolunay, " Turk J . phys.", 25, (2000) P. 215.
[4] J. singh , " optical properties of condensed Matter and applications " , John wiley & Sons , (2006) , P. 245 .
[5] W. C. Tan, K . Koughia , and S. O. Kasap, Fundamental optical properties of materials, Department of Electrical engineering, Saskatoon, Canada Faculty of

Technology , chartes Darwin University , Darwin, NT 0909, Australia , (2005).
[6] J. Desai, " Thin Solid Film", 324 , (1998), P. 300 .
[7] W.shen and H. Kwook," Appl. Phys . lett", 65, (1994) P. 218 .
[8] J. Tauc, “Amorphous and liquid semiconductors" New York, Plenum, (1974), ch. 4, P. 115.

الخلاصة

حصل على اغشية Sb_2S_3 بواسطة تبخير مسحوق مركب Sb_2S_3 على قواعد زجاجية عند درجة حرارة الغرفة وكذلك في درجة 423 K وتحت ضغط (2×10^{-5} torr). فحصت نسب مكونات المركب Sb_2S_3 بواسطة تقنية مطياف الامتصاص الذري. وجد ان الاغشية المرسبة بدرجة حرارة الغرفة تكون عشوائية التركيب اما تلك المرسبه عند درجة حرارة 423 K فهي ذات تركيب متعدد التبلور. قيست الكميات البصرية مثل معامل الامتصاص الكتلي α وفجوة الطاقة E_g وكذلك معامل الانكسار n عن طريق دراسة طيف النفاذية ضمن مدى الاطوال الموجية nm (200-1100).