The Effect of Thickness on Some Optical Properties of Sb_2S_3 Thin Films Prepared by Chemical Bath Deposition

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Abstract:

Sb_2S_3 thin films have been prepared by chemical bath deposition on a glas sub Absorbance and transmittance spectra were recorded in the wavelength range (30-900) nm.

The effects of thickness on absorption coefficient, reflectance, refractive index, extinction coefficient, real and imaginary parts of dielectric constant were estimated. It was found that the reflectivity, absorption coefficient , extinction coefficient, real part of dielectric constant and refractive index, all these parameters decrease as the thickness increased, while the imaginary part of the dielectric constant increase as the thickness increased.

Keywords: Sb_2S_3, Thin Films, CBD, Optical Properties.

Introduction:

Antimony trisulfide which desorbed as a chalcogenide material has attracted much attention due its unique properties such as high absorption coefficient, optimum band gap (E_g = 1.8 eV) [1], high refractive index [2], well-defined quantum size effects [3,4], this material exhibit structural modification when irradiated by light and by an electron beam [5, 6], their photosensitive and thermoelectric properties [7].

Therefore it is worthy to pay more attention to antimony trisulfide as a very promising material for industrial application which could be used in a potential material for applications in photovoltaic structures [8,9], optical data storage devices [10], electronic devices specially in photo conductive targets for the vidicon type of the television camera tubes [11], solar cells [12], rechargeable storage cell [13], resonant laser cavity [14]. Sb_2S_3 has been synthesized by various methods including chemical deposition method [15], thermal evaporation [16], radio frequency sputtering [17] and chemical bath deposition [18]. From the methods used for the preparation of Sb_2S_3 thin films, the chemical bath deposition method is often preferred because it offers large possibilities to modify the deposition condition so as to obtain films with good structure and physical properties. So the aim of this work is to prepare thin of Sb_2S_3 utilizing chemical bath deposition in order to study the effect of film thickness on some optical parameters of Sb_2S_3.

Material and Methods:

Antimony trisulfide thin films with different thicknesses were deposited on glass substrate using chemical bath deposition technique.

11.5 g of $SbCl_3$ was dissolved in 50 ml acetone of this solution were placed in 50 ml beaker to which 12 ml of 1M $Na_2S_2O_3$ and 33 ml of deionised water. The resulting solution was stirred for 3 minutes, the PH of the bath was

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measured at 3.5. the glass substrate were using a neutral detergent and then dried well using warm air two substrates were attached to each other and placed vertically in the beaker. This process was repeated for different dip time in order to obtain films with different thicknesses ranging from (1-5) hours, the films thickness were (0.1, 0.3, 0.4) αm .

The chemical reaction for this solution could be written as:

$$SbCl_3 + Na_2S_2O_3 \rightarrow Sb_2(S_2O_3)_3 + 6NaC$$

$$Sb_2(S_2O_3)_3 \rightarrow 2Sb^{+3} + 3S_2O_3^{2-}$$

$$Sb_2(S_2O_3)_3 \rightarrow SO_4^{2-} + S^{2-} + 2H^{+}$$

The antimony ions, together with the sulphide ions produced in the bath, condense at the substrate surface forming Sb_2S_3 Thin Film absorbance and transmittance spectra were recorded in the wavelength range (300-900) nm using UV/VIS double beam schimadzu 160 Å spectrophotometer (Japan).

Results and discussions

Fig. (1) Presents the reflectance (R) in the wavelength range (300-900) nm for different thickness of Sb_2S_3 thin films, with increasing films thickness the reflectance decrease from an average of 0.2 to less than 0.1.

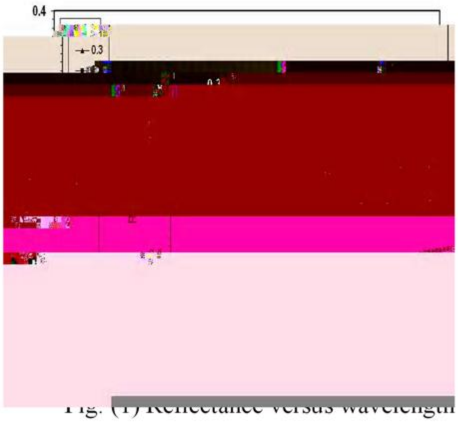

Fig. (1) Reflectance versus wavelength

for the as deposited films.

Since the reflectivity was insignificant near the absorption edge, so the following relation could be use for calculation the absorption edge, so the following relation could be use for calculating the absorption coefficient (α) [19]:

$$\alpha = \frac{2.303A}{t} \quad \ldots(1)$$

Where (A) is the absorption and (k) the film thickness.

Fig. (2) shows the dependence of □ on photon energy, the absorption edge shift toward lower wavelength range (blue shift). The shift in the absorption edge may be attributed to the difference in grain size [20] and /or carrier concentration [21].

The refractive index (n) of the Sb_2S_3 thin films were calculated by the following relation [22]:

$$n = \frac{(1+R)}{(1-R)} + \sqrt{\frac{4R}{(1-R)^2} - K^2} \quad \ldots(2)$$

Where (n) is the refractive index and (k) is extinction coefficient and was calculated using the relation [23]:

$$k = \frac{\alpha\,\lambda}{4\,\pi} \quad \ldots(3)$$

Where α is the absorption coefficient and (λ) is the incident wavelength.

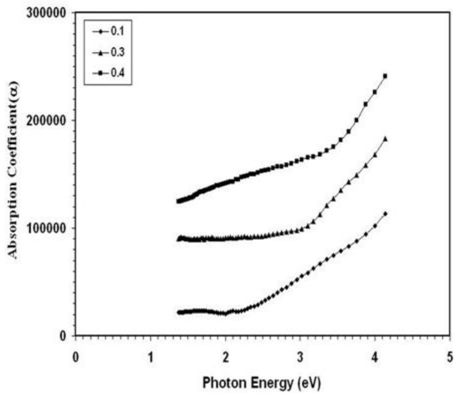

Fig. (2) Absorption coefficient versus photon energy for the as deposited films.

From Fig. (3) on can easily obtain the extinction coefficient of Sb_2S_3 with different thicknesses it can be seen that the extinction coefficient increases as the thickness increase.

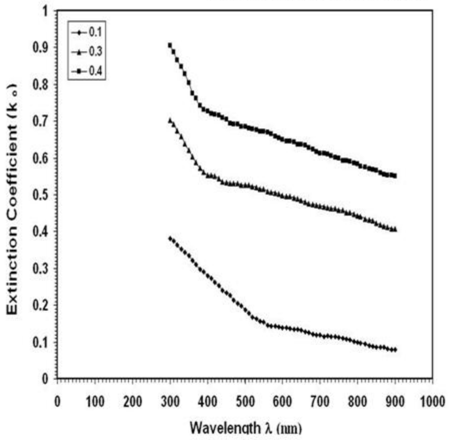

Fig. (3) Extinction coefficient versus wavelength for the as deposited films.

Fig. (4) Shows the dependence of the refractive index of Sb_2S_3 on wavelength, it can bee seen that refractive index decreases as the thickness increased. The variation of the optical constants of the films can be correlated with their structure characteristic , the decrease of n and increase of k may be due improvement of stoichiometry [24], the increase in grain size and the decrease is micro strain , this behavior of the refractive index and extinction coefficient with wavelength is in good agreements with studies reported by de Araújo, et al. [25], Rajpure and Bhosale [26], El Zawawi et al.[27]

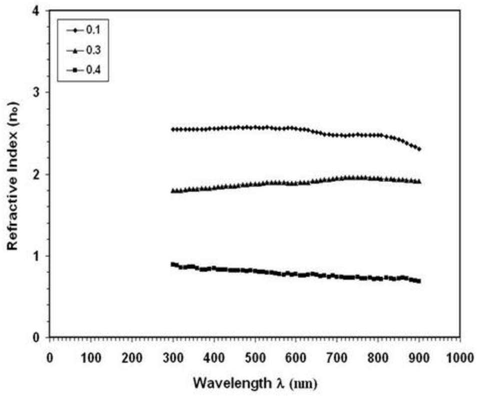

Fig. (4) Refractive indices versus wavelength for the as deposited films.

The dielectric constant (ε_T) can be defined as [28]:

$$\varepsilon_T = \varepsilon_1 - i\varepsilon_2 \qquad \ldots(4)$$

The real (ε_1) and imaginary (ε_2) parts of the dielectric constant are related to the (n) and (k) values. The (ε_1) and (ε_2) values can be calculated using the form formulas [29]:

$$\varepsilon_1 = n^2 - k^2 \qquad \ldots(5)$$

$$\varepsilon_2 = 2nk \qquad \ldots(6)$$

Fig. (5) and Fig. (6) Presents the dependence of the real dielectric constant of the Sb2S3 thin film on wavelength, it is clearly seen from the fig that both real and imaginary parts decreased as the thickness increase.

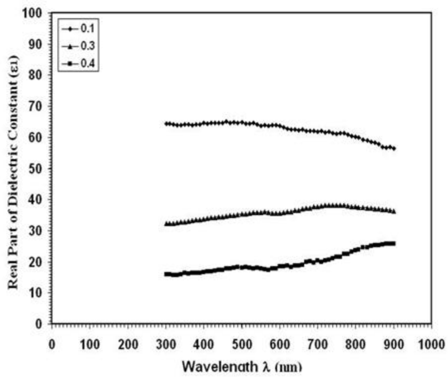

Fig. (5) Real part versus wavelength

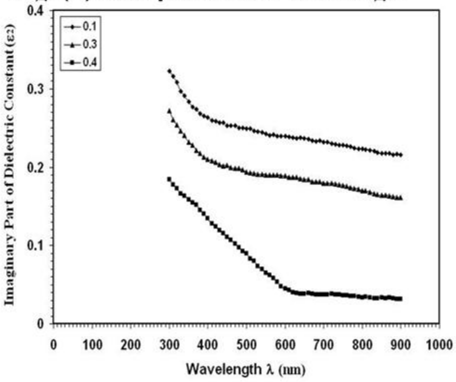

Fig. (6) Imaginary part versus wavelength for the as deposited films.

Conclusions:

1- Chemical bath deposition proved to be a featured technique to prepare Sb_2S_3.

2- The value of the absorption coefficient increases slowly at long wavelengths where as it increases rapidly at low wavelength region, this behavior supports the assumption of using these thin films as antireflection coatings in the long wavelength region, while they are used for fabrication light emitting diode in the second region.

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تأثير السمك على بعض الخصائص البصرية لأغشية كبريتيد الانتمون المحضرة بالترسيب بالحمام الكيميائي

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الخلاصة:

حضرت أغشية رقيقة من كبريتيد الانتمون بالترسيب بالحمام الكيميائي على قواعد زجاجية.
سجل طيفي الامتصاصية والنفاذية لمدى الطول الموجي nm (900-300).
تم دراسة تأثير السمك على معامل الامتصاص، الانعكاسية، معامل الانكسار، معامل الخمود، ثابت العزل الكهربائي بجزئيه الحقيقي والخيالي.لقد وجد بان الانعكاسية ، معامل الامتصاص، الجزء الحقيقي من ثابت العزل الكهربائي ومعامل الانكسار ، تقل بزيادة السمك بينما ثابت العزل الخيالي يزداد.