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Optical characteristics of crystalline antimony sulphide (Sb_2S_3) thin film

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Abstract

This paper presents the important optical characteristics of crystalline Sb_2S_3 film deposited on glass substrate using solution growth technique at 300k. These characteristics were analyzed using PYEUNICAM SP8-100 spectrophotometer in the range of UV-VIS-NIR while the morphology and the structural composition were analyzed using (metallurgical Microscope OLYMPUS BH-2 and Camera) and XRD respectively. The band gap was obtained from the plotted graph of absorption co-efficient against the photon energy. The optical characteristics of the film were manifested on the graphs of the absorbance and transmittance against wave- length.

Keywords
Optical characteristics, absorbance, transmittance, absorption-coefficient, thing film, reflectance.

1.0 Introduction

Thin films of various types are being developed using different approaches for use in optics, microelectronics, converting solar radiation into electricity etc. The analysis of the thin film helps to reveal the best way it can be utilized. Therefore the analysis carried out on these thin films was to investigate the optical properties within the range of UV, visible and near infrared (NIR) [1]. The manner in which radiation propagates through the thin film is strongly determined by the dielectric properties of the film, which is related to the refractive index and the band gap [2].

These properties on the other hand play some roles in the absorbance, transmittance and reflectance characteristics of thin film. Antimony sulphide (Sb_2S_3), a binary compound that contains Antimony and sulphide is of interest to be studied, owing to its behaviour when (UV), visible radiation and near infrared radiation pass through it [9]. Owing to such property, binary based thin- films compounds have been studied in the II-VI compounds such as ZnSe or ZnS [3 and 4] and are found to be very useful.

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Oxide-sulphide thin film materials with the some hexagonal structure like ZnO, and BeO have a wide band gap of E_g =3.85eV [5 and 6]. If the band gap of any film is wide or indirect the energy of the photons will be too weak to cause any absorption in such a material film and hence would be ineffective in converting the photon distribution to a narrow distribution. Certainly, it is only when the photon energy is greater than the band gap of the film material that it would be absorbed. Photons of longer wavelength will just pass through (i.e. transmitted) having only sufficient energy to excite electrons [2 and 7]

In this paper, the authors grew the Sb_2S_3 using solution growth technique (SGT) at the temperature of 300*k* and the optical properties of the film was investigated. The *X*-ray diffraction (XRD) analysis was carried out and the band gap was determined.

2.0 Experimental detail

Sb_2S_3 was grown on glass substrate using the method of solution growth. The substrate was prepared by dipping it into concentrated HCl for about 24 hours in order to degrease it and thoroughly washed using detergent solution with soft rubber sponge and dried in air. The film was deposited using antimony chloride (Sb_2Cl_3) dissolved in 5.0*ml* acetone, 12*ml* of 1.0*mol* of sodium thioslphate and 33*ml* of distilled water added to it make up the solution.

These preparations were poured into 50ml reaction beaker and stirred with glass rod stirrer for few minutes. Later the substrate was clamped vertically with a synthetic foam cover and gently inserted in the reaction bath. The process was repeated for different dip time with different concentration of the reaction bath. Dip time for 5 hours and 12 hours were produced and denoted A_1 and C_3 respectively. The metallurgical Microscope OLYMPUS BH-2 and Camera were used to examine the micrographs of the samples at magnification of X1000 to obtain the morphology of the thin film The optical properties such as percentage transmittance and the absorbance were measured using PYEUNICAM SP8-100 spectrophotometer. The structural patterns of the film were obtained using XRD. The work carried out at the Engineering and Material Development Institute EMID Akure.

The dielectric constant and absorption co-efficient are related theoretically by.

$$\varepsilon_r = n^2 - \kappa^2 \qquad (2.1)$$

$$\varepsilon_r = 2n\kappa \qquad (2.2)$$

where ε_r is real part of the dielectric constant n is the refractive index of the material thin film and *k* is the extinction co-efficient given by

$$\kappa = \alpha\lambda / 4\pi \qquad (2.3)$$

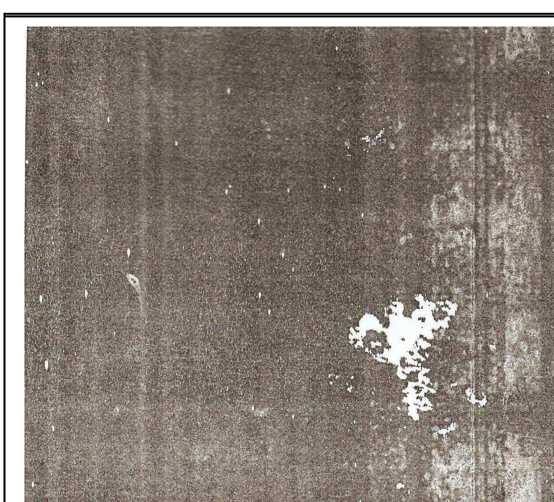
where α is the absorption co-efficient and λ is the wavelength.
The band gap is related to the absorption co-efficient through the equation

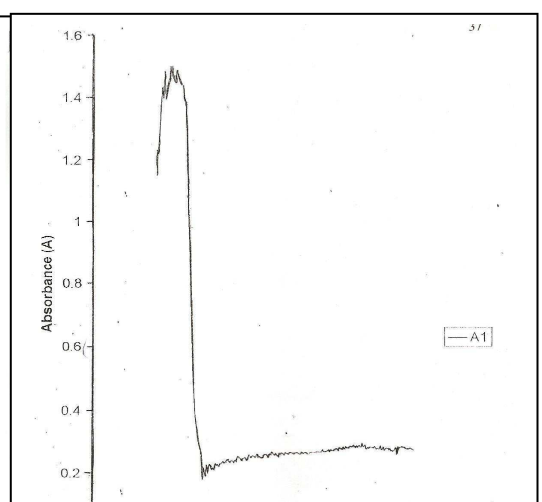
$$(\alpha h\upsilon)^2 = h\upsilon - E_g \qquad (2.4)$$

where (αhv) is the absorption factor, hv is photon energy and E_g is the band gap.

3.0 Result and discussion

The morphology of the film is shown in figure 3.1 as measured with the metallurgical Microscope OLYMPUS BH-2 and Camera. Figures 3.2 and 3.3 present the XRD spectra of the Sb_2Se layer grown under annealed condition at 300k. The patterns of the films for the number of dips did not show any abnormal peak. The peaks were seen to be almost uniform in intensity, which is an indication that the structure and the composition of the film in this work





1.6
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1
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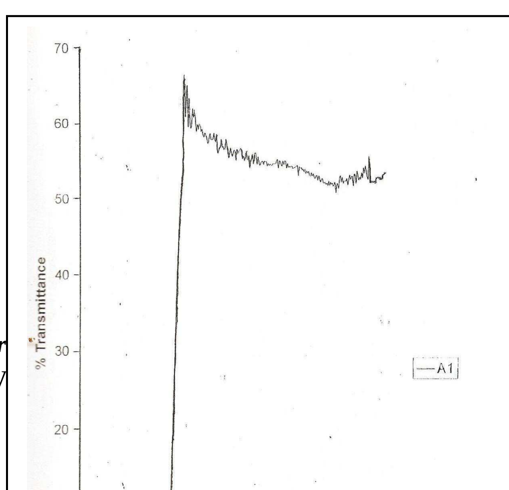

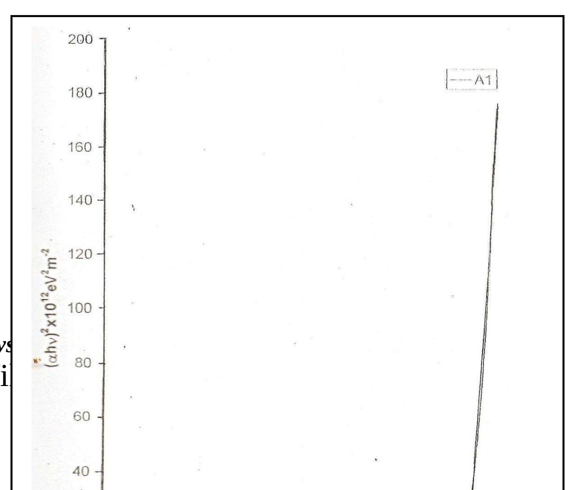

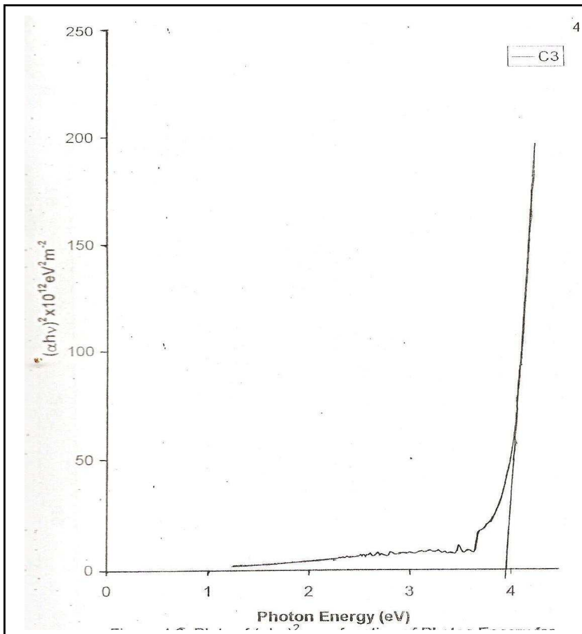

Figure 3.9: Absorption coefficient against photon energy (C_3)

is uniform. Figures 3.3 and 3.4 show the absorption characteristics of the film for A_1 and C_3 indicating high absorbance of the radiation at the UV from 0 - 25Onm and relatively low absorbance at visible and near infrared.

It is interesting to observe from figures 3.5, 3.6 and 3.7 that the percentage transmittance for the film is low for UV and high for visible and {NIR] while figures 3.8 and 3.9 present the graphs of absorption factor and photon energy. The band gap is obtained by extrapolating the graphs to intercept the photon energy axis at $(\alpha hv)^2 = 0$.

From the value of the band gap, this is observed to be narrow, direct and the value given as 3.9 *eV*. It is considered to have a high efficiency response to visible light [10, 11 and 12].

The low percentage absorbance of film at visible and NIR radiation range is a typical indication that it has a wide band gap and such may not be good to be used as solar cell, but rather as [LED] light emitting diode since the absorption is high within ultraviolet range. [5,8]. On the other hand, the percentage transmittance of the film ranges between 55% to 69% and as such can be used as selective surface for transmitting radiation for visible and near infrared.

4.0 Conclusion

In this work, we have successfully developed Sb_2S_3 thin film by method of solution growth technique (SGT) at temperature 300k on glass substrate. From the measurement obtained, the film developed, was characterized to be a good transmitter of radiation within the visible and NIR and a good absorber of UV. The XDR analysis carried out at glazing angle of 20^o showed that the film is uniform and has wide band gap of 4.0*eV*. These findings suggest that other deposition methods may be used to examine the interesting behaviour of the film and that ternary compound of this film be developed to see if the UV (LED) characteristics and the selective surface transmittance may be improved upon.

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