Global Journal of Science Frontier Research
Physics & Space Science
Volume 12 Issue 2 Version 1.0 February 2012
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Optical, Structural and Morphological Studies of Chemical Bath Deposited Antimony Sulphide Thin Film

By M.D. Jeroh & D.N. Okoli
Nnamdi Azikiwe University, Anambra State, Nigeria

Abstract - Thin films of antimony sulphide were successfully deposited on glass substrates by chemical bath deposition technique. Morphological studies and structural analysis were performed by scanning electron microscopy (SEM) and x-ray diffraction (XRD) respectively. Optical characterization was done using an AVASPEC - 2048 UV - VIS - NIR spectrophoto - meter in the wavelength range of 200-900nm. Optical studies reveal a direct band gap of about 1.6eV. The thickness of the film was calculated from surface profile analysis and estimated at about 0.7μm.

Keywords : Thin films, antimony sulphide, chemical bath deposition, scanning electron microscopy, x-ray diffraction, band gap, optical studies, morphological studies, structural analysis.

GJSFR-A Classification: FOR Code: 020501

OPTICAL, STRUCTURAL AND MORPHOLOGICAL STUDIES OF CHEMICAL BATH DEPOSITED ANTIMONY SULPHIDE THIN FILM

Optical, Structural and Morphological Studies of Chemical Bath Deposited Antimony Sulphide Thin Film

M.D. Jeroh[α] & D.N. Okoli[σ]

Abstract - Thin films of antimony sulphide were successfully deposited on glass substrates by chemical bath deposition technique. Morphological studies and structural analysis were performed by scanning electron microscopy **(SEM)** and x-ray diffraction **(XRD)** respectively. Optical characterization was done using an **AVASPEC-2048 UV-VIS-NIR** spectrophoto - meter in the wavelength range of 200-900nm. Optical studies reveal a direct band gap of about **1.6eV**. The thickness of the film was calculated from surface profile analysis and estimated at about 0.7μm.

Keywords : Thin films, antimony sulphide, chemical bath deposition, scanning electron microscopy, x-ray diffraction, band gap, optical studies, morphological studies, structural analysis.

I. Introduction

Over the years, semiconductors have gained wide usage in fabricating electronic devices. Although, silicon-based technology is by far the most advanced amongst semiconductor technology, there has been an increasing interest in the use of compound semiconductors such as GaAs, ZnO, CdTe, etc which possesses electrical and optical properties that are absent in silicon. This fact has led to increased study of binary semiconductors in the last ten years for their possible applications in electronic and photovoltaic devices respectively. Sb_2S_3 is a binary metal chalcogenide compound which can be used as target material for television cameras and as an absorber material for photovoltaic applications such as solar cells. The properties exhibited by Sb_2S_3 makes it suitable for thin film deposition.

Several techniques such as chemical bath deposition (Asogwa, P.U., 2010, Maghraoui, H.M., et al, 2010, Srikanth, S., et al, 2011), vacuum evaporation (Tigau, N., et al, 2010, Aousgi, F. and Kanzari, M., 2011), spray pyrolysis (Srikanth, S., et al, 2010) have previously been used to deposit antimony sulphide thin films.

In this research, thin films of Sb_2S_3 were deposited on glass substrates by chemical bath deposition technique. Transmittance and reflectance measurements were obtained using an AVASPEC-2048 UV-VIS-NIR spectrophotometer in the wavelength range of 200-900nm. The structural and morphological studies of the film were done by XRD and SEM respectively. All measurements were made at room temperature.

II. Experimental Details

a) Materials and Methods

All the chemicals used for the deposition process were analytical grade. They were obtained from BDH chemicals Ltd, Poole, England.

For the first time, 5ml of 1M of $SbCl_3$, 2ml of TEA, 5ml of 1M of $Na_2S_2O_3$ and 38ml of distilled water were put into a 50ml beaker in that order. Four experimental setup were made in which deposition time was varied at 12hrs, 24hrs, 36hrs and 48hrs respectively. Clean microslides were inserted vertically into each of the experimental setup and left undisturbed until the appropriate deposition time was reached. After deposition, the coated glass substrates were removed, washed well with distilled water and allowed to dry in open air for 2hrs. After drying, they were placed in an air-tight box to avoid contact with air and kept for further characterization. It is pertinent to state here that only the film deposited at 24hr dip time was used for the analysis of the result presented in this research.

III. Results And Discussions

a) Structural Characterization

The structural property of the Sb_2S_3 thin film was investigated by means of x-ray diffraction (XRD) using an X'PERT PRO MPD diffractometer with CuKα radiation (λ = 1.54060Å). The accelerating voltage and current were respectively 40KV and 30mA. The Sb_2S_3 thin film was scanned continuously between 0° and 80° at a step size of 0.004 and at a time per step of 3.175secs.

A typical XRD pattern for the as-deposited Sb_2S_3 thin film is shown in fig. 1. From the figure, sharp diffraction lines are not observed for the film, indicating that the Sb_2S_3 thin film deposited at room temperature has an amorphous nature. The findings presented in this research are in agreement with previous reports (Tigau, N., et al, 2010) on this material.

Author [α σ] *: Dept. of Physics/Industrial Physics, Nnamdi Azikiwe University, P.M.B. 5025, Awka, Anambra State, Nigeria.*

Global Journal of Science Frontier Research (A) Volume XII Issue II Version I February 2012

2

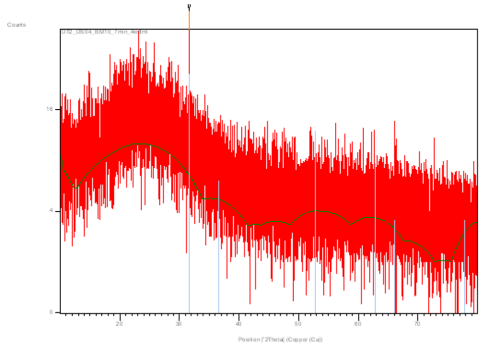

Fig. 1: Typical XRD pattern of as-deposited Sb_2S_3 thin film.

b) Morphological Studies

The surface micrograph of the film was obtained by scanning electron microscope at a magnification of 5.00KX. The surface micrograph of the as-deposited Sb_2S_3 thin film is displayed in fig. 2. The surface micrograph of the film appears to be smooth, dense and homogeneous with large spheres irregularly distributed over the surface of the film, indicating the amorphous nature of the film. This result is confirmed from XRD pattern of the grown film.

The thickness of the film was estimated to be 0.7μm from the lower part of the Data XY chart from surface profile analysis. This is shown in fig. 3.

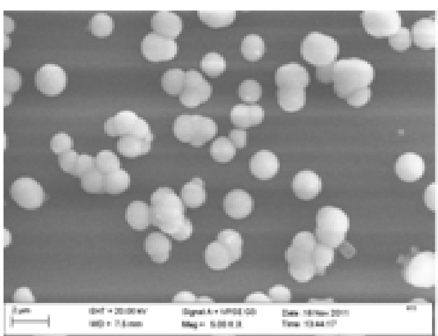

Fig. 2 : SEM micrograph of Sb_2S_3 thin film.

Fig. 3 : Surface profile analysis of the Sb_2S_3 thin film.

c) Optical Studies

The transmittance (T%) and reflectance (R%) spectra of the film were recorded on an AVASPEC-2048 UV-VIS-NIR spectrophotometer in the wavelength range of 200-900nm with an uncoated glass substrate as a reference frame.

Fig. 4 displays the spectra transmission of the Sb_2S_3 thin film deposited at room temperature. The sample show poor transmission of solar radiation which is an indication of high absorbance of solar radiation by the film. This is in agreement with the result previously reported by Ezema, F.I., et al, (2009) for as-deposited Sb_2S_3 thin film grown by chemical bath deposition technique. Fig. 4 is displayed below.

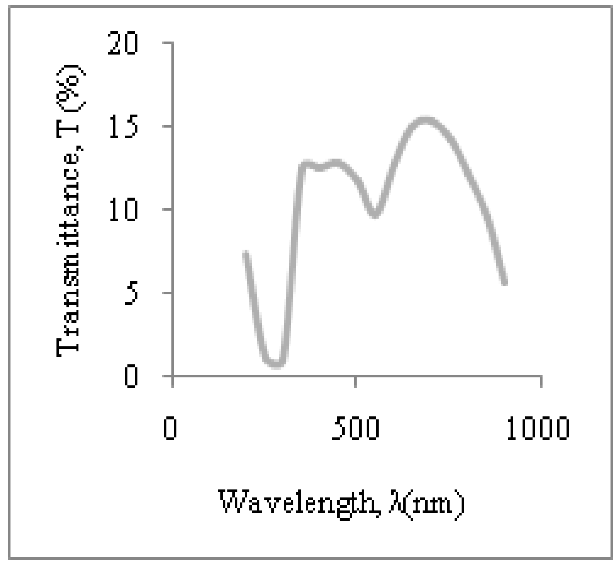

Fig. 4 : Transmittance curve for as-deposited Sb_2S_3 thin *film*

A close observation of the transmittance curve shows that the film exhibited interference pattern. This is due to optical interference which arises as a result of differences in refractive index of the thin film and glass substrate used. A similar result has been reported by Tigau, N., et al, 2010.

Fig. 5 shows the spectra reflectance of the Sb_2S_3 thin film.

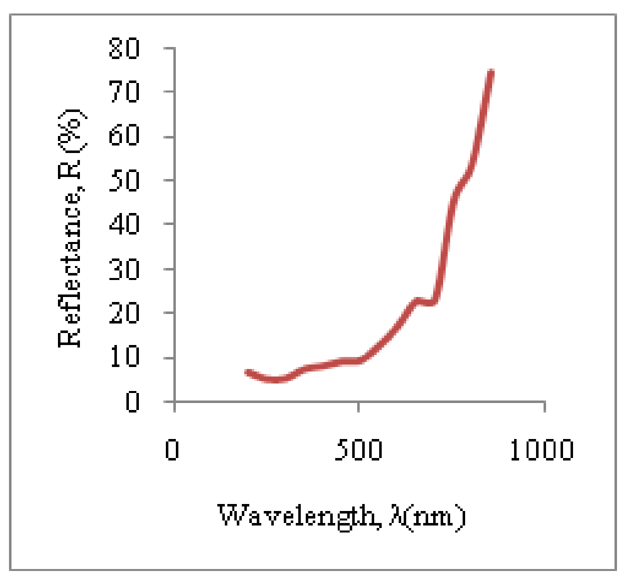

Fig. 5 : Reflectance curve of Sb_2S_3 thin film.

From fig. 5, it is observed that the reflectance of the sample show a gradual increase as wavelength increases. The sample show high reflectance of about 74% in the IR region of the electromagnetic spectrum. The high reflectance exhibited by this material makes it useful in manufacturing highly reflectance mirrors commonly found in desktop scanners, photocopy machines, astronomical telescope, car head lamps and halogen lamps.

The absorbance of the film was calculated from transmittance and reflectance values using the expression:

$$A + T + R = 1,$$

So that,
$$A = 1 - (T + R)$$

The absorbance curve for the Sb_2S_3 thin film is displayed in fig. 6. The absorbance curve decreases with increasing wavelength. The sample shows high absorbance of solar radiation above 60% in the wavelength range of 200-700nm, corresponding to the UV-VIS region of the electromagnetic spectrum with the highest absorption of about 85.8% at a wavelength of 200nm. The high absorbance exhibited by this material makes it a potential absorber in devices for photovoltaic conversion of solar energy.

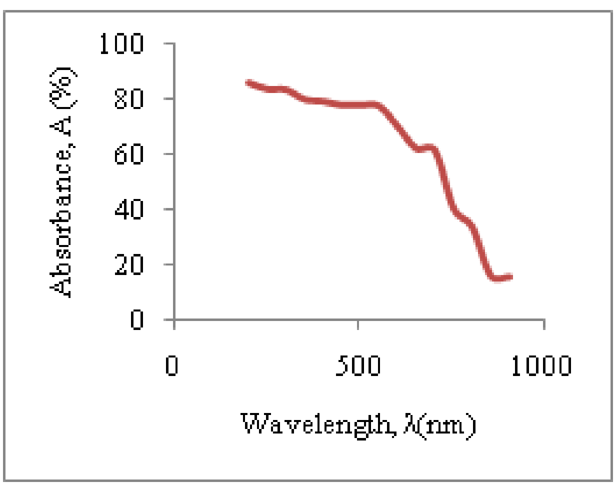

Fig. 6 : Absorbance curve for as-deposited Sb_2S_3 thin *film.*

d) Band Gap Analysis

The absorption coefficient was calculated from transmittance values using the relation:

$$\alpha = -\frac{[\ In\ T\ ]}{t}$$

where, α is absorption coefficient, T is transmittance and t is the thickness of the film.

Absorption coefficient, α, and photon energy, $h\upsilon$, are related by the expression:

$$(\alpha h\upsilon) = B(h\upsilon - E_g)^{n/2},$$

where   is a constant, n is a number that characterizes the transition process and is theoretically equal to 1 and 4 for direct and indirect transitions respectively, E_g is the optical band gap of the material.

The direct band gap of the as-deposited Sb_2S_3 thin film was obtained from the plot of $(\alpha h\upsilon)^2$ versus the photon energy, $h\upsilon$ and extrapolating the linear portion of the curve to the point on the horizontal axis where $(\alpha h\upsilon)^2 = 0$ as shown in fig. 7. The direct band gap for this material was found to be about 1.6eV.

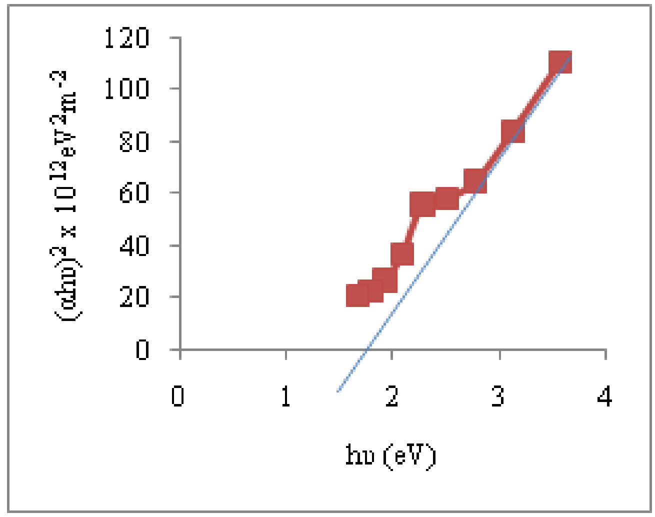

Fig. 7 : Plot of $(\alpha h\upsilon)^2$ versus $h\upsilon$ for Sb_2S_3 thin film.

Manolache, S.A., et al, (2007) previously reported that one of the requirements for an ideal absorber solar cell material is that it must have a direct band gap in the range of 0.7-2.0eV. Since the value (1.6eV) obtained in this research fall within this range (0.7eV to 2.0eV), we therefore propose a high efficiency solid state solar cell (SSSC) using antimony sulphide as an absorber material for the photovoltaic conversion of solar energy.

IV. Conclusion

Antimony sulphide thin film was successfully deposited on glass substrate at room temperature and characterized accordingly.

Optical studies conducted on the film show that the film has relatively high absorbance and reflectance, poor transmittance of solar radiation. A direct band gap of 1.6eV was obtained for the as-deposited film in this research. SEM and XRD measurements conducted on the sample confirm the amorphous nature of the Sb_2S_3 thin film grown at room temperature.

V. Acknowledgement

The authors are grateful to the management of Sheda Science and Technology Complex (SHESTCO), FCT, Abuja, Nigeria especially the deputy director of advanced physics laboratory, Dr. M.G. Zebaze-Kana for allowing us have access to the equipments used for characterizing the film.

References Références Referencias

1. Aousgi, F., Kanzari, M. (2011): Structural and Optical Properties of Amorphous Sb_2S_3 Thin Films Deposited by Vacuum Thermal Evaporation Mathod. First Euro-Mediterranean Conference on Materials Science and Renewable Energies (EMCMRE-1), Morrocco. 21-25 November, 2011
2. Asogwa, P.U. (2010): Properties of Nanostructured Sb_2S_3-TIs Thin Film Deposited By Chemical Bath Technique. Glo. J. of Sci. Front. Res. Vol. 10, Issue 3 (Ver. 1.0) pp 9-12.
3. Ezema, F.I., Ezugwu, S.C., Asogwa, P.U., Ekwealor, A.B.C. (2009): Solid State Properties and Structural Characterization of Sb_2S_3 and TI_2S Thin Film. J. of Ovo. Res., 5(5) pp 145-156.
4. Maghraoui, H.M., Nasr, T.B., Kamoun, N., Dachraoui, M. (2010): Phys. B 405, pp 3101-3105.
5. Manolache, S.A., Andronic, L., Duta, A., Enesca, A. (2007): The Influence of The Deposition Condition on Crystal Growth and on The Band Gap of $CuSbS_2$ Thin Film Absorber Used For Solid State Solar Cells (SSSC). J. of Optoelectr. and Adv. Mater. 9(5), pp 1269-1272.
6. Srikanth, S., Suriyanarayanan, N., Prabahar, S., Balasubramanian, V., Kathirvel, D. (2011): Structural and Optical Properties of Chemical Bath Deposited Sb_2S_3 Thin Films. Advs. in Appl. Sci. Res, 2(1), pp 95-104.
7. Srikanth, S., Suriyanarayanan, N., Prabahar, S., Balasubramanian, V., Kathirvel, D. (2010): Photoluminescence Studies on Sb_2S_3 Thin Films Prepared By Vacuum Evaporation and Spray Pyrolysis Technique. J. of Optoelectr. and Adv. Mater.-Rap. Comm. 4(12), pp 2057-2058.
8. Tigau, N., Simona, C.B., Romana, D. (2010): Investigation of Optical Properties of Sb_2S_3 Thin Films. J. of Sci. and Arts, yr 10, 2(13), pp 361-364.