OPTICAL PROPERTIES OF A THIN LAYER OF ANTIMONY SELENIDE USING CHEMICAL BATH DEPOSITION METHOD.

ABSTRACT

In this study antimony selenide thin films were prepared using chemical bath deposition method. The varied parameters were concentration of Ethylenediaminetetra-acetic acid (EDTA), and Ammonium solution (NH_3) at constant time. The optical properties of the thin film were studied using a UV- spectrophotometer within the range of 300-1100nm. Result showed that the thin films have very low absorbance. Transmittance was generally high reaching 94%. A low reflectance and an optical bandgap of 3.2 – 3.8eV was recorded.

INTRODUCTION

The development of thin film technology is a major factor responsible for the decrease in cost of photovoltaic solar cells [1]. In thin film based photovoltaic cells, active layer materials which are several micrometers thick are used compared to silicon based solar cells. These materials have a higher absorption coefficient than crystalline ones. As a result, only a very thin absorber layer is needed for sunlight absorption [2]. Antimony selenide (Sb_2Se_3) is a primary absorber material. Antimony selenide is a binary metal chalcogenide that has an absorption coefficient in the order of 10^5 cm^{-1} at short wavelength [3].The component elements Se and Sb are inexpensive and widely available on earth. Because of this, the substance is a very promising absorber material for thin film solar cells [4]. Antimony selenide is used as an optical coating in thermos photovoltaic systems, as well as in the creation of available solar cells and hall effect devices. A variety of methods, including electro deposition, SILAR, [5], pulsed laser ablation, thermal and photochemical chemical vapor deposition can be used for the preparation semi-conductor materials

Chemical bath deposition method was chosen for this research due to its low temperature, cheap cost, and non-polluting nature. This thin film preparation method is receiving a lot of interest. It is the most convenient method for large area deposition [6]. The basic principle involved in the chemical bath deposition method is the controlled precipitation of the desired compound from a solution of its constituents.

In this study, antimony selenide thin film was prepared from a solution of $SbCl_3$ and $NaHSeO_3$ as a source of Sb^{3+} and Se^{2-} ions respectively using chemical bath method. EDTA was used as complexing agent. The influence of increase in NH_3 and EDTA, as a major deposition parameter in preparing the thin film was studied. Optical characterization was carried out to determine the bandgap, transmittance, reflectance, absorbance.

1. EXPERIMENTAL METHODS

All solvents and reagents used for the thin films growth includes; Ethylenediaminetetra-acetic acid (EDTA), Ammonium solution (NH_3), Antimony trichloride ($SbCl_3$), Sodium hydrogen selenium oxide ($NaHSeO_3$) and distilled water. Apparatus used include digital meter balance, beakers, stirrer, glass substrate, microscope rack, syringes, masking tape, pen, detergents and hydrochloric acid. 0.1M of each of the reagents were prepared at room temperature. NH_3 is already in a solution form. Other masses of the reagents were obtained using a meter balance.

The method used in this research work is the chemical bath deposition technique. In order to avoid spontaneous precipitation of the reaction bath, a suitable complexing agent is added to the reaction bath to control the release of the metallic ion in the solution. Although thin films can be deposited on different kinds, shape and size of substrate [7], a microscope slide was used as the substrate in this work. The procedure on how to clean the substrate is very important in deposition of thin film [8]. The substrate on which the desired compound is to be deposited is immersed in the beaker containing the solution. The glass substrates were suspended into the chemical bath using rack holder to hold the substrate firmly with the tip not touching the bottom of the chemical bath. Dip time of 12 hours was maintained for each chemical bath. The deposited antimony selenide thin film was uniform and adhesive. Optical properties were measured using a M 501 UV –VIS spectrophotometer at normal incidence of light in the wavelength ranging from 300 - 1100nm for variation of EDTA and NH_3.

Total volume of all the solution in the chemical bath = 50ml as seen in the table below.

List 1 :VARIATION OF EDTA CONCENTRATION AT CONSTANT TIME (12HRS)

Solution	Chemical bath 1	Chemical bath 2	Chemical bath 3	Chemical bath 4
$SbCl_3$	5	5	5	5
NH_3	5	5	5	5
EDTA	2	4	6	8

$NaHSeO_3$	5	5	5	5
Distilled water	33	31	29	27

List 2 :VARIATION OF NH_3 CONCENTRATION AT CONSTANT TIME (12HRS)

Solution	Chemical bath 1	Chemical bath 2	Chemical bath 3	Chemical bath 4
($SbCl_3$)	5	5	5	5
EDTA	5	5	5	5
NH_3	2	4	6	8
($NaHSeO_3$)	5	5	5	5
Distilled water	33	31	29	27

RESULTS & DISCUSSION

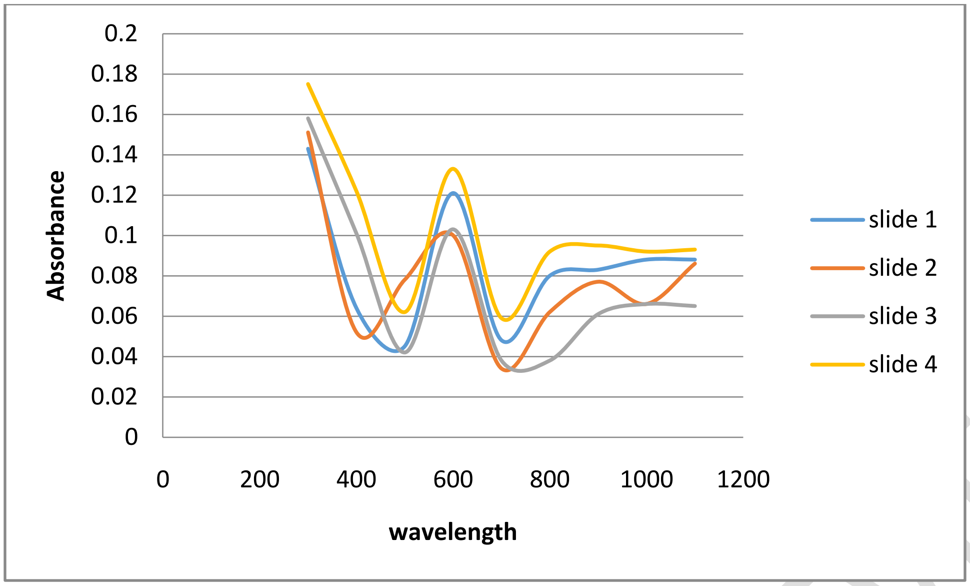

Figure 1, Plots of absorbance against wavelength for variation of EDTA concentration

From the plot of figure 1 above, it can be observed that thin films generally have a very low absorbance. Slide number 4 with 8ml concentration of EDTA has the highest absorbance of 17.5% than others. Hence the higher the concentration of EDTA, the higher the absorbance of the thin films. This observation of the thin films having a very low absorbance is likely due to their thinness, as the thickness of a material can affect its absorbance properties.

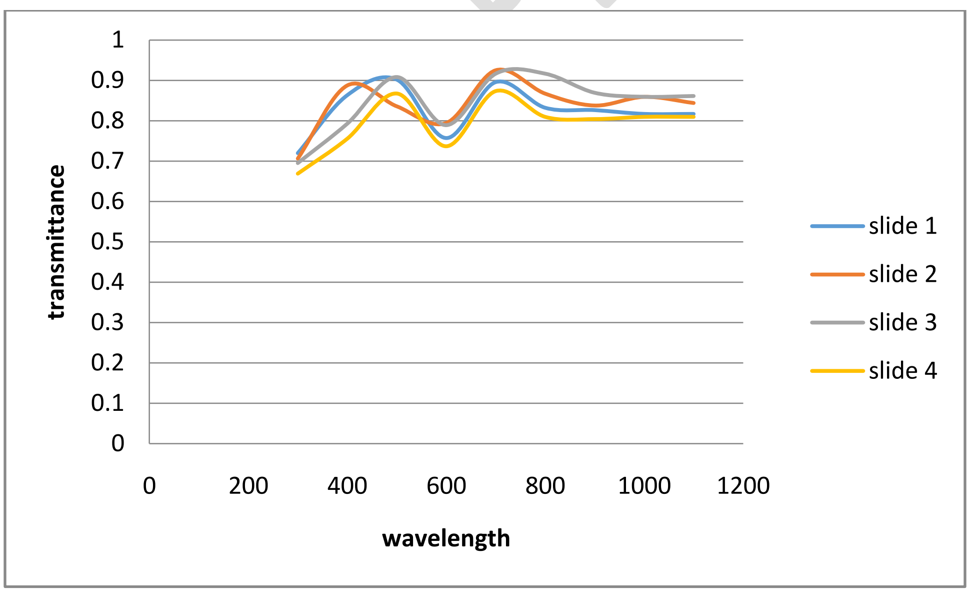

Figure 2 Plots of transmittance against wavelength for variation of EDTA concentration at constant time.

From the graph above in figure 2, it can be observed that thin films generally have a higher transmittance. Slide number 2 with 4ml concentration of EDTA has the highest transmittance of 94%. This suggests that the thin film is likely to allow more light to pass through it. Hence it can be used as a good transmitting material.

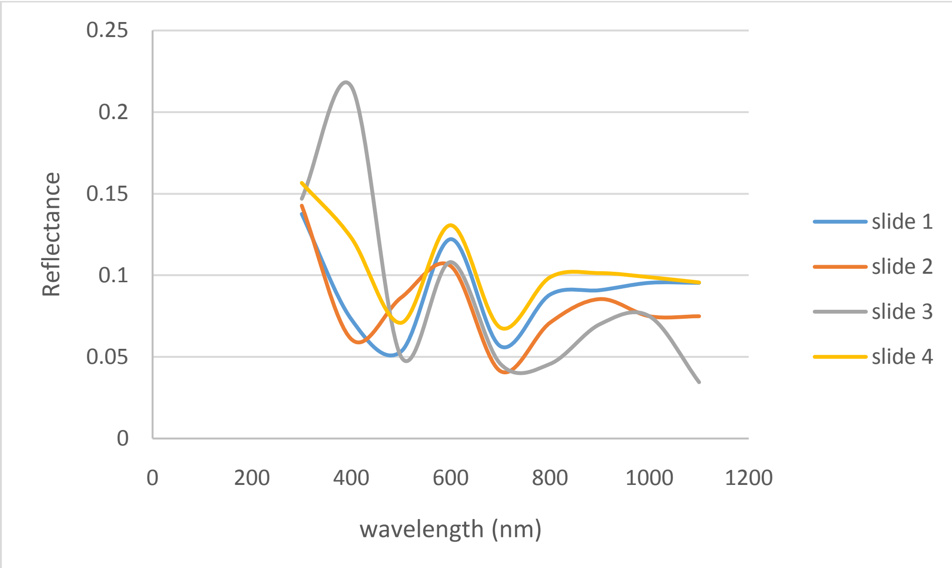

Figure 3 Plots of reflectance against wavelength for variation of EDTA concentration at constant time.

Considering the graph in figure 3 above, it can be seen that thin films have a very low reflectance. Slide number 3 has the highest reflectance of 22.6 % more than the others.

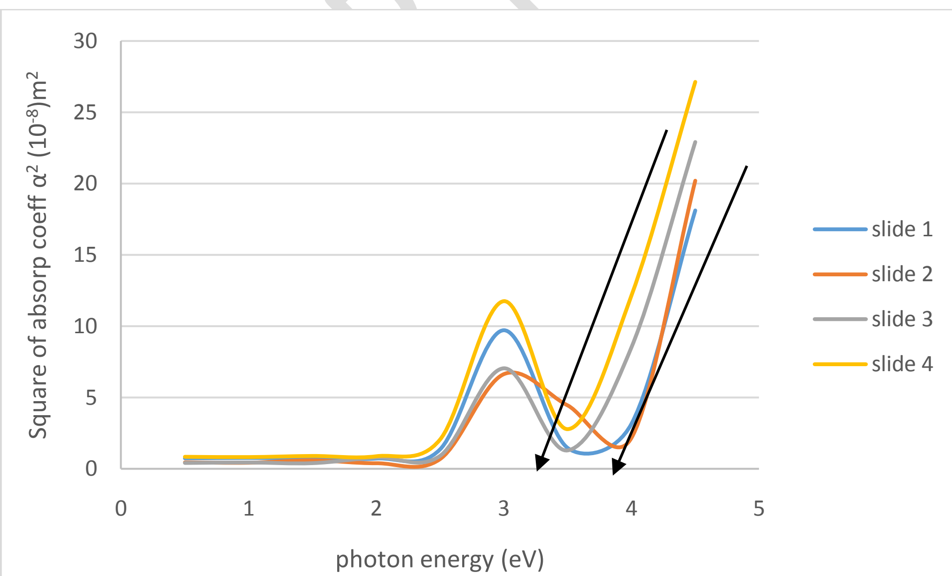

Figure 4 Plots of square of absorption coefficient against photon energy for variation of EDTA concentration at constant time.

The graph for the variation of EDTA concentration at constant timefrom the figure 4 above reveals that the band gap energy for antimony thin films was found to be within the range of 3.2 – 3.8eV. Band gap energy is an important parameter that determines the electrical and optical properties of a material. The optical band gap with direct transition can be calculated from the following relation $\alpha h\nu = A(h\nu\text{-}Eg)^{n}$ [9, 10, 11]. The value of the energy gap Eg was determined by plotting $(\alpha h\nu)^2$ versus hν and then extrapolating the straight line portion to the energy axis at $\alpha = 0$. High absorption coefficient shows it can be applied in photovoltaics cell materials.

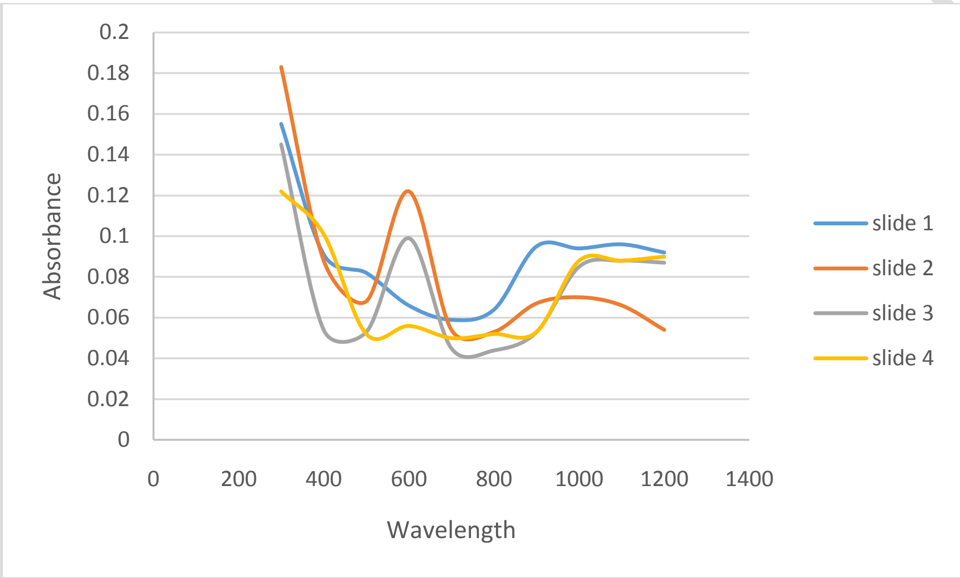

Figure 5 Plots of Absorbance against wavelength for variation of NH_3 concentration at constant time.

From the graph of figure 5 above for the variation of ammonia concentration, it wasobserved that the thin films have very low absorbance. Slide number 2 with 4ml concentration of ammonia has the highest absorbance of 18.2% more than others.

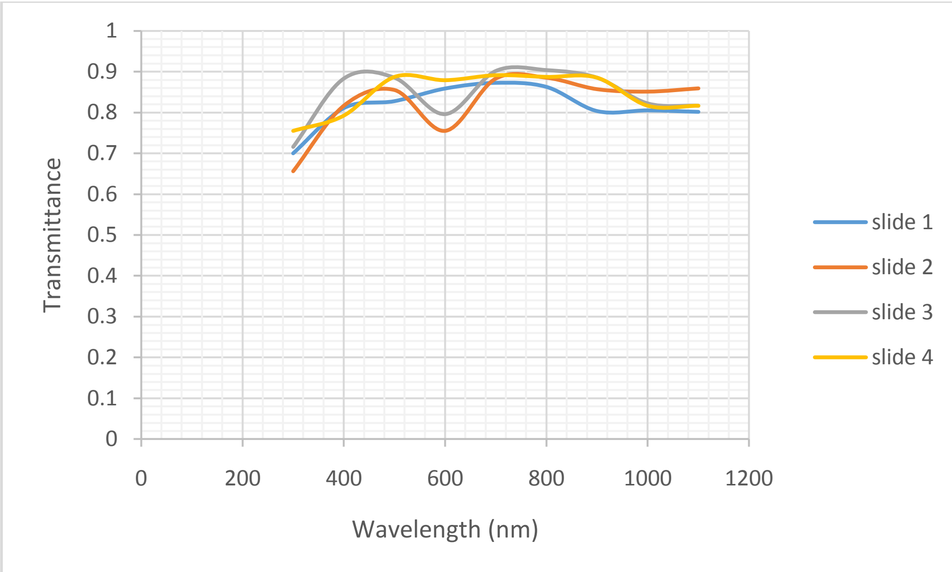

Figure 6 Plots of transmittance against wavelength for variation of NH_3 concentration at constant time

From the graph of figure 6 above, it is generally observed that thin films have a high transmittance. But slide number 3 has the highest transmittance of 91%. Hence antimony selenide can be used as a good transmittance material that could be serve in various optical applications, such as lenses, windows, and prisms.

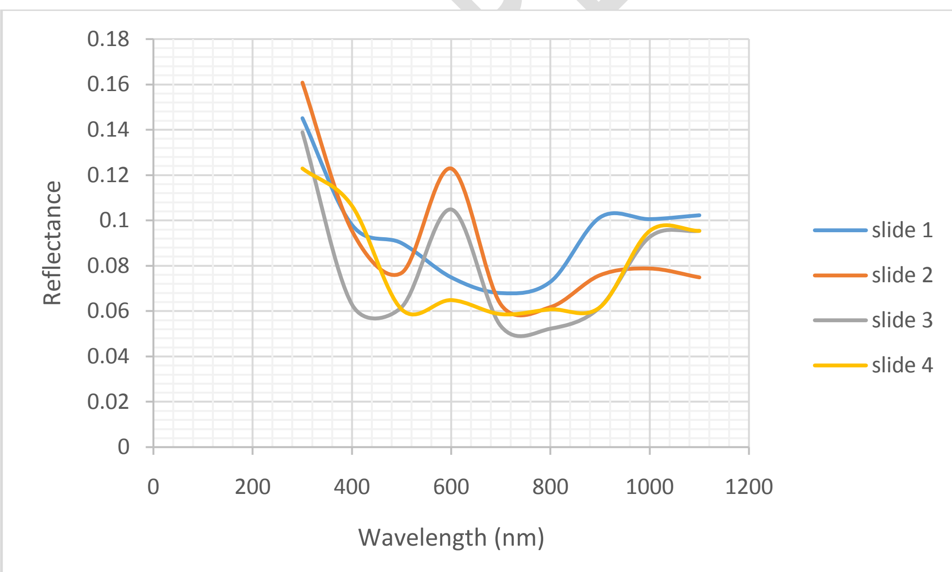

Figure 7 Plots of reflectance against wavelength for variation of NH_3 concentration at constant time.

From the chart above (figure 7), it was observed that the thin films generally have low reflectance. Slide number 1 with 2ml concentration of ammonia has the highest reflectance of 16.1% more than the others.

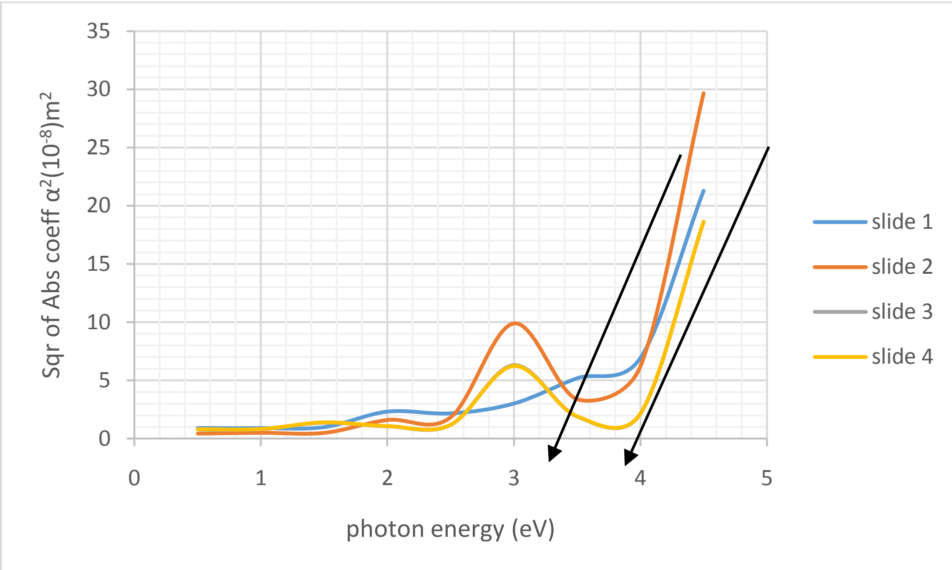

Figure 8 Plots of square of absorption coefficient against photon energy for variation of NH3 concentration at constant time.

From the above graph, the values of band gap energy for antimony thin films was found to be in the range 3.3 – 3.9eV.

CONCLUSION

The thin film of antimony selenide was successfully grown and deposited using chemical bath technique. The films had good adherence to the substrates. The optical characterization of the deposited thin films was done with M501 single beam scanning spectrophotometer. The results show that;

- Optical absorbance of antimony selenide tin film was found to be generally low at higher concentration of complexing agent EDTA. The highest value was found to be 17.5% which is too low.
- Optical transmittance of antimony selenide thin film was found to generally high with the highest value of 94%
- Optical reflectance of antimony selenide thin film was also low
- Optical band gap energy was measured at room temperature. The value of the band gap energy obtained for antimony selenide thin film was at the range of 3.3 – 3.9eV. The absorption coefficient was found to be very high which concur with its application in photovoltaics cell / solar cell.

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