*Scientific Journal of Impact Factor (SJIF): 5.71*

e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406

**International Journal of Advance Engineering and Research Development**

*International Conference on Momentous Role of Nanomaterials in Renewable Energy Devices*

*Volume 5, Special Issue 07, April-2018 (UGC Approved)*

# SYNTHESIS AND CHARACTERISATION OF ANTIMONY SELENIDE THIN FILM

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**Abstract -** *Antimony Selenide was successfully deposited on ITO substrate under optimized condition by electro deposition technique. The film is uniform and had well adherence to the substrate without any pores. As the annealing temperature increases the orientation of the crystallites is more randomized than in the as prepared film. The structural, optical and morphological properties of the film were investigated by XRD, UV-Visible PL and SEM. The XRD pattern indicates that this film was crystallized in the structure.*

***Keywords*:** *Antimony Selenide, electro deposition, SEM, UV, XRD.*

## I. INTRODUCTION

Antimony Selenide have attracted considerable attention due to their interesting properties and potential applications. Antimony Selenide ($Sb_2Se_3$) are interesting semiconductor compounds that are widely used as holographic recording systems, optical and optoelectronic materials in infrared electronic and memory switching devices and in photoelectrical cells [1]. Antimony Selenide is a interesting metal chalcogenide semiconductor materials [2]. The purpose of present study is to explore and report in detail the structural properties, optical properties and morphological properties of Antimony Selenide thin film prepared by electro deposition technique.

## II. EXPERIMENTAL PROCEDURE

Precursor solution is prepared by taking 0.5g of Antimony sulphate, 0.25g of selenium dioxide in mixed with 5 ml of distilled water. Stirring, until the powder is totally mixed to get saturated solution. The Antimony Selenide thin films were prepared by electro deposition technique. The films were grown on Indium doped Tin Oxide (ITO) substrate under optimized condition. These grown films are uniform. The color of the film is white. Well adherent with the surface. All chemicals were of AR grade. The as prepared films are annealed at 200°C for one hour.

## III. RESULTS AND DISCUSSION

### A. XRD Analysis

Figures 1. Shows the X-ray diffraction pattern of the electro deposited Antimony Selenide thin film. The XRD pattern obtained correlated well with the standard JCPDS data card file [15-0861].

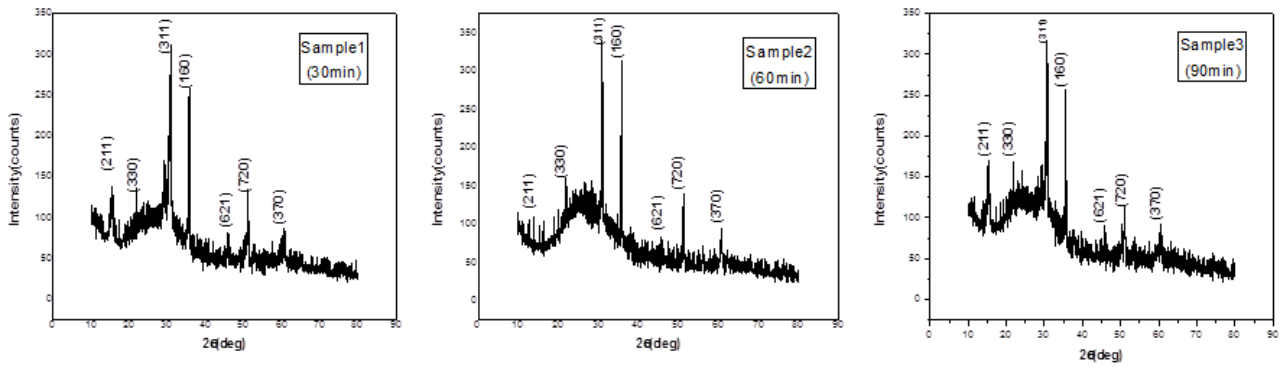

***Fig.1. XRD pattern of $Sb_2Se_3$ Thin Film***

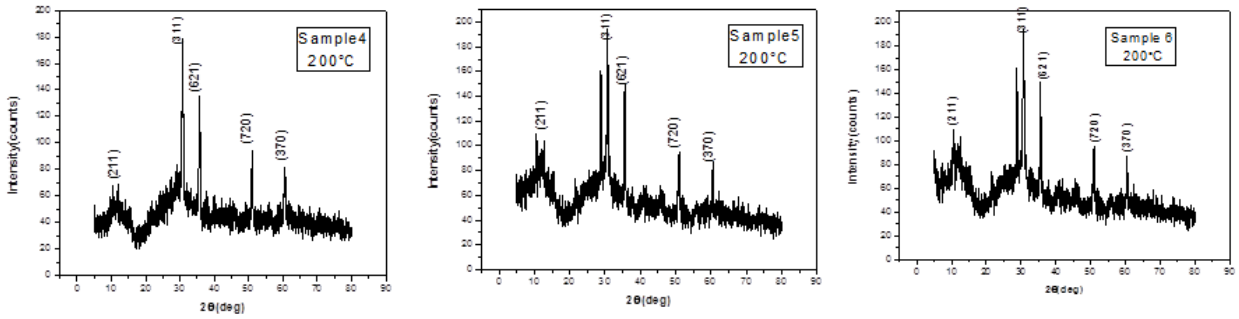


***Fig.2. XRD pattern of $Sb_2Se_3$ Thin Film (annealed at 200$^o$C)***

Crystallite size (D) was calculated using Debye-Scherrer's formula [3],

$$D = \frac{0.9*\lambda}{\beta*cos\theta}$$

Where D is the crystallite size, λ is the wavelength of the $k_\alpha$ line, β is the full width at half maxima (FWHM) in radians and θ is the Bragg's angle. The crystallite grain size increased from 76 – 94 nm as the annealing temperature increased [4]. It shows seven prominent peaks having (211) (330) (311) (160) (621) (720) (370). It forms orthorhombic structure with value of a =11.63 A°, b = 11.78A°, c = 3.98 A°. The XRD pattern of samples annealed at 200°C (4, 5, 6) are shown in the Fig .2 The XRD pattern reveals the presence of $Sb_2Se_3$.The observed peak for $Sb_2Se_3$ are in good agreement with the JCPDS data card file [(72-1184)], shows Five prominent peaks having (2 1 1) (3 1 1) (6 2 1) (7 2 0) (3 7 0). It forms orthorhombic structure with value of a =11.62 A°, b = 11.77A°, c = 3.96 A°.

**B. Morphological studies and compositional analysis**

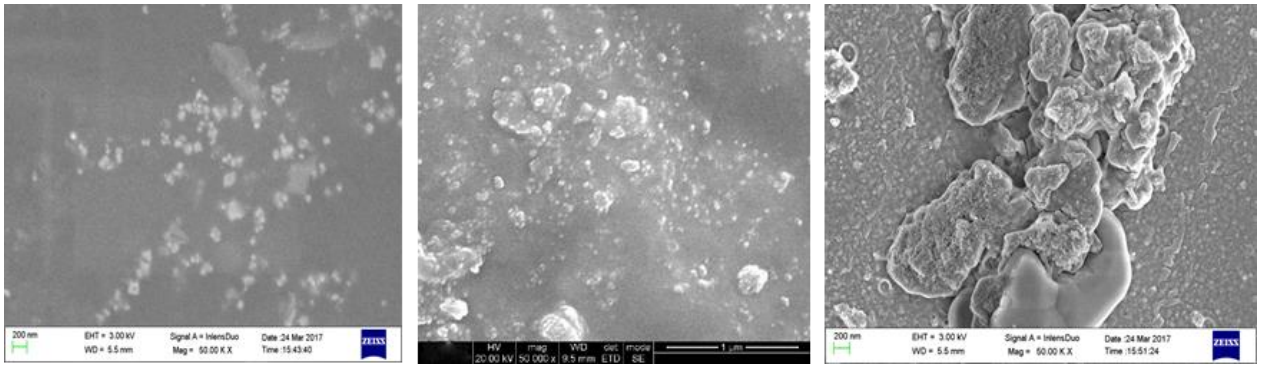

***Fig.3.SEM image of $Sb_2Se_3$e as deposited for 30 minutes, 60 minutes and 90 minutes***

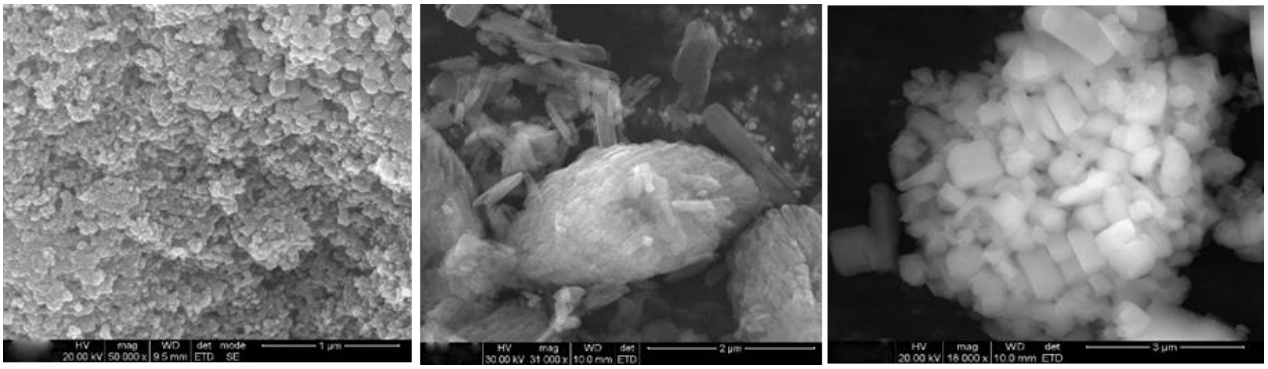

***Fig.4.SEM image of $Sb_2Se_3$e as deposited for 30 minutes, 60 minutes and 90 minutes (annealed at 200$^o$C)***

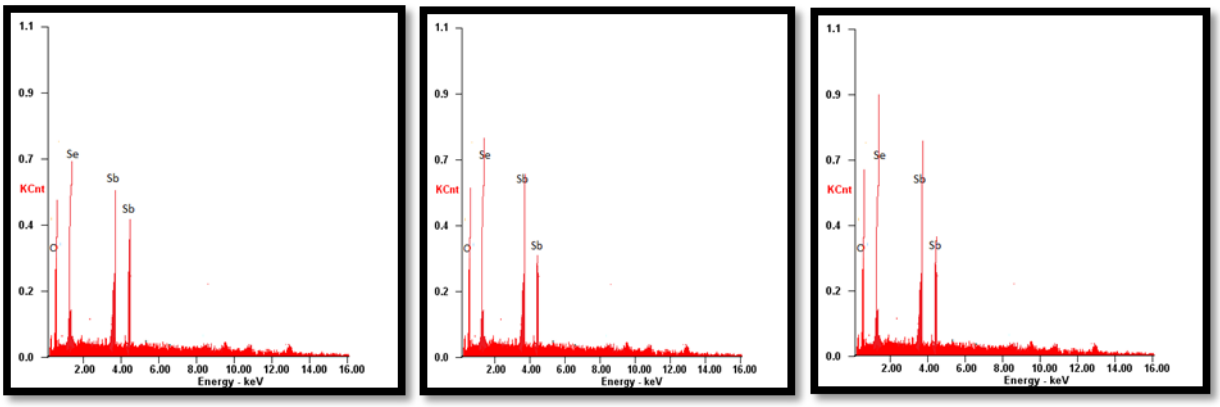


***Fig.5.EDAX images of $Sb_2Se_3$ as deposited for 30 minutes, 60 minutes and 90 minutes (annealed at 200°C)***

Scanning electron microscopy is a convenient tool to study the surface morphology of micro and nano scale material as well as thin film. From the figures 3 and 4 show the SEM images of $Sb_2Se_3$thin films and annealed at 200°C recorded at 20kV with the magnification 50k using the instrument ZEISS. The particle size increases as the annealing temperature increased [5].

The EDAX analysis from figures 5 revealed that the presence of antimony, selenium, oxygen and other elements like silicon, tin on the ITO substrate. EDAX spectrum recorded in the binding energy region of 0-16 keV shows the presence of antimony and selenium in thin films. EDAX analysis of the mass% and atom% of Antimony Selenide films are tabulated in Table 1. EDAX spectrum confirms the presence of antimony and selenium in thin films [6].

***Table 1. Mass and Atom percentage of $Sb_2Se_3$ annealed at 200°C***

| | **Sample 1 (30 min)** | | **Sample 1 (60 min)** | | **Sample 1 (90 min)** | |
|---|---|---|---|---|---|---|
| **Element** | **Weight%** | **Atomic%** | **Weight%** | **Atomic%** | **Weight%** | **Atomic%** |
| O K | 28.06 | 36.18 | 51.24 | 70.16 | 34.87 | 33.84 |
| Se L | 51.97 | 46.14 | 41.81 | 20.79 | 46.08 | 41.23 |
| Sb L | 19.97 | 3.14 | 6.95 | 1.38 | 19.05 | 3.22 |
| **Total** | 100.00 | | 100.00 | | 100.00 | |

## C. OPTICAL ABSORPTION, TRANSMITTANCE AND REFLECTANCE MEASUREMENT

The Optical absorbance of $Sb_2Se_3$ thin film were studied in the wavelength range 600-1100 nm using JASCO v-530 model spectrophotometer. All measurements were made in the laboratory at room temperature.

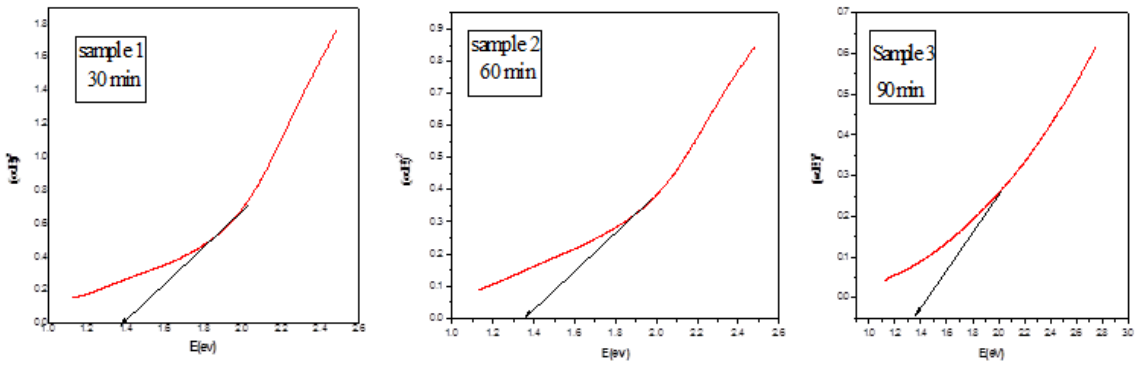


***Figure 6. Tauc plot of $Sb_2Se_3$ as deposited for 30 minutes, 60 minutes and 90 minutes***

The Optical band gap is calculated using Tauc and Davis Mott relation $\alpha h\gamma = (h\gamma - E_g)^n$ , where $h\gamma$ is the incident photon energy, n is the exponent that determine the type of electronic transition. n = 1/2 , direct allowed transition, n = 1, non – metallic materials, n = 3/2 , direct – forbidden transition, n = 2, indirect allowed transition, n = 3, indirect forbidden transition. An extrapolation of the linear region of a plot of the graph gives the value of the optical band gap. The indirect allowed transition band gap of $Sb_2Se_3$ thin films was found to be in the range of 1.3 eV and 1.38 eV respectively. All these optical band gap values are close to that reported earlier for the material used for solar cells, which means that these materials have good chance to be used for this purpose [7].

### D. PHOTOLUMINESCENCE SPECTRUM

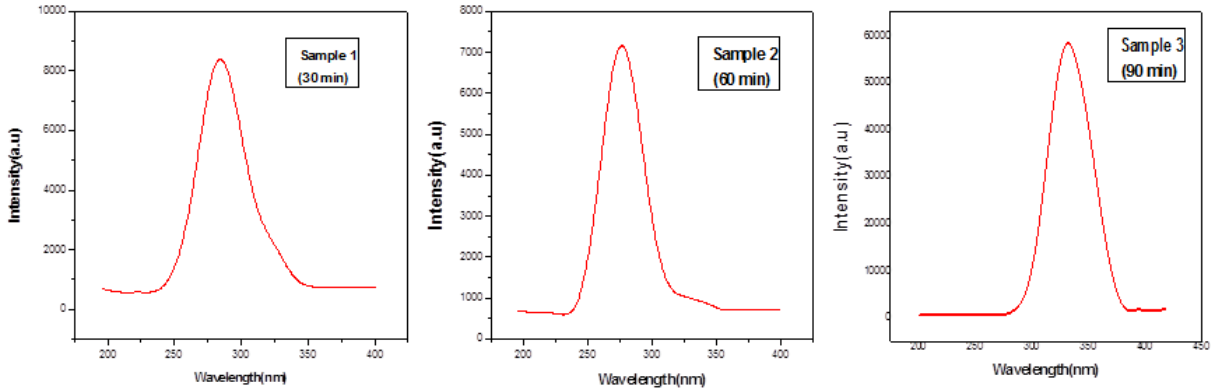


***Figure 7.Excitation Spectra of $Sb_2Se_3$***

The photoluminescence spectra of $Sb_2Se_3$ thin films are shown in Figure.7. The calculated band gap using the Photoluminescence spectrum ranges from 4.37 to 3.7 eV as the time variation increases. The decrease in the band gap is observed as the time variation increases in Photoluminescence spectrum. As the time variation increases, the band gap of Antimony Selenide decreases.

## IV. CONCLUSION

Antimony Selenide thin films were successfully deposited on ITO substrates by electro deposition technique. The films were uniform and had good aherence to the substrate. The XRD of Antimony Selenide films formed a orthorhombic structure. The crystalline size of the films were determined by scherrer's formula and it increases from 76 – 94 as the annealing temperature increases. The energy gap values of the films were determined and compared with the reported one. The emitted and excited wavelength were determined from the photoluminescence spectra. The structural properties, surface morphological studies and chemical composition analysis were investigated and reported.

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