

## **EFFECT OF OBLIQUE DEPOSITION ON OPTICAL AND ELECTRICAL PROPERTIES OF $\text{As}_2\text{S}_3$ AND $\text{As}_2\text{Se}_3$**

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The effect of oblique deposition on the optical and electrical properties of  $\text{As}_2\text{S}_3$  and  $\text{As}_2\text{Se}_3$  thin films has been investigated. Amorphous films of  $\text{As}_2\text{S}_3$  and  $\text{As}_2\text{Se}_3$  were deposited on glass substrate by vacuum evaporation of source materials. The indirect- optical bandgap energy was obtained to be 2.40eV for  $\text{As}_2\text{S}_3$  and 1.81 eV for  $\text{As}_2\text{Se}_3$ . The band gap was found to be independent of angle of deposition. DC conductivity of the films was very low. The refractive index and extinction coefficient have been calculated using the transmission spectra

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### **1. Introduction**

For the past four decades, devices based on amorphous and disordered materials have grown in importance. The atomic bond in these materials is covalent, while it can be modified to be metallic or ionic. It is this flexibility that enables tailoring of their properties over a wide range. The unique ability of amorphous materials to be engineered at molecular level and fabricated by vapour deposition processes in highly uniform large area structures has permitted them to be used in wide range of devices for sensing, encoding, switching, transmission and storage of information. It has also assisted the development of new, pollution free technology for the generation of electrical energy. Detailed studies have been reported on photoinduced structural transformations in amorphous chalcogenides[1-5]. These changes have been found to accompany different phenomena such as changes in refractive index, optical bandgap, film thickness and chemical activity.

In the present work, we report the effect of oblique deposition on optical and electrical properties of  $\text{As}_2\text{S}_3$  and  $\text{As}_2\text{Se}_3$  thin films. For optoelectronic devices, an accurate determination of the optical constants such as absorption coefficient, refractive index and dielectric constant of semiconductor thin films is important to precisely model their spectral response. To predict the photoelectronic behaviour of a device, it is important to know the variation of refractive index and absorption coefficient with wavelength. The DC conductivity has been determined to elucidate the conduction mechanism of the films.

### **2. Experimental details**

The normal and oblique films of  $\text{As}_2\text{S}_3$  and  $\text{As}_2\text{Se}_3$  were prepared by vacuum evaporation technique. The oblique films were deposited at an angle of  $80^\circ$ , this being the angle between the normal to the substrate and direction of incidence of the evaporated atoms. An optical glass slide with a thickness of about 1.5mm was used as the substrate for the films. Prior to evaporation, the substrate was cleaned with distilled water, acetone and ethanol respectively and then dried using a blower. The evaporation was conducted on the substrate at room temperature in a vacuum of about  $1 \times 10^{-6}$  Torr from a molybdenum boat heater. A surface profiler (Dektok 3) was used to measure the thickness of the films. The results presented here for typical film having thickness in the range 0.7-1.2 $\mu\text{m}$ .

The optical transmission measurements were performed on thin films using UV-VIS spectrophotometer (Hitachi 330). DC conductivity measurements were made on the films by evaporating aluminium contacts in a coplanar configuration.

### 3. Results and discussion

The amorphous nature of the samples was confirmed by the X-ray diffraction measurements. Refractive index and extinction coefficient have been calculated using the method suggested by Swanepoel [6-8]. The refractive index and absorption coefficient are obtained using the transmission spectra. The refractive index ( $n$ ) has been obtained using the following expressions,

$$n = \left[ M + \left( M^2 - s^2 \right)^{\frac{1}{2}} \right]^{\frac{1}{2}}$$

$$\text{where } M = \frac{2s}{T_m} - \frac{(s^2 + 1)}{2} \quad \text{for transparent region}$$

$$\text{and } = \frac{s^2 + 1}{2} + 2s \frac{T_M - T_m}{T_M T_m} \quad \text{for weak and medium absorption region}$$

$T_M$  and  $T_m$  are the values of maximum and minimum transmission at a particular wavelength.  $s$  is the refractive index of the substrate

The absorption coefficient was determined using the relation  $\exp(-\alpha t) = T$  where  $t$  is the thickness of the film and  $T$  is the transmittance.

The bandgap, of the films has been estimated using Tauc's relation

$$\alpha = (B/h\nu)(h\nu - E_{opt})^n$$

where  $B$  is a constant,  $E_{opt}$  is the optical bandgap energy and  $h\nu$  is the photon energy.  $n$  depends on electronic transitions in  $k$ -space and takes the values  $1/2, 1, 2$  and  $3$ .

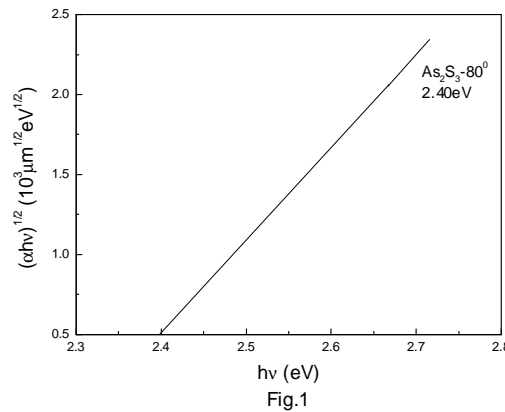


Fig.1. Variation of  $(\alpha h\nu)^{1/2}$  Vs photon energy for  $As_2S_3$ .

The results are shown in Fig.(1) and Fig.(2) as a plot of  $(\alpha h\nu)^{1/2}$  Vs photon energy ( $h\nu$ ). On extrapolating the linear portion of the curve to x-axis,  $E_{opt}$  is found to be 2.4eV for  $As_2S_3$  and 1.81eV for  $As_2Se_3$ . The estimated value of the band gap is very close to the reported value of 2.4eV for  $As_2S_3$  and 1.8eV for  $As_2Se_3$  [9].

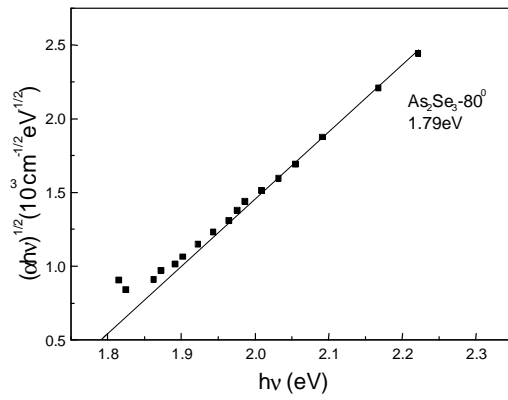


Fig. 2. Variation of  $(\alpha hv)^{1/2}$  Vs photon energy for  $As_2Se_3$ .

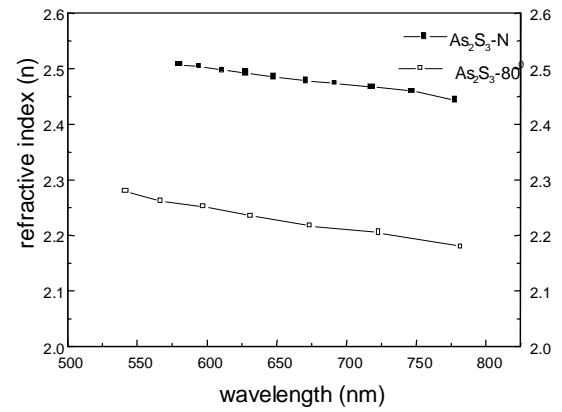


Fig. 3. Variation of refractive index with wavelength for  $As_2S_3$ .

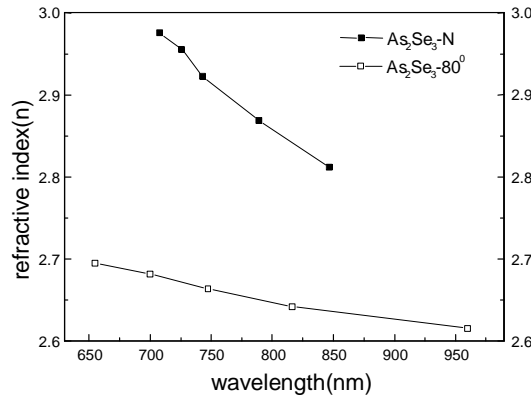


Fig. 4. Variation of refractive index with wavelength for  $As_2Se_3$ .

Fig. (3 and 4) show the refractive index( $n$ ) and Fig.(5 and 6) show extinction coefficient( $\kappa$ ) as a function of wavelength for the films deposited at normal and  $80^\circ$  oblique incidence of  $As_2S_3$  and  $As_2Se_3$  respectively.

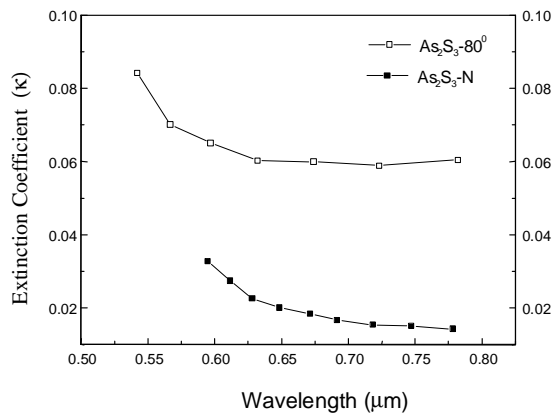


Fig. 5. Variation of extinction coefficient with wavelength for  $As_2S_3$ .

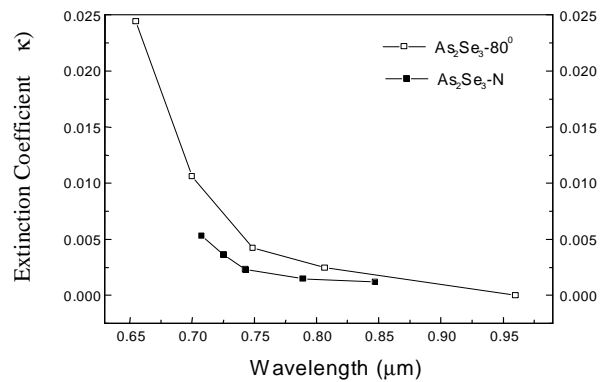


Fig. 6. Variation of extinction coefficient with wavelength for  $As_2Se_3$ .

The refractive indices of the films are found to obey the normal dispersive law. The typical values of refractive index 2.49 for  $\text{As}_2\text{S}_3$  at 630nm wavelength and 2.95 at 730nm for  $\text{As}_2\text{Se}_3$  are in close agreement with the reported data [10]. However the refractive index for obliquely deposited films were found to be low as compared to the normal deposited films. This change in refractive index could be attributed to the structural changes occurring in obliquely deposited films.

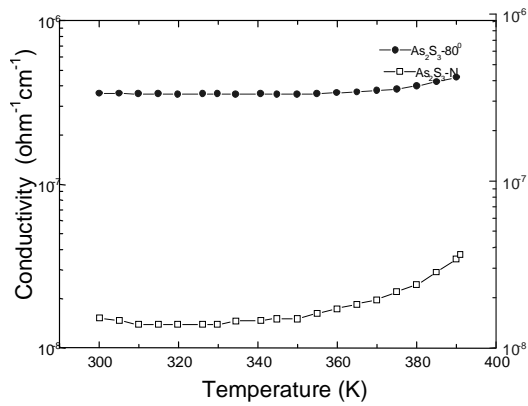


Fig. 7. Variation of dark conductivity with temperature for  $\text{As}_2\text{S}_3$ .

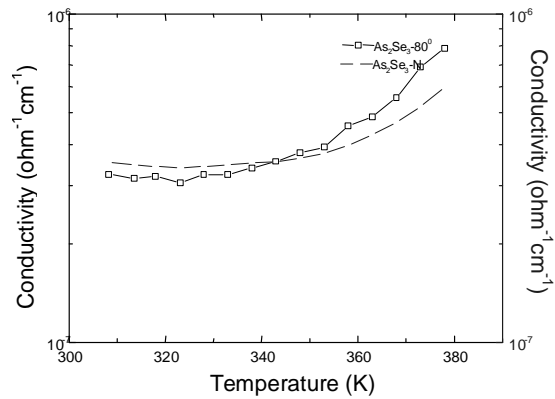


Fig. 8. Variation of dark conductivity with temperature for  $\text{As}_2\text{Se}_3$ .

Fig. (7 and 8) show the temperature dependence of the dark conductivity, for the samples of  $\text{As}_2\text{S}_3$  and  $\text{As}_2\text{Se}_3$  respectively. It has been observed that the conductivity increases with temperature, that can be attributed to thermal activation of carriers.

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