Effect of additive on Refractive index and Extinction Coefficient of Chalcogenide Glasses

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Abstract: Chalcogenide glasses are formed from the group VI elements of the periodic table such as S, Se and Te. These elements are known as chalcogens. Chalcogenide glasses are also called Lone-pair semiconductors due to it's distinguish characteristics.. Chalcogenide glasses are less robust and weekly bonded than oxide glasses. Alloys of $In_{10}Se_{90}$ and $In_{10}Pb_5Se_{85}$ are prepared by melt-quenching technique. Thin films are deposited by the thermal evaporation technique on glass substrates under a pressure of 10^{-6} torr. Scanning Electron Microscope (SEM) images show the surface topology and nuclei growth. Optical analysis such as refractive index and extinction coefficient were carried out by the Ultra violet visible (UV-Vis) Spectroscopy in the range of 250-1050 nm. It is found that on addition of Pb refractive index and extinction coefficient decrease. This material can be used in optical switching.

Keywords: Chalcogenide Glass, SEM, UV Vis, Refractive index, Extinction Coefficient

1. Introduction

Amorphous semiconductors which contain one or more chalcogenide such as Sulphur (S), Selenium (Se), and Tellurium (Te) etc are called chalcogenide glasses. Se-based chalcogenide glasses have wide applications in switching, memory devices, xerography and photo cells etc [1-5]. Since pure selenium has short lifetime and low sensitivity, therefore it is mixed with impurity atom such as In, S, Sb, and Pb etc to make it more robust, high crystallization temperature, high sensitivity and smaller aging effects [6-9]. The addition of impurity atoms make compositional disorder and widen the glass forming area [10-11]. Optical-absorption spectra of chalcogenide glasses exhibits relatively sharp absorption edges from which optical gaps can be deduced [12-13]. Doped Se has large effect on their optical properties such as refractive index and extinction coefficient [14-16].

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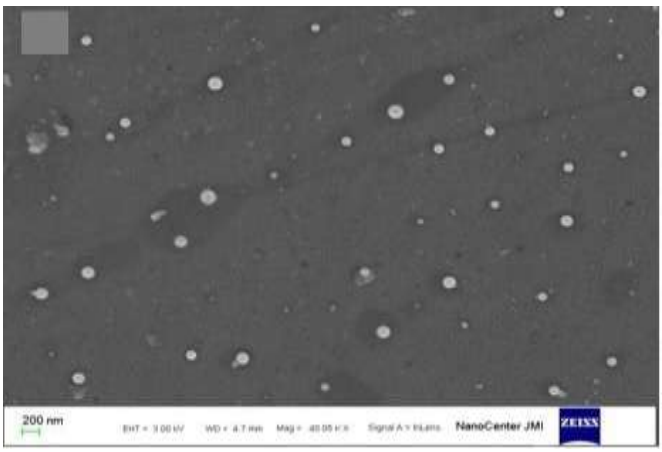
In the present case we studied the $In_{10}Se_{90}$ and $In_{10}Pb_5Se_{85}$ thin films. These prepared materials have been found to exhibit the change in refractive index and extinction coefficient under the influence of light. The refractive index (n) and extinction coefficient (k) are important parameters to study the thin films of chalcogenide glasses.

2. Experimental

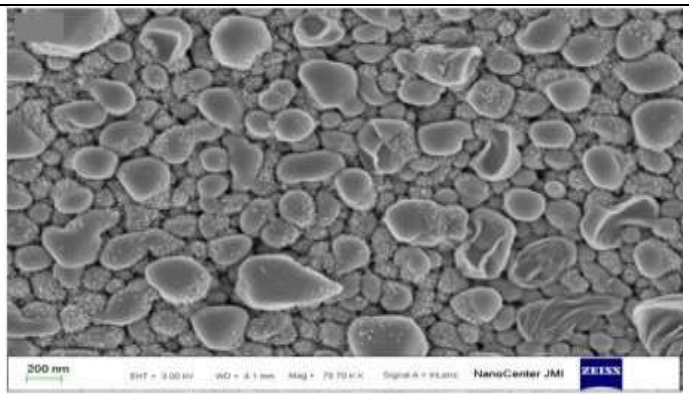
Chalcogenide glass alloys $In_{10}Se_{90}$ and $In_{10}Pb_5Se_{85}$ were prepared from high purity constituent elements (99.999%) in stoichiometric ratio by melt quench technique. The constituent elements were sealed in quartz ampoules under a vacuum of 10^{-6} torr. The ampoule was kept inside a furnace at 800^0C for 10 hrs so that all elements were melted. The temperature was raised at the rate of 3^0C/min. The ampoules were shaken continuously during the heating so that it can become homogeneous. Quenching was done in ice water and the ingots were taken out by breaking the ampoule. Thermal evaporation technique used to deposit the films on clean glass substrate at a pressure of 10^{-6} torr. Scanning Electron Microscope (SEM) was carried out to study the surface morphology.The optical measurement was carried out by using UV/Vis spectrophotometer in spectral wavelength range 250–1050 nm.

3. Results and discussion

The morphological analysis of $In_{10}Se_{90}$ and $In_{10}Pb_5Se_{85}$ thin films was carried out using SEM. The SEM image shows the growth of nuclei as shown in Fig. 1. The grains size decreases with the addition of Pb content. This may be due to reduction in disorderness and hence decrease in density of defect states [17].



(a)



(b)

Fig. 1. SEM images of (a) $In_{10}Se_{90}$ (b) $In_{10}Pb_5Se_{85}$ thin films.

The values of refractive index (n) and extinction coefficient (k) have been calculated by using the theory of reflectivity of light. According to this theory, the reflectance of light from a thin film can be expressed in terms of Fresnel's coefficient. The reflectivity [18] of an interface can be given by

$$R = [(n-1)^2 + k^2] / [(n+1)^2 + k^2] \quad (1)$$

and $\alpha = 4\pi k/\lambda$, where λ is wavelength of the incident photon

The photon energy dependent refractive index (n) and extinction coefficient (k) for $In_{10}Se_{90}$ and $In_{10}Pb_5Se_{85}$ thin films are shown in Figs. 2 &3.The value of refractive index (n) decreases and value of extinction coefficient (k) increases with the increase of photon energy. The values of n and k with additivehave been shown in Table1.

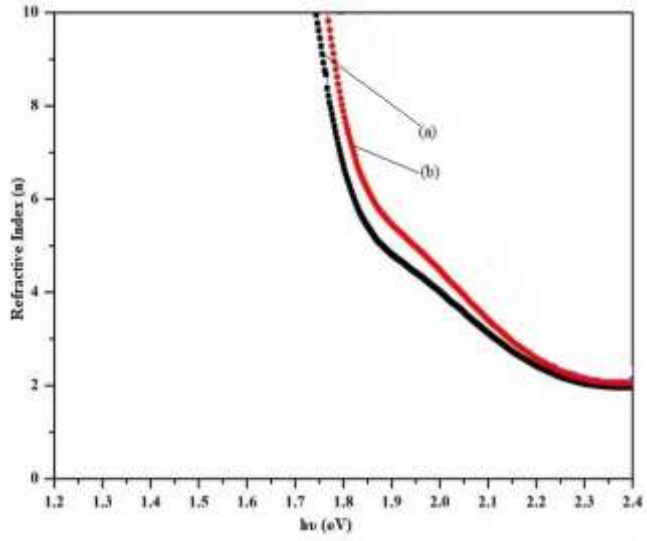


Fig. 2. Variation of Refractive index (n) with hυ in of (a) $In_{10}Se_{90}$ (b) $In_{10}Pb_5Se_{85}$

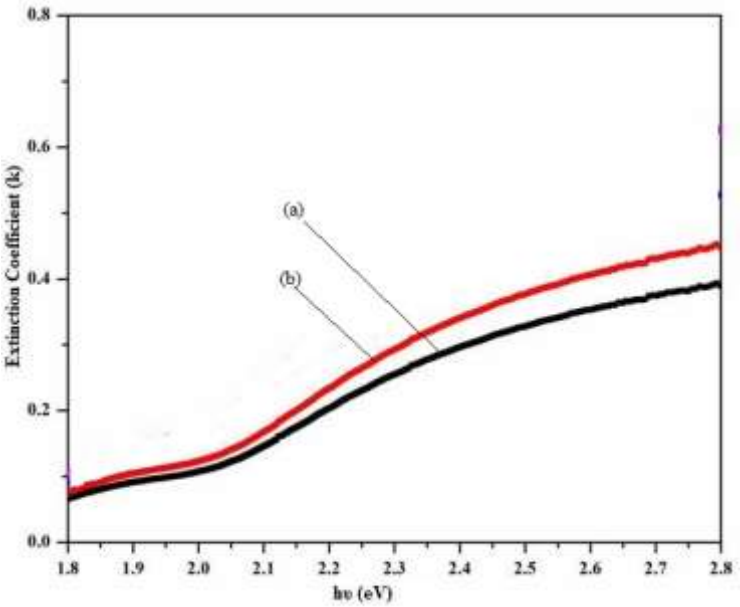


Fig. 3 . Variation of Extinction Coefficient (k) with hυ in of (a) $In_{10}Se_{90}$ (b) $In_{10}Pb_5Se_{85}$

It is evident from the Table 1 that the values of Refractive index (n) and Extinction coefficient (k) with addition of Pb increase.

Table: 1. Changes in Refractive index (n) and Extinction coefficient (k) with additive

Sample	n	k
$In_{10}Se_{90}$	3.210	0.347
$In_{10}Pb_5Se_{85}$	2.921	0.287

4. Conclusion

The alloys of $In_{10}Se_{90}$ and $In_{10}Pb_5Se_{85}$ have been deposited on clean glass substrate by thermal evaporation technique at room temperature and under the pressure of 10^{-6} torr. SEM images show the surface morphology of the thin films. The values of Refractive index (n) and Extinction coefficient (k) increase with addition of Pb. These types of chalcogenide materials can be used in optical switching.

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