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Variation of Dielectric constant of amorphous semiconductor with additive

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Abstract: Amorphous semiconductors are glassy form of crystalline semiconductors and also called non- crystalline semiconductors. Chalcogenide glasses are non-oxide amorphous semiconductors. Se-based chalcogenide glasses have several applications in semiconductor devices. $In_7Te_{13}Se_{80}$ and $In_7Te_{13}Bi_4Se_{76}$ are prepared by melt-quenching technique. Thin films are deposited by the thermal evaporation technique on ultra clean glass substrates under a pressure of 10^{-6} torr. The structural analyses of these films were carried out by Energy Dispersive X-ray Scattering (EDS). EDS analysis confirms the presence of the compositional elements in the thin films. Optical studies such as variation in dielectric were carried out by the Ultra violet visible (UV-Vis) Spectroscopy in the range of 350-950 nm. It is found that on addition of bismuth real part and imaginary part of dielectric constant decrease. This material can be used in optoelectronic devices.

Keywords: Amorphous semiconductor, UV-Vis Spectroscopy, EDS, Dielectric constant,

1. Introduction

Chalcogenide glasses are widely used by virtue of it being exhibit phase change under the influence of heat, light, pressure etc. Se based chalcogenide glasses have many applications in solid state electronic devices, memory devices etc. Since pure selenium is fragile and have short life time; therefore some external elements from group II-VI are added to make it more robust. These chalcogenide glasses are non-linear, low phonon energy and transparent in IR region which make it useful for optical applications [1-4]. Se-Te alloys have small aging effect, greater hardness, and higher photosensitivity [5-9]. Dielectric constant is important parameters to study the amorphous thin film. Thin films of $In_7Te_{13}Se_{80}$ and $In_7Te_{13}Bi_4Se_{76}$ are found to exhibit the change in refractive index under the influence of UV-Vis light which makes that material to use in optical memory devices [10].

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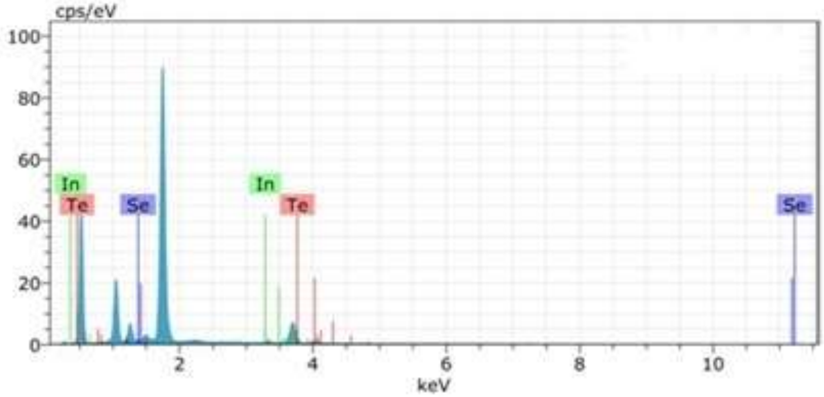
Ternary assets deliver an opportunity of altering and improving natural and physical liberty, which makes it appropriate for the tender in solar cells [11]. Due to this reason numerous researchers take interest to study of InTeBi alloy following electrical properties, structural, optical properties. Ensuing this way it may be conceivable to form novel materials with chemical and structure freedom, which has substantial care in the arena of device applications. The structure of the material and optical parameters in an amorphous semiconductor may be widely different consequence of an impurity added into material [12]. Although in crystalline semiconductors a suitable impurity is continually to deliver a new donor or acceptor states, which is not vital in amorphous semiconductor [13]. An impurity may just change the mobility of the charge carries or might familiarize structural modification in its place of if a localized impurity level in the forbidden gap exists with or without alteration of the localized states in the prohibited gap in amorphous semiconductors [14-15].

2. Experimental

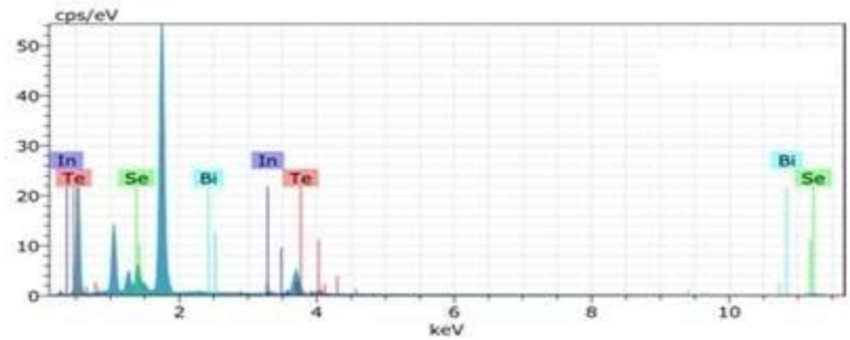
Amorphous alloys of $In_7Te_{13}Se_{80}$ and $In_7Te_{13}Bi_4Se_{76}$ were prepared from high purity constituent elements (99.999%) in stoichiometric ratio by using melt quench technique. The constituent elements were sealed in quartz ampoules under a vacuum of 10^{-6} torr. The ampoule was kept inside a furnace at 700^0C for 12 hrs so that all elements were melted. The temperature was raised at the rate of 2^0C/min. During the heating process, the ampoule was shaken continuously so as to make it homogeneous. Quenching was done in ice water and the ingots were taken out by breaking the ampoule. Glassy alloys compositions have been studied by SEM image and EDS respectively.The optical measurement such dielectric constant was carried out by using UV/Vis spectrophotometer in spectral wavelength range 350–950 nm.

3. Results and discussion

The elemental composition of as-prepared$In_7Te_{13}Se_{80}$ and $In_7Te_{13}Bi_4Se_{76}$ thin films are checked by using the Energy Dispersive X-ray (EDX) spectroscopy. Fig.1 shows the images of EDX patterns of as-prepared thin films of $In_7Te_{13}Se_{80}$ and $In_7Te_{13}Bi_4Se_{76}$. This image confirms the presence of constituent's elements In, Te, Bi and Se.



(a)



(b)

Fig.1 Images of EDS (a) $In_7Te_{13}Se_{80}$ and (b) $In_7Te_{13}Bi_4Se_{76}$ thin films.

According to this theory, the reflectance of light from a thin film can be expressed in terms of Fresnel's coefficient. The reflectivity [16]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 real (ε_r') and imaginary (ε_r'') parts of the dielectric constant for as prepared$In_3Te_7Bi_xSe_{90-x}$ thin films have been calculated by using the relation

$$\varepsilon_r' = n^2 - k^2 \quad (2)$$

$$\varepsilon_r'' = 2nk \quad (3)$$

The variations of these two parameters i.e. real and imaginary parts of dielectric constant with photon energy are shown in Figs. 2(a) and (b).

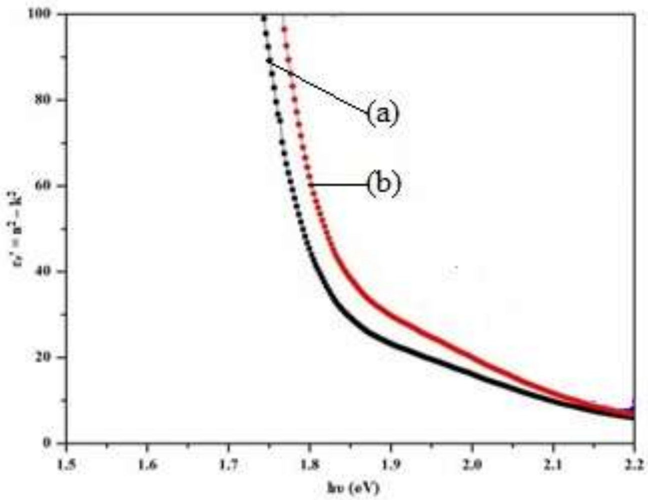


Fig. 2 (a) Variation of Real part of dielectric constants with hυ in (a) $In_7Te_{13}Se_{80}$ and (b) $In_7Te_{13}Bi_4Se_{76}$ thin films

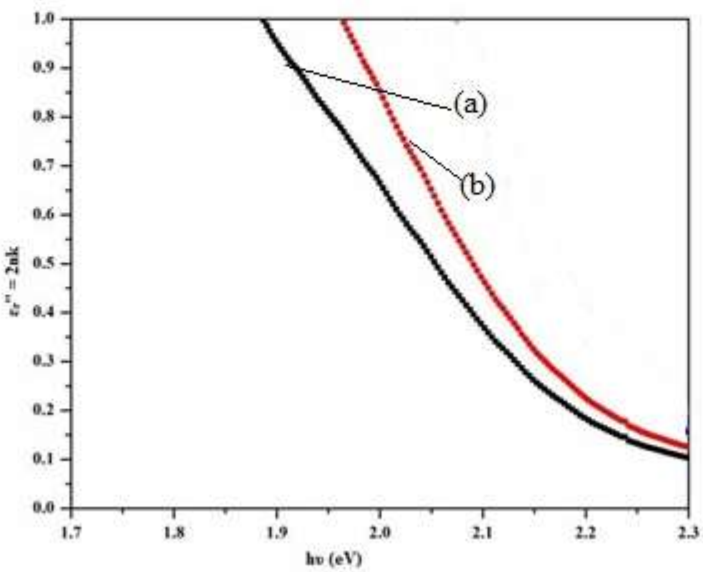


Fig. 2(b) Variation of Imaginary part of dielectric constants with hυ in (a) $In_7Te_{13}Se_{80}$ and (b) $In_7Te_{13}Bi_4Se_{76}$ thin films

The values of real part (εr') and imaginary part (εr'') of the dielectric constant decreases with photon energy in all samples of $In_7Te_{13}Se_{80}$ and $In_7Te_{13}Bi_4Se_{76}$ thin films. It is clear from the Table 1 that the value of εr' and εr'' both decrease on addition of bismuth in thin films.

Table 1 Variation of Real and Imaginary part of dielectric constants of thin films at a wavelength of 650 nm

Sample	ε_r'	ε_r''
$In_7Te_{13}Se_{80}$	16.03	0.693
$In_7Te_{13}Bi_4Se_{76}$	12.62	0.487

4. Conclusion

Amorphous alloys of $In_7Te_{13}Se_{80}$ and $In_7Te_{13}Bi_4Se_{76}$ have been deposited on ultraclean glass substrate by thermal evaporation technique at room temperature and under the pressure of 10^{-6} torr. EDS analysis shows the presence of constituent elements in the thin films. The value of optical such as dielectric constant (εr') and dielectric loss (εr'') changes significantly with incident photon energy on addition of bismuth. This material can be used in optoelectronic devices.

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