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THERMAL AND OPTICAL STUDY OF $TE_{15}(SE_{100-X}BI_X)_{85}$ (X = 0, 1, 3) CHALCOGENIDE GLASSES

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The present paper reports the thermal and optical study of $Te_{15}(Se_{100-x}Bi_x)_{85}$ *(*$x = 0, 1, 3$ *at. %) glassy alloys. The glass transition temperature (*T_g*), crystallization temperature (*T_c*) and melting temperature (*T_m*) are found from the DTA plots taken at different heating rates of* 10, 15, 20 *and* 25 *K/min. The glass transition temperature and melting temperature have been found to increase and the crystallization temperature has been found to decrease with increase in Bi content (*x*). Refractive index and optical energy gap of the films have been calculated from the transmission spectra taken in the spectral range* 400-2300 *nm. The refractive index decreases with wavelength and the optical band gap decreases with increase in Bi content.*

Keywords: *DIFFERENTIAL THERMAL ANALYSIS, GLASS TRANSITION TEMPERATURE, OPTICAL BAND GAP, REFRACTIVE INDEX AND THERMAL STABILITY.*

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1. INTRODUCTION

Se based amorphous semiconductors such as Se-Te have attracted attention due to their technological applications. The optical and thermal properties of these glasses can be varied by adding a third dopant to make them suitable for various technological purposes. The glass transition temperature, the crystallization temperature and optical band gap are found to change with composition [1, 2]. The present paper reports the thermal stability of bulk glasses prepared by melt quenching, refractive index and optical band gap of thin films prepared by thermal evaporation.

2. EXPERIMENTAL PROCEDURE

Bulk samples of glasses were prepared by the melt quenching technique. Shimadzu DTG-60 system has been used to obtain the DTA thermograms at different heating rates. Thin films are prepared on glass substrates by vacuum evaporation technique at room temperature and base pressure of 10^{-5}

Torr using HINDIHIVAC model 12A4D India. Amorphous nature of the samples/films has been confirmed from their X-Ray diffraction pattern. The normal incidence transmission spectra of thin films have been taken using a double beam UV/VIS/NIR spectrophotometer. All the measurements were taken at room temperature.

3. RESULTS AND DISCUSSIONS

3.1 Thermal study

DTA thermograms of glasses for $x = 3$ at heating rate 10, 15, 20, 25 K/min are shown in fig. 1. The glass transition temperature, the crystallization temperature and the melting temperature are found to increase with increase in heating rate. These characteristic temperatures are listed in table 1. The glass forming ability can be estimated from Hruby's parameter [3].

$$K_{gl} = \frac{T_c - T_g}{T_m - T_c} \tag{1}$$

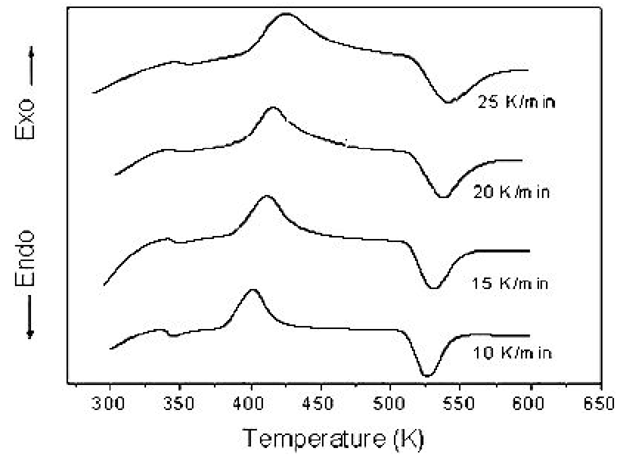

Fig. 1 *– DTA thermograms for $Te_{15}(Se_{100-x}Bi_x)_{85}$ glassy alloys for ($x = 3$ at %) at heating rates of* 10, 15, 20, 25 *K/min.*

The calculated values of Hruby's parameter are listed in Table 1. The glass forming ability, represented by this parameter has been found to decrease with increase in Bi content for all compositions.

The decrease in thermal stability with increase in Bi content has been explained on the basis of formal theory of transformation kinetics. Surinach et al. [4] and Hu and Jiang [5] introduced the kinetic parameter,

$$K(T_g) = K_0 \exp(-E_c / RT_g) \tag{2}$$

The smaller the value of $K(T_g)$ implies the better glass forming ability. In our system the value of $K(T_g)$ increases with increase in Bi content means the glass forming ability decreases with increase in Bi content.

Table 1 *– Values of T_g, T_c, T_m, K_{gl} for $Te_{15}(Se_{100-x}Bi_x)_{85}$ (x = 0, 1, 3 at %) glassy alloys at the heating rate of 10, 15, 20 and 25 K/min*

composition	Heating Rate (μ)	T_g	T_c	T_m	K_{gl}
$x = 0$	10	341	408	520	0.598
	15	344	418	527	0.679
	20	348	424	530	0.717
	25	350	430	531	0.792
$x = 1$	10	342	405	522	0.538
	15	345	415	529	0.614
	20	348	421	532	0.658
	25	350	427	533	0.726
$x = 3$	10	344	401	526	0.456
	15	347	412	530	0.551
	20	350	420	538	0.593
	25	352	425	542	0.624

Table 2 *– Values of n (at 800 nm) and E_g for $Te_{15}(Se_{100-x}Bi_x)_{85}$ (x = 0, 1, 3 at. %) glassy alloys.*

composition	n	E_g (eV)
$x = 0$	2.95	1.37
$x = 1$	3.03	1.29
$x = 3$	3.27	1.26

3.2 Optical study

The transmission spectra of thin films are shown in Fig. 2. The maxima and minima fringes at different wavelengths have been used to calculate the refractive index of the thin films using Swanepoel method [6].

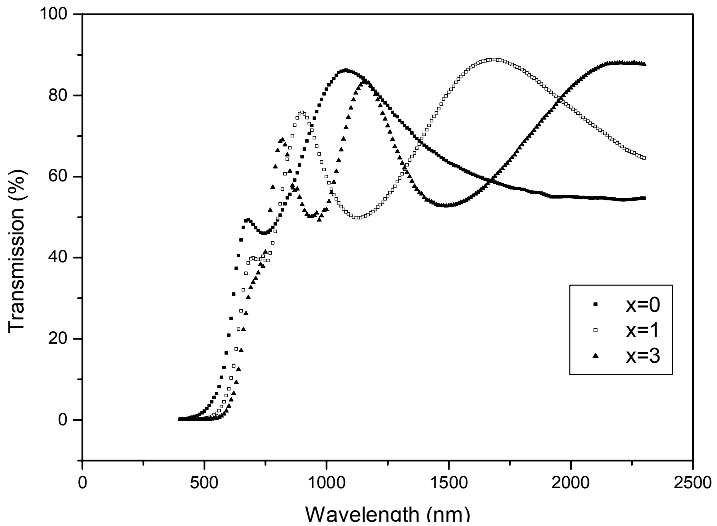

Fig. 2 *– Transmission spectra for the $Te_{15}(Se_{100-x}Bi_x)_{85}$ (x = 0, 1, 3 at%) thin films*

The refractive index is found to decrease with increase in wave length showing normal dispersion behaviour. The refractive index is found to increase with Bi content. This increase is probably due to replacement of lighter Se by heavier Bi which increases the density and hence the refractive index. The calculated values of refractive index for different compositions are plotted with wavelength in Fig. 3.

The optical band gap (E_g) has been calculated by plotting a graph between $(\alpha h\nu)^{1/2}$ and $h\nu$ using the Tauc relation [7],

$$(\alpha h\nu)^{1/2} = B(h\nu - E_g) \quad (3)$$

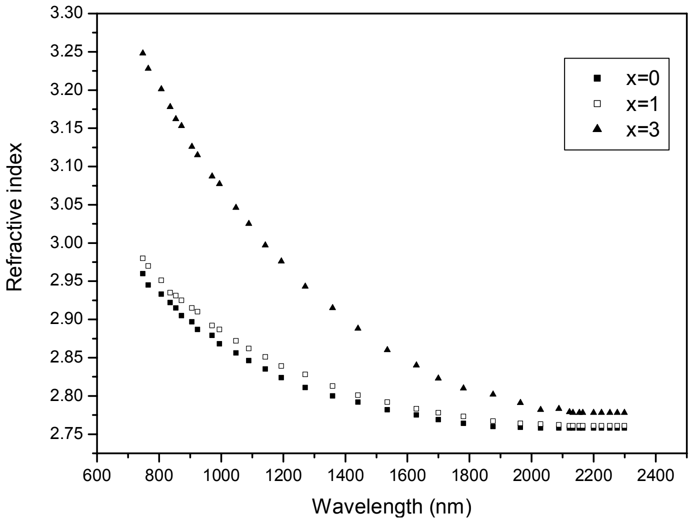

Fig. 3 *– Variation of refractive index (n) with wavelength (λ) for* $Te_{15}(Se_{100-x}Bi_x)_{85}$ *(x = 0, 1, 3 at%) thin films*

The optical band gap has been calculated from Tauc plots (Fig. 4) by taking the intercepts of extrapolation to zero absorption with photon energy axis as $(\alpha h\nu)^{1/2}$ approaches zero. The optical band gap decreases with increase in Bi content and is probably due to decrease in cohesive energy. The calculated values of refractive index and optical band gap for different compositions are shown in Table 2.

4. CONCLUSION

The characteristic temperatures increase whereas the thermal stability decreases with increase in Bi content to Se-Te glasses. The refractive index increases and the optical band gap decreases with the dopant for the thin films.

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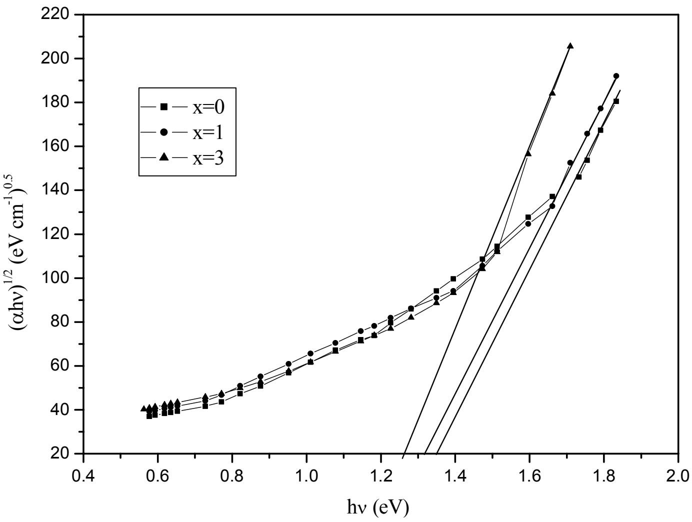

Fig. 4 *– Plot of* $(\alpha h\nu)^{1/2}$ *with* $h\nu$ *for* $Te_{15}(Se_{100-x}Bi_x)_{85}$ $(x = 0, 1, 3$ *at%) thin films*

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