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Temperature and composition dependence of crystallization rate constant for $Se_{90}In_{10-x}Sb_x$ (0≤x≤10) glasses

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Crystallization kinetics of chalcogenide glasses is very important in determining the transport mechanism and thermal stability [1-4]. Differential Scanning Calorimetry (DSC) is one such technique, which is used for quantitative measure of different kinetic parameters. Non-isothermal scanning in Differential Scanning Calorimetry has been widely used in the investigations of glass transition and crystallization kinetics of glasses [5-6].

Crystallization rate constant (K) plays an important role on determining the thermal stability of glasses. The minimum value of crystallization rate constant gives an indication of the retardation of the crystallization while its higher value diminishes the glass-forming ability. The non-isothermal crystallization data is usually interpreted in terms of Johnson-Mehl-Avrami (JMA) theoretical model in which the crystallization fraction χ can be described as a function of time t.

In the present paper, $Se_{90}In_{10-x}Sb_x$ (x=0, 2, 4, 6, 8, 10) chalcogenide glasses have been prepared by melt quenching method and amorphous nature has been cauterized by X-ray diffraction technique. DSC runs of these samples have been taken at six different heating rates (5, 10, 15, 20, 25, 30 K/min). The activation energy (E_c) and pre-exponential factor have been evaluated using Augis - Benett's model. Table 1 depicts the values of activation energy of crystallization, E_c, and pre exponential factor K_o for $Se_{90}In_{10-x}Sb_x$ (0≤x≤10) glasses. It is clear from Table 1 that E_c is maximum for 4 at.% of Sb concentration. Since E_c is the amount of energy needed by a group of atoms in the glassy state to jump to crystalline state, therefore, at 4 at.% of Sb concentration, barrier to crystallization is highest, indicating the stability of the glassy matrix. Thus, $Se_{90}In_6Sb_4$ composition can be considered as a critical composition at which the system becomes a chemically ordered alloy containing high-energy Sb-Se hetropolar bondsThe obtained values of ln K_o and E_c are used to obtain crystallization rate constant K.

From Figure 1, it is observed that values of ln K are minimum for 4 at.% of Sb concentration, which again confirms that this glass has good glass forming tendency. Crystallization rate constant (K) increases on further increase (beyond 4 at.%) in Sb concentration. Variation of crystallization rate constant (K) as function of Sb concentration shows that crystallization rate constant (K) increase linearly with increase in temperature. As temperature increase, more fraction of atoms gets crystallized and hence crystallization rate increase, which indicated by an increase in crystallization rate constant (K).

Table 1: Values of activation energy of crystallization, E_c, pre exponential factor K_o, and S-parameter for $Se_{90}In_{10-x}Sb_x$ (x=0, 2, 4, 6, 8, 10) glasses

Sample	E_c (kJ/mol)	K_0 (sec^{-1})	S-parameter (10 K/min)
$Se_{90}In_{10}$	102.84	1.10 x 10^{13}	1.66
$Se_{90}In_8Sb_2$	105.51	1.37 x 10^{13}	3.82
$Se_{90}In_6Sb_4$	110.33	4.79 x 10^{11}	4.62
$Se_{90}In_4Sb_6$	106.01	1.50 x 10^{12}	4.40
$Se_{90}In_2Sb_8$	104.34	1.34 x 10^{13}	3.16
$Se_{90}Sb_{10}$	104.01	1.15 x 10^{13}	2.42

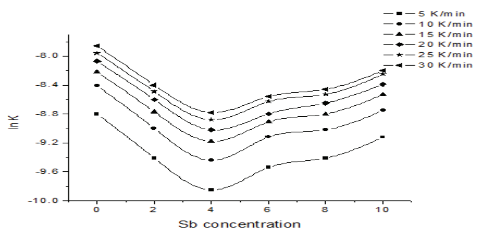

Figure 1: Variation of ln K with Sb concentration

A systematic study of $Se_{90}In_{10-x}Sb_x$ (0≤x≤10) chalcogenide glasses has been carried out The activation energy of crystallization, E_c, is found to be maximum for $Se_{90}In_6Sb_4$ glass. This indicates higher stability of this glass against crystallization. The values of frequency factor also confirm the same fact.

References

1. P.Sharma, M.Vashistha and I.P. Jain, Chal. Lett. 2 (11) (2005) p.113.
2. H.A.Abd El Ghani, M.M.Abd El Rahim, M.M.Wakkad, A.Abo Sehli and N. Assaraan, Physica B 381(2006) p. 156.
3. Dessour JH, Clarke HE, Xerography and related processes, London: Local, 1965.
4. E.A.Davis and N.F.Mott, Electronic Processes in non-crystalline materials, Oxford, Clarendon 1979.
5. N.B. Maharjan, Deepika Bhandari, N.S. Saxena, D.D. Paudyal, M. Hussain, Ind. J. Phys. 74A 3, 343 (2000).
6. PK Jain, Deepika, NS Saxena PHilosopHical magazine B 89 (7), 641-650