STUDY OF CRYSTALLIZATION KINETICS IN $Se_{90}Cd_{10-x}In_x$ CHALCOGENIDE GLASSES

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ABSTRACT

The present paper reports the Differential Scanning Calorimetric (DSC) study of in doped Se-Cd chalcogenide glasses. DSC runs were taken at 10K/min heating rate. Well defined endothermic and exothermic peaks were obtained at glass transition (T_g) and crystallization temperatures (T_c). The result shows that the value of glass transition and crystallization temperature increases with increase in In content in Se-Cd matrix.

KEYWORDS: Chalcogenide glasses, melt quench technique, DSC technique.

INTRODUCTION

Chalcogenide glasses have been subject of great interest for the material science researcher's because of their wide spread application in science and technology specially in solid state devices, optoelectronic devices, solar cell, memory switching, infrared photo detectors, high efficiency thin films transistor, electron beam pumped laser, LED, electroluminescent devices, holographic recording systems, thermal imaging, photo-voltaicsand bio-sensors [1-10].Among VI-II-III group ternary compounds selenium-cadmium-indium(Se-Cd-In) has found applications in optoelectronics and solar cells due to its higher value of absorption coefficient.

The crystallization kinetics in chalcogenide glasses can be studied using isothermal and non-isothermal methods.In isothermal method,the sample is brought near to crystallization temperature very quickly and then any physical quantity which changes drastically is measured as a function of time. In non-isothermal method, the sample is heated at a fixed rate and the

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physical parameter is recorded as a function of temperature. A disadvantage of the isothermal method is the impossibility of reaching a test temperature instantaneously and during the time which system needs to stabilize, no measurements are possible. On the other hand, measurements can be achieved in a relatively rapid and precise manner by non-isothermal technique [11].

In the present work In has been chosen as an additive element in Se-Cd alloys. The literature survey on crystallization kinetics show that relatively very few research works have been reported on Crystallization kinetics of Se-Cd-In.

In the present work Differential Scanning Calorimetric (DSC) study of $Se_{90}Cd_{10-x}In_x$(x=2, 4, 6, 8) chalcogenide glasses have been carried out at a particular heating rate of 10K/min. The dependence of glass transition temperature (T_g) and crystallization temperature(T_c) with In concentration are discussed.

EXPERIMENTAL

Glassy alloys of $Se_{90}Cd_{10-x}In_x$(x=2,4,6,8) were prepared by the melt quenching technique. High purity (99.999%) Se, Cd and In elements were weighed accordance to their atomic percentage by using an electronic balance (LIBROR, AEG-120) with the least count of 10^{-4} gm and placed into ultra-cleaned quartz ampoules (length ~ 5 cm and internal diameter ~ 8

mm). The ampoules were evacuated and sealed under a vacuum of 10^{-5}Torr to avoid reaction of alloying elements with oxygen at a higher temperature. Each ampoule was kept inside the furnace at an appropriate temperature; the temperature was raised at a rate of 3 - 4 ^{0}C / minute. The ampoules were rocked frequently by rotating a ceramic rod to which the ampoules were tucked away in the furnace for 10-12 hours at the maximum temperature(800^0C) to make the melt homogeneous. After the above said time, the ampoules with molten materials were rapidly quenched in ice-cooled water. The quenched sample was then taken out by breaking the quartz ampoule.

The glasses, thus prepared were grind to make fine powder for DSC studies. This technique is particularly important due to the fact that: (1) it is easy to carry out;(2) it requires little sample preparation;(3) it is quite sensitive and (4) it is relatively independent of the sample geometry.

10 to 20mg of each sample was heated at a constant heating rate and the changes in heating flow with respect to an empty pan were measured.

RESULT AND DISCUSSION

Figure 1 show the typical DSC thermograms for $Se_{90}Cd_{10-x}In_x$(x=2,4,6,8) at a particular heating rate of 10K/min. It is clear from Fig.1 that well defined endothermic and exothermic peaks are

observed at glass transition temperature(T_g) and crystallization temperature(T_c) respectively. The value of glass transition temperature(T_g) and crystallization temperature(T_c) for all the glassy alloys at 10K/min heating rates are given in table 1.
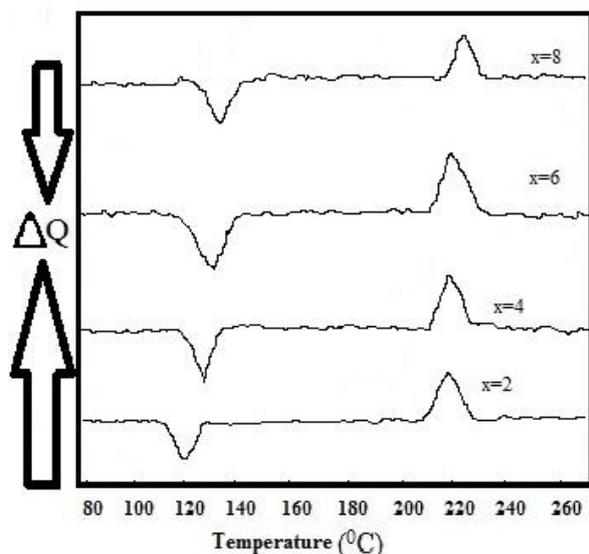

Fig.1. DSC Thermograms for glassy $Se_{90}Cd_{10-x}In_x$(x=2,4,6,8) alloys at heating rate of 10K/min.

Table 1. Values of glass transition temperature(T_g) and crystallization temperature(T_c) of glassy $Se_{90}Cd_{10-x}In_x$(x=2,4,6,8) alloys.

S. No.	Samples	$T_g(^0C)$	$T_c(^0C)$
1.	$Se_{90}Cd_8In_2$	120	218
2.	$Se_{90}Cd_6In_4$	126	219
3.	$Se_{90}Cd_4In_6$	128	220
4.	$Se_{90}Cd_2In_8$	130	224

From table 1 it is clear that glass transition temperature (T_g) and crystallization temperature (T_c) increases with increase in In content in Se-Cd matrix. In the present Se-Cd-In system the various bonds involved are Se-Cd,Cd-In, Se-In, Se-Se, Cd-Cd etc.

Addition of In leads to the formation of Se-In bonds at the expense of Se-Se bonds. When the atomic percentage of In is increased in Se-Cd-In glassy system, In is expected to combine preferably with Se. This results in decreasing Se-Se bonds. The number of the Se-In bonds increases with increasing In content. This explain the increase in glass transition temperature(T_g) with the increase in In content due to the formation of large number of hetropolar Se-in bonds and decrease in homopolar Se-Se, Cd-Cd bonds [12].

CONCLUSIONS

Glassy alloys of $Se_{90}Cd_{10-x}In_x$(x=2,4,6,8) were prepared by melt quench technique. Differential Scanning Calorimetric (DSC) studies have been carried out on the present sample. It has been observed that both glass transition temperature (T_g) and crystallization temperature (T_c) increases with increase in In content in Se-Cd matrix, which can be attributed to formation of large number of hetropolar Se-In bonds and decrease in homopolar Se-Se, Cd-Cd bonds.

REFERENCES

[1] H.F. Hamann, O.M. Boyle, Y.C. Martin, M. Rooks, H.K. Wickramasinghe, Nat. Mater.5 (2006) 83.

[2] M. Bayindir, O. Shapira, D.S. Hinczewski, J. Viens, A.F. Abouraddy, J.D. Joannopoulos, Y. Fink, Nat. Mater. 4 (2005) 820.

[3] S.A. Mcdonald, G. Konstantatos, S. Zhang, P.W. Cyr, E.J.D. Klem, L.

Levina, W.H. Sargent, Nat. Mater. 4 (2005) 138.

[4] H. Fritzsche, J. Phys. Chem. Solids 68 (2007) 878.

[5] V. Balitska, O. Shpotyuk, H. Altenburg, J. Non-Cryst. Solids 352 (2006) 4809.

[6] A. Ganjoo, H. Jain, C. Yu, R. Song, J.V. Ryan, J. Irudayaraj, Y.J. Ding, C.G. Pantano, J. Non-Cryst. Solids 352 (2006) 584.

[7] G. Boudebs, S. Cherukulappurath, M. Guignard, J. Troles, F. Smektala, F. Sanchez, Opt. Commun. 230 (2004) 331.

[8] P. Pattanayak, S. Asokan, Europhys. Lett.75 (2006) 778.

[9] Abhay Kumar Singh,Neeraj Mehta, Kedar Singh,Physica B, 404 (2009) 3470.

[10] D.K.dwivedi,NiteshShukla,H.P.Pathak,KedarSingh,American Journal of Materials Science and Engineering 2(2) (2014) 13.

[11] N.Mehta,M.Zulfequar,A.kumar, Journal of Optoelectronics and Advanced Materials 6(2) (2004) 441.

[12] Manish Saxene, Bull.Mater.Sci. 27(6) (2004) 543.