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Kinetics of non-isothermal crystallization and glass transition phenomena in $Ga_{10}Se_{87}Pb_3$ and $Ga_{10}Se_{84}Pb_6$ chalcogenide glasses by DSC

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ABSTRACT

The crystallization process affects solid properties through the crystal structure and morphology established during the transition process. An important aspect of the crystallization process is its kinetics, both from the fundamental point of view of amorphous material as well as the modeling and phase transition. In the present research work, non-isothermal crystallization data in the form of heat flow vs. temperature curves has been studied by using some well known models for amorphous $Ga_{10}Se_{87}Pb_3$ and $Ga_{10}Se_{84}Pb_6$ chalcogenide glasses, prepared by the melt quenching technique. The glass transition phenomena and crystallization of these glasses have been studied by using non-isothermal differential scanning calorimetery (DSC) measurements at constant heating rates of 5, 10, 15, 20, 25 and 30 K/min. The glass transition temperature (T_g), crystallization temperature (T_c), and melting temperature (T_m) were determined from DSC thermograms. The dependence of T_g and T_c on the heating rate was used to determine different crystallization parameters such as the order parameter (n), the glass transition energy (ΔE_g) and the crystallization activation energy (ΔE_c). The results of crystallization were discussed on the basis of different models such as Kissinger's approach and the modification for non-isothermal crystallization in addition to Johnson, Mehl, Ozawa and Avrami.

1. Introduction

The great development of modern science and technology has led to the synthesis of new chalcogenide alloys with different compositions to fabricate new materials which can be used to make more advanced and cheap solid state electronic devices. Chalcogenide glasses based on chalcogen elements (S, Se and Te) are attractive and widely investigated materials as they possess high optical transparency in the IR region. They have low phonon energy, high photosensitivity, easy fabrication and good chemical durability. So, they are used in ultrafast optical switches, frequency converters, optical amplifiers, optical recording devices, integrated optics, infrared lasers etc.

Kinetic studies are always connected with the concept of activation energy. The activation energy in the glass transition phenomenon is associated with nucleation and growth process. Studies of the glass transition and crystallization of a glass upon heating can be interpreted in terms of several theoretical models. The study of crystallization kinetics using the differential scanning calorimetry (DSC) methods has been widely used. Thermally activated transformations in the solid state can be investigated by isothermal or non-isothermal experiments. Experiments performed at constant heating rate are the most rapid way for studying the transformation, while isothermal experiments are generally time consuming. DSC is one of the important tools to study of glass transition phenomena and crystallization kinetics, which has been widely discussed in the literature [1–9]. Zhang et al. [10] has studied the crystallization kinetics of $Si_{15}Te_{85}$ and $Si_{20}Te_{80}$ chalcogenide glasses, El-Raheem et al. [11] has studied the crystallization kinetics determination of $Pb_{15}Ge_{27}Se_{58}$ chalcogenide glass by using the various heating rates method, Elabbar et al. [12] has studied the crystallization kinetics study of $Pb_{4.3}Se_{95.7}$ chalcogenide glass using DSC technique, Aly et al. [13] has studied the effect of Te additions on the glass transition and crystallization kinetics of $(Sb_{15}As_{30}Se_{55})_{100-x}Te_x$ amorphous solids.

The work on structural characterization and phase transformation kinetics of $Se_{58}Ge_{42-x}Pb_x$ chalcogenide glasses by Deepika et al. [14], crystallization kinetics and composition dependence of some physical properties of Sn–Sb–Bi–Se chalcogenide glasses by Ahmad et al. [15], studying the crystallization behavior of $Se_{85}S_{10}Sb_5$ chalcogenide semiconducting glass by Shapaan et al. [16], on the glass transition phenomenon in Se–Te and Se–Ge based ternary chalcogenide glasses by Mehta et al. [17], kinetics of crystallization in glassy $Se_{70}Te_{30-x}Zn_x$ using DSC technique by Srivastava et al. [18], calorimetric studies of $Se_{75}Te_{15}Cd_{10}$ and $Se_{75}Te_{10}Cd_{10}In_5$ multicomponent chalcogenide glasses by Kumar et al. [19], measurements of DSC isothermal

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