Enthalpy relaxation and microstructure evolution in hyperquenched SiO2–Al2O3-ZrO2 system

Zhang, Y.F.; Zhao, D.H.; Yue, Yuanzheng

Published in:
The 24th International Congress on Glass - Abstracts

Creative Commons License
Unspecified

Publication date:
2016

Document Version
Publisher's PDF, also known as Version of record

Link to publication from Aalborg University

Citation for published version (APA):
Enthalpy relaxation and microstructure evolution in hyperquenched \( \text{SiO}_2-\text{Al}_2\text{O}_3-\text{ZrO}_2 \) system

Y. F. Zhang\(^1\), D. H. Zhao\(^2\), Y. Z. Yue\(^1,3\)

\(^1\)Key Laboratory of Processing and Testing Technology of Glass & Functional Ceramics of Shandong Province, Qilu University of Technology, Jinan 250333, China
\(^2\)Unifrax I LLC, Tonawanda, NY 14150, USA
\(^3\)Department of Chemistry and Bioscience, Aalborg University, 9220 Aalborg, Denmark

Zhang-yanfei@hotmail.com

A study of the sub-\( T_g \) enthalpy relaxation in glass far from equilibrium is crucial for understanding nature of glass. Recently, considerable progress has been made towards understanding the sub-\( T_g \) enthalpy relaxation in glass by using the hyperquenching-annealing calorimetry (HAC) method\(^{1,2}\) as well as modeling. However, most of the sub-\( T_g \) enthalpy relaxation studies have been done on stable oxide glass systems, i.e., those with low tendency to crystallization. Only a very few studies have been carried out on extremely unstable glasses.\(^{1}\) In order to get a broad picture about glass relaxation and glass transition, it is also necessary to investigate those extremely poor glass formers. Such investigation can provide valuable information on the structural heterogeneity in glass and liquid.

In this work, we study sub-\( T_g \) enthalpy relaxation and microstructure evolution of an extremely unstable glass former, i.e., a ternary oxide system \( \text{SiO}_2-\text{Al}_2\text{O}_3-\text{ZrO}_2 \). This special glass system arouses our interests mainly from three aspects. First, it is a material with broad applications in high temperature insulation. Second, it is obtained by hyperquenching \((-10^9 \text{ K/s})\) the liquid during which high potential energy is frozen in. In the subsequent sub-\( T_g \) annealing process, the frozen-in energy will be gradually released, providing opportunities to study its microstructure evolution and sub-\( T_g \) enthalpy relaxation. The amorphous nature of the as-produced glass is verified by the X-Ray Diffraction (XRD) pattern as shown in Figure 1. Thirdly, it is an extremely unstable glass against crystallization since its crystallization peak overlap with the glass transition peak in the isobaric heat capacity \( (C_p) \) curve. The results show that the structural ordering can take place during multiple DSC upscans from 333 to 1260 K at 20 K min\(^{-1}\). In addition, the dynamics of microstructure evolution during sub-\( T_g \) annealing is also studied by XRD, high resolution transmission electron microscopy (HRTEM) and nuclear magnetic resonance (NMR). This work provides insight into both the thermal and structural origin of the extremely poor glass forming ability in \( \text{SiO}_2-\text{Al}_2\text{O}_3-\text{ZrO}_2 \) glass.


Figure 1. XRD patterns of both the fresh sample (HQ \( \text{SiO}_2-\text{Al}_2\text{O}_3-\text{ZrO}_2 \) glass, in black) and the sample after multiple (5) DSC upscans in red).

Figure 2. Isobaric heat capacity \( (C_p) \) against temperature for the HQ \( \text{SiO}_2-\text{Al}_2\text{O}_3-\text{ZrO}_2 \) glass subjected to multiple DSC upscans. Structural ordering could take place during the multiple upscans in DSC.