Tracking the atomic structural modification of uniaxial compressed glasses around glass transition temperature by Brillouin and Infrared spectroscopy

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Abstract

With an increase of need of photonic applications like glass fibers for high-speed internet the role of glass and the precise production gains more and more importance. The controlled processing of glasses makes an essential contribution to the final product. Among others, uniaxial deformation of glasses at high temperatures is performed for fiber drawing, extrusion and precision molding. During these processes, a change of reflective index is induced by the deformation and temperature, the phenomenon of which is already known. However, so far, the modifications of the atomic structure which is leading to this change are not understood. With an insight of the atomic alignment and more information of its influencing parameter, an exact control of the refractive index change could be realized. Knowing the way different glass systems will react to the deformation would help to decide suitable glass for specifically desired applications.

For this study, glass cylinders of comparable geometries were compressed uniaxially at temperatures of the glass transition temperature and below. The compression experiments were performed with different loads at constant temperature. Afterwards the samples were cooled down with defined cooling rates. For each deformation temperature, a reference sample with the same thermal history, which includes heating, holding and cooling, was produced. The use of the glass transition temperature still enables the deformation of the glass. The cooling time simultaneously is decreased to minimize relaxation and therefore its structural effects. The compressive load conditions allow then tracking the structural modifications.

Brillouin spectroscopic measurements were performed after the deformation experiments at room temperature with the aim to observe different regions impacted by the deformation. Therefore, the edges, intermediate areas and centers of the face sides of the samples were subjected to the measurements. The effect of different applied loads (2, 5 and 20 kN) and temperatures (0.9Tg, 0.97Tg and Tg) was analyzed for 3 different glass systems. In addition, the Brillouin measurements were compared with photo-elastic circular polarized observations to examine if links can be found. Complementary infrared mapping will be presented to try to track more specifically the evolution of the network modifier environment.

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