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Pressure-Induced Changes in Inter-Diffusivity and Compressive Stress in Chemically Strengthened Glass

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ABSTRACT

Glass exhibits a significant change in properties when subjected to high pressure, since the short- and intermediate-range atomic structures of a glass are tunable through compression. Understanding the link between the atomic structure and macroscopic properties of glass under high pressure is an important scientific problem, since the glass structures obtained via quenching from elevated pressure may give rise to properties unattainable under standard ambient pressure conditions. In particular, the chemical strengthening of glass through Na^+-for-K^+ ion exchange is currently receiving significant interest due to the increasing demand for stronger and more damage resistant glasses. However, the interplay among isostatic compression, pressure-induced changes in alkali diffusivity, compressive stress generated through ion exchange, and the resulting mechanical properties are poorly understood. In this work, we employ a specially designed gas pressure chamber to compress bulk glass samples isostatically up to 1 GPa at elevated temperature before or after the ion exchange treatment of a commercial sodium-magnesium aluminosilicate glass. Compression of the samples prior to ion exchange leads to a decreased Na^+-K^+ inter-diffusivity, increased compressive stress, and slightly increased hardness. Compression after the ion exchange treatment changes the shape of the potassium-sodium diffusion profiles and significantly increases glass hardness. We discuss these results in terms of the underlying structural changes in network-modifier environments and overall network densification.