Load and Compositional Dependence of Strength in Calcium Aluminosilicate Glasses

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Knowing how calcium aluminosilicate (CAS) glasses resist permanent deformations is essential for understanding their mechanical behaviors for a wide range of applications. Here we elucidate the functional dependence of modulus, hardness, densification and shear flow in the pressure and composition spaces. We chose a family of CAS glasses with constant CaO/Al2O3ratio and varying SiO2content, as well as a commercial ~100% SiO2glass. We perform a series of microindentation tests coupled with AFM surface measurements on each indent. Using a method proposed by Yoshida et al., we reveal and quantify the densification and shear flow, responsible for the inelastic energy dissipation. The reduction of hardness, caused by indentation size effect (ISE), is shown to be compositionally dependent; glasses with higher silica content show a greater reduction in their hardness. We demonstrate that this is intimately linked with the inelastic deformation processes, as glasses with larger silica content also experience a reduction in contribution in shear flow and an increase in densification for a fixed load. Finally, we show that the compositional dependence of the inelastic behaviors are positively correlated with the atomic packing density and Poisson's ratio of the glass, confirming that these properties also governs the ISE.