Fracture toughness and indentation cracking resistance in the Na2O-Al2O3-B2O3-SiO2 chemical system

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Abstract

Due to an increasing demand for oxide glasses with a better mechanical performance, there is a need to improve our understanding of the composition-structure-mechanical property relations in these brittle materials. At present, some properties such as Young's modulus can to a large extent be predicted based on the chemical composition, while others – in particular fracture-related properties – are typically optimized based on a trial-and-error approach. In this work, we study the mechanical properties of a series of twenty glasses in the quartenary Na2O-Al2O3-B2O3-SiO2 system with fixed soda content, thus accessing different structural domains. Ultrasonic echography is used to determine the elastic moduli and Poisson's ratio, while Vicker's indentation is used to determine hardness, as well as the resistance to indentation cracking. Furthermore, the Single-Edge-Precracked-Beam (SEPB) method is used to estimate the fracture toughness (KIc) for some compositions of interest. KIc data are then compared to the predicted values derived by means of a model based on the strength of the bonds supposed to be involved in the fracture process. The correlations among crack resistance, toughness, and elasticity are discussed in the light of structural features such as the fraction of non-bridging oxygens and boron speciation.

Keywords: fracture toughness, indentation cracking, SEPB, mechanical properties

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