Tuning Mechanical Properties of Aluminoborate Glasses by Modifier Substitution

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Resumo:
Aluminoborate glasses exhibit a superior resistance to sharp contact-induced cracking compared to most silicate glasses, which reduces the risk of initiating catastrophic fracture. The high crack resistance is associated with the ability of the glasses to adapt the connectivity of their network under compressive stress, which facilitates densification and thus aids in dissipation of the energy supplied during impact. However, the influence of modifier oxides (e.g., alkali or alkaline earth) on the mechanical performance and on the degree of network self-adaptivity under stress of aluminoborate glasess has not been investigated. Here, we study two series of melt-quenched R2O (R = Cs, Rb, K, Na, and Li) and RO (R = Ba, Sr, Ca, and Mg) containing aluminoborate glasses with fixed Al/B molar ratio. We examine their mechanical properties including Vicker’s hardness, Young’s modulus, and crack resistance using micro-indentation and ultrasonic echography. We also probe the coordination environments of the network-forming Al and B atoms through solid state nuclear magnetic resonance spectroscopy. We correlate the compositional trends in mechanical properties to the strength of the R–O bond as well as the underlying structural features. We find that hardness and modulus increase with increasing bond strength, while crack resistance displays a non-monotonic composition variation, which can be explained by significant differences in connectivity of the investigated networks.