Advances and Challenges in Designing Damage Resistant Oxide Glasses

Invited Talk

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Advances and Challenges in Designing Damage Resistant Oxide Glasses

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Oxide glasses are brittle materials, i.e., they cannot deform plastically on the macroscale without fracture, which seriously limits the scope of their applications. As such, it is important to avoid the formation of strength-limiting surface cracks, but the resistance to crack initiation in these materials remains poorly understood. In this talk, we review recent advances and challenges in designing new damage resistant, and potentially tough, oxide glass compositions. First, we consider the use of Poisson's ratio (ν) as a surrogate for ductility, based on the observed brittle-to-ductile transition in metallic glasses. In order to accelerate the search for high-ν compositions, we test the previously proposed relationships of Poisson's ratio with atomic packing density, indentation deformation mechanism, and liquid fragility. Then, we investigate a recently proposed model for predicting the composition dependence of fracture toughness based on the strength of the bonds assumed to be involved in the fracture process. Finally, we explore the possibility to improve crack resistance, and thus the practical strength, through composition optimization. We show that a bulk, transparent, melt-quenched aluminoborate glass can survive Vickers indents at loads as high as 50 kgf without forming any strength-limiting cracks. In order to further tune the structure of such aluminoborate glasses to achieve high crack resistance, we also explore the possibility to predict their network former speciation using a statistical mechanical approach.