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A structural approach towards the design of a hard and crack-resistant Al₂O₃–rich glass

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Designing new glasses with excellent ability to resist stress-induced crack initiation and growth is of utmost importance for advanced glass applications. Al₂O₃–rich glasses have been shown to possess both high hardness (HV) and crack resistance (CR). However, their limited glass forming ability and extremely high processing temperatures (>1800°C) constrains them to the realms of academic research. In this study, we report on the structural design of a hard (HV > 7 GPa at 200 gf Vickers load), crack-resistant glass with Al₂O₃ ≳ 30 mol.%. The as-designed glass can be synthesized by conventional melt-quench technique at temperature ≤ 1675°C and can be produced in any desired shape and size. The Vickers’ hardness of the annealed glass was measured to be ≥7 GPa at 200 gf, while no cracks were observed up to 2 kgf load under ambient conditions. The MAS-NMR spectroscopy adjoined with atomic force microscopy (AFM) and simulated nano-indentation studies have been employed to understand the structural origin of the elastic and mechanical properties of this glass.