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Compositional Control of Sub-Critical Crack Growth in Silicate Glasses

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Improving the mechanical reliability of glass and its resistance to breakage is important for enabling advanced glass applications. The presence of water in the surrounding atmosphere can cause sub-critical crack growth (SCCG) in glasses, a phenomenon known as fatigue or stress corrosion. To facilitate the compositional design of more fatigue-resistant glasses, we here investigate the composition dependence of SCCG by studying fourteen silicate glasses [1]. The fatigue curves (V-K_I) have been obtained by indentation experiments through measurements of the crack length as a function of post-indentation fatigue duration. Interestingly, we find that the fatigue resistance parameter N is generally improved by increasing the alumina content and is thereby found to exhibit a fairly linear dependence on the measured Vickers hardness H_V for a wide range of N and H_V values. This finding highlights the important role of network topology in governing the SCCG in silicate glasses, since hardness has been shown to scale linearly with the number of atomic constraints [2-5]. Our results therefore suggest that glasses showing under-constrained flexible networks, which feature floppy internal modes of deformation, are more readily attacked by water molecules, thus promoting stress corrosion and reducing the fatigue resistance.

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