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Influence of Phase Separation Morphology on the Mechanical Properties of Transparent Modifier-Free Glasses

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The mechanical properties of oxide glasses can be improved by various extrinsic and intrinsic approaches, but many of these techniques will lead to a loss of transparency. Furthermore, it is difficult to simultaneously optimize multiple mechanical properties, such as resistances to both crack initiation and growth. Here, we use heat treatment to control the size of nanoscale droplets in a phase-separated B_2O_3-SiO_2-Al_2O_3-P_2O_5 glass without traditional modifiers and explore the effect of phase separation on the mechanical properties. The melt-quenched version of this glass already exhibits phase separation with a droplet phase rich in B_2O_3. The glass transition temperature of the droplet phase is lower than that of silica-rich glass matrix. By controlling the heat treatment temperature, the size and fraction of the droplet phase changes. We show that the mechanical properties of the glass can be improved while maintaining transparency. Overall, this work shows that nanoscale phase-separation can be used to produce transparent oxide glasses with improved toughness and crack resistance.