Improving the Fracture Toughness of Oxide Glasses through Bond Switching

Smedskjær, Morten Mattrup; To, Theany; Sørensen, Søren Strandskov; Christensen, Johan Frederik Schou; Christensen, Rasmus; Jensen, Lars Rosgaard; Bockowski, Michal; Bauchy, Mathieu

Publication date:
2021

Improving the Fracture Toughness of Oxide Glasses through Bond Switching

Morten M. Smedskjaer[1], Theany To[1], Søren S. Sørensen[1], Johan F. S. Christensen[1], Rasmus Christensen[1], Lars R. Jensen[2], Michal Bockowski[3], Mathieu Bauchy[4]

[1] *Department of Chemistry and Bioscience, Aalborg University, Aalborg, Denmark*
[2] *Department of Materials and Production, Aalborg University, Aalborg, Denmark*
[3] *Institute of High-Pressure Physics, Polish Academy of Sciences, Warsaw, Poland*
[4] *Department of Civil and Environmental Engineering, University of California, Los Angeles, USA*

The low fracture toughness and practical strength of oxide glasses continue to be their Achilles heel, limiting both future applications and the possibility to make thinner, more environmentally-friendly glasses. In this work, we show that through control of a bond switching mechanism, record-high values of fracture toughness for transparent bulk oxide glasses can be achieved. Specifically, this is achieved by gas-mediated permanent densification of a structurally adaptive lithium aluminoborate glass. The fracture toughness of this densified bulk glass (1.4 MPa $m^{0.5}$) is twice as high as that of standard window glass (0.7 MPa $m^{0.5}$). Classical molecular dynamics simulations reveal that the permanent densification enables more coordination number changes and bond swapping during deformation, ultimately enhancing the degree of plasticity and toughness upon fracture.

Reference: To T., Sørensen S. S., Christensen J. F. S., Christensen R., Jensen L. R., Bockowski M., Bauchy M., Smedskjaer M. M. Bond switching in densified oxide glass enables record-high fracture toughness. *ACS Applied Materials & Interfaces* **13**, 17753-17765 (2021).