Towards the Design of Indentation Crack Resistant Oxide Glasses

Invited Talk

Smedskjær, Morten Mattrup

Publication date:
2018

Towards the Design of Indentation Crack Resistant Oxide Glasses (Invited Talk)

Morten M. Smedskjaer

Department of Chemistry and Bioscience, Aalborg University, DK-9220 Aalborg, Denmark
e-mail : mos@bio.aau.dk

Keywords: crack resistance, oxide glasses, deformation mechanism, self-adaptivity

Despite their transformative role in our society, oxide glasses suffer from inherent brittleness and poor crack resistance, limiting their future applications. Impact or scratch events can lead to formation of cracks that amplify local tensile stresses, resulting in catastrophic failures. Therefore, increasing the hardness and crack resistance of glasses is critical for the development of damage resistant and mechanically durable glasses [1,2]. These properties can conventionally be measured using instrumented indentation that mimics the real-life damage for certain applications. Early indentation experiments have shown that oxide glasses exhibit pronounced tendency to densify under compressive load. Knowledge of the indentation deformation mechanism is crucial for understanding the link between chemical composition and resistance to cracking in oxide glasses, since densification is an efficient way to dissipate the elastic energy applied to the material during indentation. Here, we discuss how knowledge of the deformation mechanism and the accompanying structural changes in the glassy network can be used to design crack resistant glasses. We have recently discovered that melt-quenched alkali aluminoborate glasses exhibit superior resistance to sharp contact-induced cracking compared to most oxide glasses [3,4]. The high crack resistance is associated with the ability of the glasses to self-adapt the connectivity of their network under compressive stress, which facilitates densification and thus aids in dissipation of the energy supplied during impact.

Acknowledgement
This work was supported by VILLUM FONDEN under research grant no. 13253.

References
1) Smedskjaer M. M., Mauro J. C., Yue Y. Z. Prediction of Glass Hardness Using Temperature-Dependent Constraint Theory. *Physical Review Letters* **105**, 115503 (2010).
2) Mauro J. C., Tandia A., Vargheese K. D., Mauro Y. Z., Smedskjaer M. M. Accelerating the Design of Functional Glasses through Modeling. *Chemistry of Materials* **28**, 4267-4277 (2016).
3) Januchta K., Youngman R. E., Goel A., Bauchy M., Rzoska S. J., Bockowski M., Smedskjaer M. M. Structural Origin of High Crack Resistance in Sodium Aluminoborate Glasses. *Journal of Non-Crystalline Solids* **460**, 54-65 (2017).
4) Januchta K., Youngman R. E., Goel A., Bauchy M., Logunov S. L., Rzoska S. J., Bockowski M., Jensen L. R., Smedskjaer M. M. Discovery of Ultra-Crack-Resistant Oxide Glasses with Adaptive Networks. *Chemistry of Materials* **29**, 5865-5876 (2017).