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Mapping densification and cracking in glass using nanofocus X-ray scattering

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The practical strength of oxide glasses is greatly reduced by surface flaws that form during processing and use. Instrumented indentation can mimic such real-life damage events and induce flaws and cracking under controlled conditions. At the same time, instrumented indentation allows for systematic examination of the deformation and structural changes of the regions of the glass being indented. However, structural probing is nearly always performed after rather than during the sharp contact event, limiting our understanding of the indentation process. To overcome this, we here demonstrate the use of nanofocus X-ray scattering experiments to probe the local mechanical and structural response of vitreous silica during indentation. Two-dimensional mapping of the scattering pattern in the zone below a sharp diamond wedge indenter reveals local changes in the atomic structure and density as well as cracking behavior. These in situ experiments during indentation reveal the formation and evolution of the densification zone and cracking with nanoscale resolution. Understanding the interplay between structural densification and cracking behavior in glasses is deepened through this work, which is crucial for the development of more damage-resistant and thus stronger glasses as well as fundamental understanding of glass deformation mechanisms.

Morten Matrup Smedskjaer is a professor at the Department of Chemistry and Bioscience, Aalborg University, where he is head of the Oxide Glass Chemistry Group. His research area is glass and glass ceramic materials; structure/professional ratio; mechanical properties of amorphous solids; topological and structural modelling; molecular dynamics; machine learning.