

INFLUENCE OF DENSIFICATION ON THE INDENTATION CRACKING BEHAVIOR

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Nanoindentation is a versatile method to study the plastic deformation and cracking behavior of glasses on various length scale. For fused silica, plastic deformation occurs by volume conservative shear flow and inelastic densification. The Drucker-Prager-Cap (DPC) plasticity finite element analysis approach was used to describe the yield surface of fused silica by an ellipsis. This approach was extended by the implementation of a sigmoidal hardening behavior to take densification saturation into account. Cohesive Zone (CZ) FEM was used to model indentation cracking along median/radial axis. By using Raman spectroscopic mapping of indents and literature data on high pressure densification, the behavior of the finite element analysis approach to describe the densification profiles of indents is determined. Further the sensitivity of estimating densification from shifts in the Raman signal was investigated for different indent sizes. The results show that the precision of the densification estimate increases with indentation size and a rule of thumb for an appropriate experimental set-up is proposed. The extended Drucker-Prager-Cap approach in FEA delivers an accurate description of the densification field of a pyramidal indentation (i.e. Berkovich or Vickers) of silica glass and reproduces experimental data remarkably better than the conventional model. In CZ-FEM densification inhibits the crack extension by a factor of 15 % compared to the case of pure shear flow. This factor however is significant smaller than improvements in fracture behavior, which are often attributed to densification found in literature. For pillar splitting densification plays a negligible role.