CONSTITUTIVE MODELING OF INDENTATION CRACKING IN FUSED SILICA

Sebastian Bruns, Physical Metallurgy, TU Darmstadt, Germany
s.bruns@phm.tu-darmstadt.de
Kurt E. Johanns, Physical Metallurgy, TU Darmstadt, Germany
Hamad ur Rehman, Physical Metallurgy, TU Darmstadt, Germany
George M. Pharr, Oak Ridge National Laboratory, Tennessee
Karsten Durst, Physical Metallurgy, TU Darmstadt, Germany

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Fused silica shows three distinct regimes during nanoindentation, that is, plastic deformation, inelastic densification, and cracking. Cohesive zone FEM is used to study these regimes for different indenter geometries. In a three-dimensional model, the median/radial cracking is considered by introducing cohesive element planes that are aligned along the indenter edges perpendicular to the indented surface. In addition to comparing indentation cracking data with experimental data, the role of densification on indentation crack growth is critically examined using a pressure independent von Mises and a pressure dependent Drucker-Prager Cap constitutive model. The results show that the Drucker-Prager Cap model delivers an accurate description of the elastic-plastic deformation conditions for all examined indenter geometries. Material densification leads to shorter crack lengths and thus the approach by Lawn, Evans and Marshall (LEM) [1] results in larger indentation-based fracture toughness values (Equation 1).

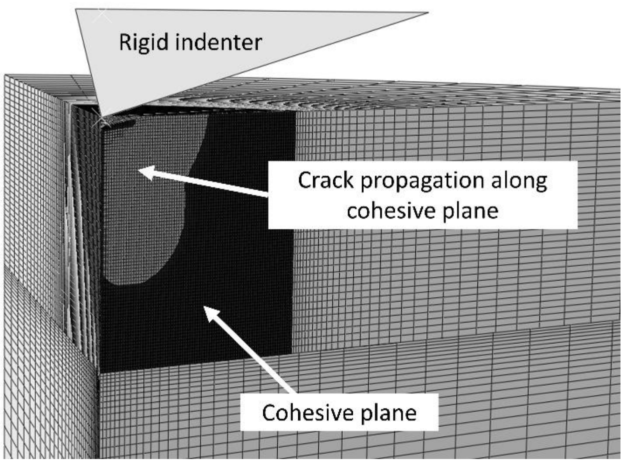

Figure 1: One sixth symmetry model of an indentation cracking process. The crack (light gray) runs along a pre-defined cohesive plane (dark gray).

$$\frac{K_{IC} \cdot c^{3/2}}{P_{max}} = \alpha \cdot \left(\frac{E}{H}\right)^{\frac{1}{2}} \quad (1)$$

Comparing in- and output fracture toughness, an overestimation of K was found for all examined indenter geometries and both constitutive laws using the common calibrations of parameter α [2, 3]. The results indicate that those calibrations are not valid for fused silica.

The results are published in the Journal of the American Ceramic Society [4].

Literature

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