Understanding the fracture behaviour of tough alumina-based ceramic inspired by nacre.

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Abstract

Millions of years of evolution have gifted natural materials with sophisticated hierarchical structures that enable them to resist fracture despite being primarily composed of brittle ceramics. Nacre stands out as having one of the simplest natural microstructures, resembling a brick-and-mortar wall, yet exhibiting many toughening mechanisms leading to a pseudo-ductile behaviour in tension. Today's nacre-like composites exhibit higher values of fracture toughness and improved crack-resistance curves compared to bulk ceramics. However, characterizing fracture in such materials remains a challenge, and understanding the link between the microstructure and the crack resistance is necessary to improve these materials further. We worked on characterizing fracture in nacre-like ceramics composed of alumina bricks with various ceramic interface, with the aim of determining the role of microstructure and composition on the mechanical response. We have developed analytical tools validated by finite element analysis to measure crack resistance curves of highly deflected and branched cracks. Supported by in-situ synchrotron tomography fracture testing and wedge splitting, we assessed the stress intensity mode-mixity at the crack tip and quantified the damage evolution in 3D. This analysis reveals important lessons on the effect of the microstructure and mortar properties to guide the improvement of these materials.

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