Effect of testing geometries and notch milling processes on micro-scale fracture energy measurements in ceramics

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Abstract

The single cantilever beam (SCB) with a straight-through notch is widely used for testing the fracture properties of brittle materials at the microscale due to its flexibility in accommodating various materials and the straightforward calculation of fracture toughness, requiring only the peak load and cantilever geometry. However, during the final notching process, ion implantation from the focused ion beam (FIB) induces residual stresses that may resist crack nucleation, resulting in a toughening effect and inflated fracture toughness values. This experimental study investigates the effect of different notching methods on the measured fracture energy of the prismatic plane in 6H-SiC with straight-through notched SCBs, focusing on reducing or eliminating FIB damage through cryo-FIB milling or post-mortem annealing. First, double cantilever beam (DCB) splitting experiments are conducted to establish baseline fracture energy values, as the stable crack growth in this geometry allows calculation of fracture energy away from the notch, mitigating potential inaccuracies in measurements near the notch surface caused by FIB damage. Results from room-temperature Ga-FIB notched SCBs showed systematic inconsistencies with the results from DCB tests. In this talk, we discuss the effectiveness of using cryo-FIB for the final notching and post-notching annealing of reducing the systematic errors in fracture energy calculation with SCB testing geometry. The findings contribute to more accurate measurements of microscale fracture properties using the widely applicable SCB geometry.

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