Fracture of Solids with Covalent Bonds

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Abstract

Solids in nano-scales hold the promise to exhibit extreme strength due to the absence of interior defects and the designability of micro-arrangements. A nano-scaled bulk sample can be made by diamond or cubic boron nitride (cBN), featuring the covalent bonds. A loading stage capable of 4-DoF movements was designed and built to achieve multi-axials mechanical loading inside a transmission electronic microscope (TEM) chamber with sub-nanometer loading precision. For single crystal diamond in the shape of nano-needles, we were able to achieve an extreme bending strength of 125GPa at the tensile side, approaching the theoretical strength of diamond. For cBN crystals, a fracture path inclined to the stacking hexagon planes would result in a new failure mechanism of layered decohesion, triggered by the extremely large elastic strain ($> 7\%$) along the edge of the sub-micron scaled specimen. These results indicate ample room for the understanding of the fracture mechanisms of solids with covalent bonds.

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