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SIZE EFFECTS AND DEFORMATION MECHANISMS IN DIAMOND AND SILICON

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At ambient temperature and pressure, most of the semiconductor materials are brittle. Traditionally, use of confining pressure via indentation or a hydrostatic confining medium [1, 2] has been required to study the plasticity of such brittle materials. In the case of group IV semiconductors (Diamond, Silicon, and Germanium) the situation is further complicated by pressure-induced phase transformations occurring underneath the indentations. However, previous work has demonstrated that sample miniaturization can also prevent the onset of cracking and allow plastic deformation [3]. Recent advances in *in situ* instrumentation have enabled micro-compression techniques to extract temperature- and time-dependent deformation parameters [5, 6]. Thus, micro-pillar compression is a promising technique for investigating the plasticity of these semiconductors in their brittle regimes.

Previous work has noted a brittle-ductile transition in Silicon which is dependent on orientation, size, and temperature. This has been tied to transitions between partial and perfect dislocations in III-V semiconductors, but the extreme brittle character of silicon has prevented characterization of plastic flow in the low temperature regimes. In this work, [123]-oriented crystals are utilized to prevent the onset of cracking and allow plastic deformation. Micro-compression is shown to be capable of achieving incredibly high stresses (>100 GPa), and this is applied to investigate the behavior of the hardest natural material - diamond - and its nearest analog – silicon.

References

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