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Diamene: Ultrahard Single Layer Diamond formed from two-layer Epitaxial Graphene upon Impact

Atomically thin graphene exhibits fascinating mechanical properties, although its hardness and transverse stiffness are inferior to those of diamond. So far, there has been no practical demonstration of the transformation of multilayer graphene into diamond-like ultrahard structures. Here we show that at room temperature and after nano-indentation, two-layer graphene on SiC(0001) exhibits a transverse stiffness and hardness comparable to diamond (Fig. 1), is resistant to perforation with a diamond indenter and shows a reversible drop in electrical conductivity upon indentation. Density functional theory calculations (Fig. 2) suggest that, upon compression, the two-layer graphene film transforms into a diamond-like film, producing both elastic deformations and sp2 to sp3 chemical changes. Experiments and calculations show that this reversible phase change is not observed for a single buffer layer on SiC or graphene films thicker than three to five layers. Indeed, calculations show that whereas in two- layer graphene layer-stacking configuration controls the conformation of the diamond-like film, in a multilayer film it hinders the phase transformation.

References

[1] Nature Nanotechnology (2018), https://doi.org/10.1038/s41565-017-0023-9

Figures

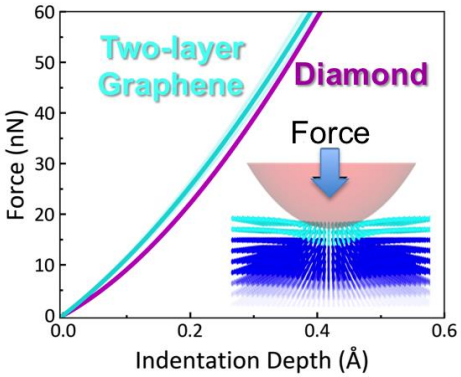

Figure 1: Experimental load vs. indentation curves showing that two-layer epitaxial graphene is stiffer than diamond.

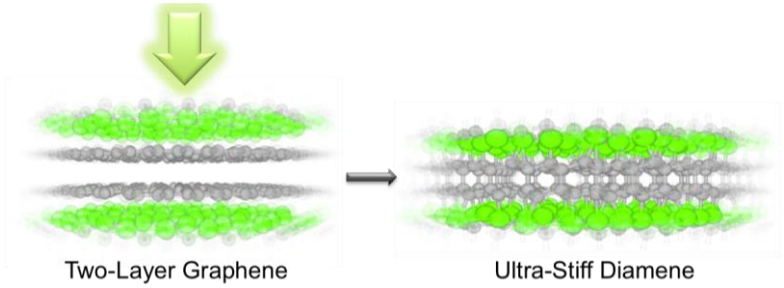

Figure 2: DFT simulations of the transformation of two-layer graphene into diamene under pressure.