Shear driven formation of nano-diamonds at sub-gigapascals and 300 K

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Abstract The transformation pathways of carbon at high pressures are of broad interest for synthesis of novel materials and for revealing the Earth's geological history. We have applied large plastic shear on graphite in rotational anvils to form hexagonal and nanocrystalline cubic diamond at extremely low pressures of 0.4 and 0.7 GPa, which are 50 and 100 times lower than the transformation pressures under hydrostatic compression and well below the phase equilibrium. Large shearing accompanied with pressure elevation to 3 GPa also leads to formation of a new orthorhombic diamond phase. Our results demonstrate new mechanisms and new means for plastic shear-controlled material synthesis at drastically reduced pressures, enabling new technologies for material synthesis. The results indicate that the micro-diamonds found in the low pressure-temperature crust could have formed during a large shear producing event, such as tectonic rifting and continued plate collision, without the need to postulate subduction to the mantle.

Keywords: graphite-diamond phase transformation; shear strain; sub-gigapascal