Flow Mechanism and Constitutive Law of Nano- & Micron-grained Superhard cBN: *In-situ* Deformation Study at Simultaneous High Pressure and Temperature

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Cubic boron nitride (cBN) as classical superhard material is technologically significant because of its extreme hardness, large bulk moduli, high melting temperature, and high thermal conductivity. It is currently used under high-stress conditions from cutting, grinding to drilling. As the second hardest material known to mankind, cBN is experimentally difficult to deform, particularly at room temperature. The current knowledge of the plastic deformation in cBN is mainly from the first principles calculations and experiments under uncontrolled stress conditions. The strain-stress relation, which is fundamentally important to the understanding of the plasticity of cBN, has yet to be established under both room and elevated temperatures. Furthermore, it is unknown how much difference there is in the strain-stress relation and flow mechanism between nano- and micron-grained samples. Here we report the strain-stress relations and the evolution of deformation mechanism in cBN at high pressure. The in-situ deformation experiments were carried out at 6-BM-B of APS (formerly X17B2 at NSLS-I) using the D-DIA module and sintered polycrystalline diamond anvils. The recovered samples were investigated using transmission electron microscope at CFN of BNL. Lattice distortion and boundary sliding on {111} plane dominate the deformation path of nano- and micron-grained cBN without plastic yielding at uniaxial strains up to 15% at room temperature. Crystals of cBN reveal remarkable ductile flow at moderate temperatures of 1000 °C and 1200 °C. Surprisingly, nano-grained cBN crystals exhibit a smaller micro-stress than micron-grained cBN at 1200 °C. At high temperature, the plastic flow in cBN is meditated by partial dislocations and micro-twinning.