Nano-polycrystalline diamond synthesized through the decomposition of stearic acid under high pressure and high temperature condition

*Hideaki Kawamura[1], Hiroaki Ohfuji[1]

1. Geodynamics Research Center, Ehime University

Nano-polycrystalline diamond (NPD) synthesized by the direct conversion of graphite under high pressure and high temperature conditions (15-25 GPa, 2000-2500℃) has an ultra-high hardness and superior mechanical properties and is therefore widely used for various industrial and scientific applications. In the present study, we found a novel route for synthesizing NPD using stearic acid ($C_{18}H_{36}O_2$) as a starting material. The temperature condition required for the synthesis of transparent NPD from stearic acid is as low as 1000℃ at 13 and 17 GPa, which is surprisingly lower (by ~1000℃) than those for the conventional NPD synthesis using graphite and related carbon sources such as glassy carbon. We also characterized the microtexture and crystallographic feature of the products recovered from a wide range of temperature and pressure conditions using TEM and discussed the formation mechanism from stearic acid at significantly lower temperatures. The samples recovered from 13 and 17 GPa are transparent NPD composed of extremely fine diamond crystals with grain sizes smaller than 20 nm. In contrast, those synthesized at 10 GPa are composed exclusively of graphite, whose crystallinity and grain size clearly change from almost amorphous like to platy crystals up to 100 nm with heating temperature.

Our study suggests that the amorphous-like, extremely poorly crystalline carbon produced by the thermal decomposition of stearic acid provides preferential nucleation sites for diamond and significantly lower the activation energy for diamond formation. The removal of volatile components such as H_2O generated through the stearic acid decomposition from the system is also important to obtain pore-free transparent NPD. Our finding would open up new possibilities for further sizing-up of NPD samples (at present 1 cm both in diameter and height at maximum) at moderate temperature and pressure, which will be essential for new and advanced applications of NPD in both scientific and industrial fields.

Keywords: Nano-polycrystalline diamond (NPD), High Pressure, C-H-O fluid, TEM

