Pressure-temperature-induced transformations of polyhedral carbon nanoparticles in hydrogen-containing system

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Transformations of polyhedral carbon nanoparticles (PCN) in the hydrogen-containing system have been studied in the framework of investigations of relative stability of different carbon allotropes at high pressures and temperatures in pure carbon and hydrocarbon systems.

The present work has been carried out on binary mixtures of PCN with naphthalene. Homogeneous mixtures of PCN with the initial sizes in the 30-80 nm range with naphthalene have been treated under pressure of 8 GPa, variable temperatures up to 1600°C and isothermal exposure times from 20 to 300 s. High-pressure states obtained at different temperatures have been isolated by quenching to room temperature under pressure followed by characterization of the samples at normal conditions by X-ray diffraction, Raman spectroscopy and scanning electron microscopy (SEM).

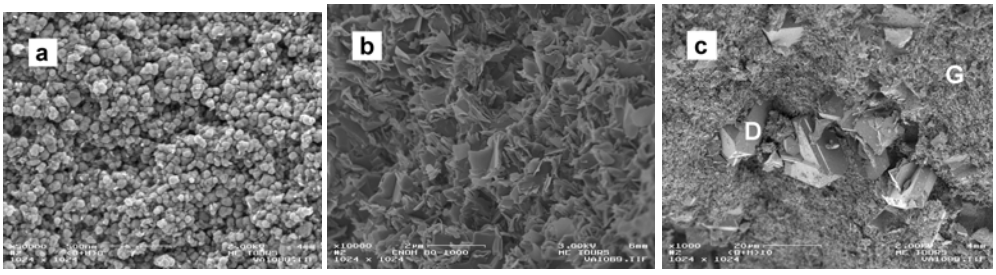

Figure 1. SEM images of treatment products of binary mixtures of PCN with naphthalene at 8 GPa and temperatures of 800 °C (a), 1000°C (b), 1100°C (c): D – diamond, G – graphite.

An evolution of high-pressure carbon states as a function of temperature has been studied. As the result, qualitative distinction of the mechanism of PCN transformations in the single-component carbon system from binary hydrocarbon system has been established. Even tiny amount of hydrogen, remaining at the final step of naphthalene carbonization at 8 GPa in the temperature range 800-1000°C, becomes sufficient for catalyzing the processes of PCN destruction and subsequent cumulative recrystallization of carbon material. At 8 GPa, the destruction of PCN in the binary system starts at ~900°C. Cumulative recrystallization of the system results in formation of micron-sized crystallites of graphite at 1000°C and diamond at temperatures above 1100°C (Figure 1).

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