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Different mechanisms of diamond-graphite transformation: an experimental study

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Graphite-coated diamonds frequently occur as inclusions in refractory minerals (e.g. garnet, clinopyroxene, zircons) in ultrahigh pressure metamorphic (UHPM) rocks and the partial graphitization of diamond is predominant model to explain the coexistence of diamond and graphite (Massonne et al., 1998; Ogasawara et al., 2000; Dobrzhinetskaya et al., 2003). However, short UHP event and fast exhumation rates should prevent significant diamond-graphite transformation. Recently experimental studies of partial graphitization of diamond crystal (up to 40 μm in size) reveal that this processes is quite fast even at temperature about 1000C (Pantea et al., 2002, Quian et al., 2004 and references therein) in the “wet” systems, but negligible in the “dry” systems.

In this study we used synthetic diamond crystals of cubo-octahedron form and natural octahedron and cuboid diamonds. The size of crystals was 0.5–0.7 mm. Several crystals were placed inside MgO powder of grain size 1–2 μm, which subsequently was pressed into solid tablets. Experiments were made in a split sphere type apparatus at a pressure of 2.0 GPa, temperature 1300, 1400, 1500, 1800, 2000 and 2300 K. Additional experiments were run at 10^{-4} MPa at 1500 and 2400 K. Heating time was 60 min at P= 10^{-4} MPa, T=2300 K, and 10 min P=2.0 GPa, T=2300 K, and 5 min in all other experiments. After treatments crystals were mechanically extracted from MgO and were studied by Raman, and scanning electron microscopy (SEM) methods.

In all experiments at temperature below 2000K only very thin graphite layers appear on surface of diamond crystals (making them grayish or black) and no significant changes in degree of diamond graphitization were documented even for experiment with duration up to 24 hours.

Graphitization of {100} and {111} faces of synthetic diamond crystals at pressures of 10^{-4} MPa and 2 GPa and temperature 2300K was studied by Raman spectroscopy, scanning electron microscopy. Different morphology of newly formed graphite at {100} and {111} faces of diamond crystals are discussed. The growth of oriented graphite crystallites was observed only on the {111} diamond faces at P=2 GPa and 10^{-4} MPa. Randomly oriented graphite crystallites were observed on {100} and especially {110}. Internal morphology of graphite pseudomorphs were studied by reflected light optical microscopy. Contrary to external morphology no differences in mechanism or growth rate of graphite between {111}, {110} and {100} sectors of diamond crystals were observed. Predominant orientation of graphite {002} plane in respect to {111} diamond face was found all over the crystal.

We believe that “low” temperature partial graphitization of diamond crystals related with presence small amounts of H_2O, O_2, or others catalytic components, which absorb on the wall of experimental cells, and therefore it is likely that it is a dissolution-precipitation process, rather than solid state phase transformation occurring at temperature 2000-2300K. This work was supported by the Russian Foundation for Basic Research (07-05-00308-a), MK-259.2008.5 and Russian Science Support Foundation.