On the Mechanism of Formation of Detonation-Synthesized Ultradisperse Diamond Particles

Oleinik G.S.[1], Bochechka A.A.[2]

[1]*Frantsevich Institute for Problems of Materials Science of the NASU, Kyiv, Ukraine*
[2]*Bakul Institute for Superhard Materials of the NASU, Kyiv, Ukraine*

A new mechanism of formation of ultradisperse diamond from the products of decomposition of explosive substances has been studied. A scheme of the structural transformations under diamond synthesis has been proposed.

1. Formation of flat six-atom carbon clusters with sp^2 bonds in the form of benzol rings as products of explosive decomposition or interaction in the system of C_2 dimers as constituents of carbon plasma.

2. Formation of graphene layers on the basis of the above clusters.

3. Rearrangement in the system of such layers according to the sequence grapheme →nanographite →coarsening nanographite particles yielding graphite crystals.

4. The martensite graphite-diamond transformation. The particles of the formed diamond inherit the plate-like shape of the graphite particles and are characterized by a four-level substructure: particle-packet-rod-boundaries in rods such as cubic/hexagonal diamond interfaces and twin boundaries in the cubic diamond, which promote fragmentation of rods up to sizes of 2-10 nm.

5. Deformation of diamond particles through plastic changes in their shape due to the movement along the boundaries of the packets, rods and their fragments as well as to the mechanical destruction of particles including that along the above indicated boundaries.

6. The diamond-graphite phase transformation, which proceeds along different surfaces, primarily along the interfaces and twin boundaries (as the most chemically active structural elements) located in rods.

After removal of the non-carbon component out of the synthesis product, dispersion of particles into independent fragments, the sizes of which are determined by the scale of the regions separated in rods by interphase and twin boundaries, takes place. Such fragments are independent monocrystalline particles of detonation-synthesized diamond (DSD). Their flaky and multilayer form is related both to the inheritance of the initial state of the synthesized diamond and to coagulation processes in the system of independent nanoparticles.

Generally, the proposed scheme of DSD formation is consistent with the logic of development of phase transformations according to Ostvald”s law of stepped phase transformations.