Single crystal diamond needles fabrication, characterization and application

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Diamond is known as one of the most attractive material for the centuries. Nowadays its importance is greatly increasing due to demands in different areas from micromachining to quantum information processing. Crystalline structure and properties of diamond investigated in details and are deeply understood. In particular, shapes of the well-ordered diamond crystals are represented by cubic, octahedron and intermediate forms predetermined by the lattice symmetry. At the same time electronic and other properties are predetermined by strong covalent bonding of carbon atoms with sp3 hybridized orbitals. The shapes of small-size crystallites may be drastically different from ideal bulky diamonds. With crystallite size decrease relative amount of atoms situated at surface in respect to total number of atoms is increased. Additionally, hybridization of atomic orbitals for the surface atoms is changed from sp3 to sp2 and to sp1 leading to significant properties variations of nano-sized diamonds in comparison with the crystals of larger size.

Herein we present results of investigations on production, characterization and potential applications of pyramid-shaped needle-like diamond crystallites. These single-crystal diamond needles having dimensions of their rectangular base and length of micrometer size with apexes and cross-sections in nanometer scale possess unique combination of properties of bulky and nano-sized diamonds. The individual needles were extracted from a powdered material produced by oxidation of polycrystalline diamond film grown using chemical vapor deposition (CVD) method. Experimental investigations, modelling and computer simulations were used to reveal mechanisms of the needles formation.

We present results of needles characterization obtained with electron microscopy, electron emission, luminescent and Raman spectroscopy [1-3]. Developed methodologies allow manipulation by the individual needle crystallites and their assembling with the massive holders providing further applications. The potential applications of the needles include: probes for atomic force microscopy [4]; point electron beam source [5-8]; nano-dynamometer and electric field detector [9,10]; nano-thermometer [11]; optical sensing elements [11]; electro-mechanical devices [13]

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