

Researchers synthesize diamond nanorods; hardest and least compressive material in the world

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Nanorods of many materials are proving very successful, and their properties often exceed that of nanotubes, making them excellent candidates for industrial applications. Theoretical calculations predicted that diamond nanorods too would have properties superior to that of [carbon nanotubes](#). But, so far, nobody had been able to actually synthesize [diamond](#) nanorods. This is no longer true.

A team from the Bayerisches Geoinstitut (Universität Bayreuth) has just reported the synthesis of these aggregated diamond nanorods (ADNR) and their remarkable properties, after having measured them at the ESRF.

The Bayreuth team tested the compressibility and density of this new material. Experiments conducted at the ESRF on the High-Pressure beamline confirmed that the X-ray density of the ADNR material is higher than that of diamond by 0.2 –0.4%; thus making it the densest form of carbon. Subsequent experiments, carried out by loading a diamond anvil cell with both single crystal diamond and ADNR material, in order to directly compare their behaviour under static load, identifies that ADNR is also 11% less compressible than diamond.

The combination of the hardness of the ADNR and its chemical stability makes it a potentially excellent material for machining ferrous materials. "The fact that diamond nanorods are very dense and non-compressible

has not only strengthened theoretical predictions, but also given a positive sign that they have very interesting unique properties", explains Leonid Dubrovinsky, one of the authors of the paper.

At the ESRF, researchers tested the "Vickers microhardness", using a diamond indenter. They showed directly that the probe tip failed to make an indentation on the surface of the ADNR. Moreover ADNR can scratch (111) faces of type-IIa natural diamonds, thus ADNR is harder than natural diamond and consequently more resistant against abrasion. The random arrangement of the nanorods most probably gives rise to the increased hardness of ADNR and the reduction in C-C bond length in outer layers of nanorods gives rise to the increased density.

Mechanical testing has also shown that under the same conditions, due to the increased resistance against graphitisation, ADNR material is a much more effective grinding piece than synthetic or natural diamond. This makes it a potentially valuable material in machining ferrous metals and ceramics and, due to its nanocrystalline nature, for precision machining and polishing.

The invention of the team (Natalia Dubrovinskaia, Leonid Dubrovinsky, and Falko Langenhorst) describing the method of synthesis of superhard, wear resistant, and thermally stable aggregated diamond nanorods and their applications has been patented.

References:

(Ref. 1) Natalia Dubrovinskaia, Leonid Dubrovinsky, Wilson Crichton, Falko Langenhorst, Asta Richter. Aggregated diamond nanorods, the densest and least compressible form of carbon. *Applied Physics Letters*, 22 August 2005.

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