Researchers grow needle- and thread-like diamonds

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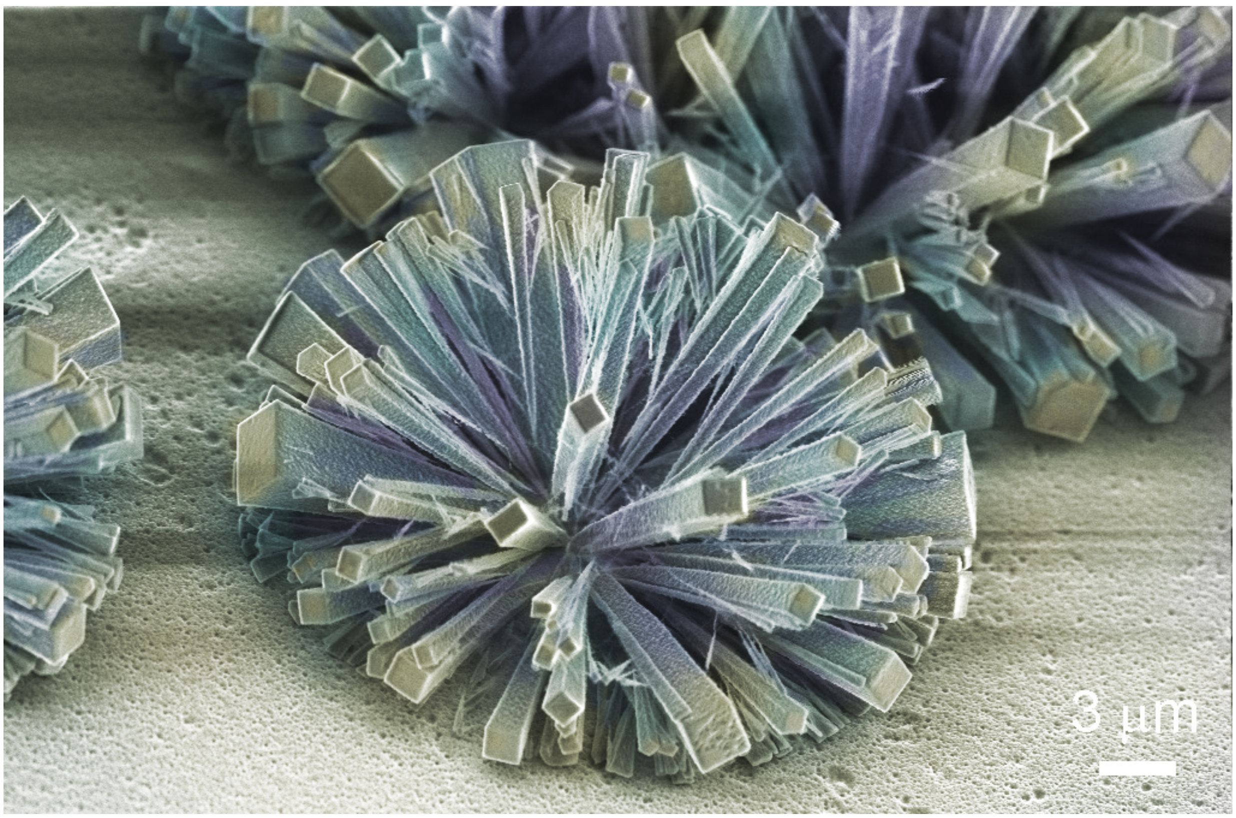


Example of diamond crystallites of different shapes, obtained with the help of the technology, worked out in the Lomonosov Moscow State University. There are electron microscopy images of diamond films' fragments after their oxidation in the air. The material left after the oxidation is represented by needle-like diamond monocrystals of pyramid shape. Credit: Alexander Obraztsov

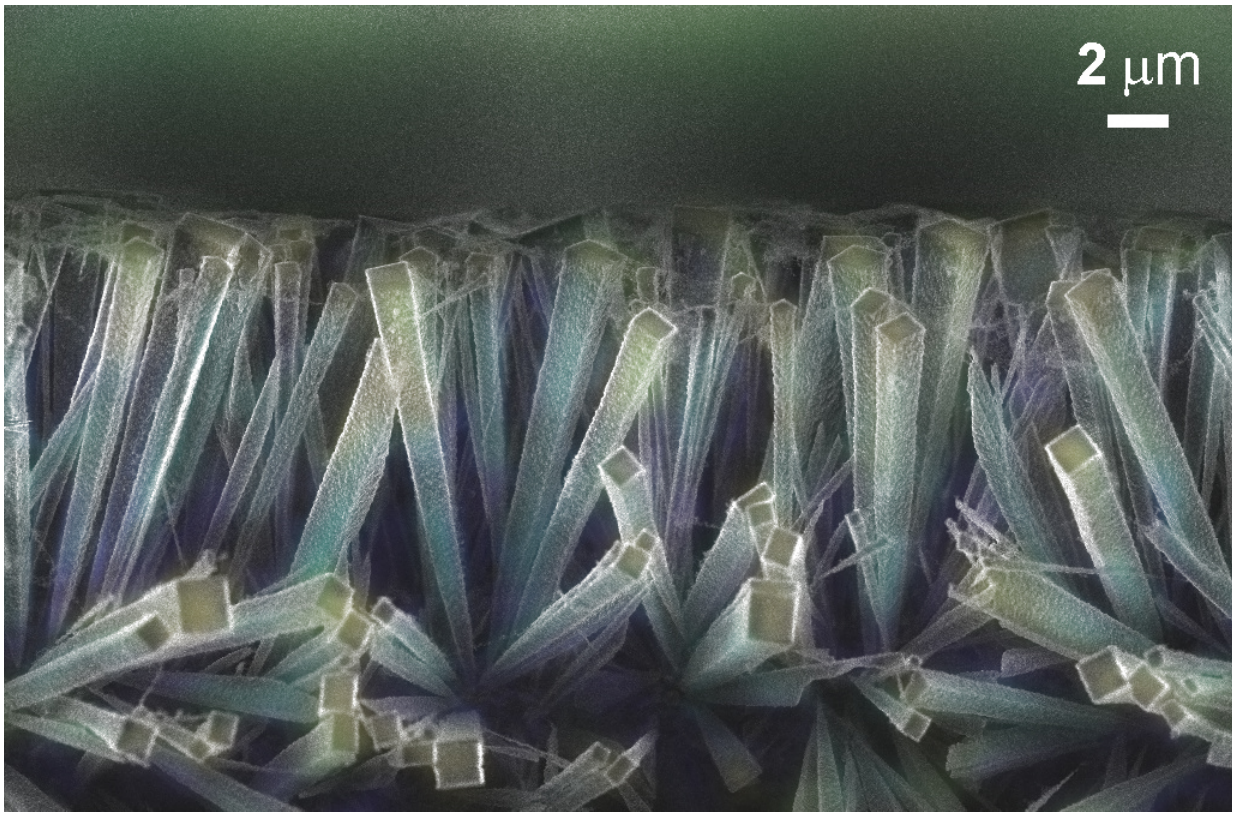
Physicists from the Lomonosov Moscow State University have obtained micrometer-sized diamond crystals in the form of a regular pyramid. In cooperation with co-workers from other Russian and foreign research centers, they have also studied the luminescence and electron emission properties of these diamond crystals. The research results have been published in a series of articles in journals including *Scientific Reports*.

The researchers have described structural peculiarities of micrometer-sized diamond crystals in needle- and thread-like shapes, and their interrelation with luminescence features and field electron emission efficiency. The luminescence properties of such thread-like diamond crystals could be useful in different types of sensors, quantum optical devices, and also for quantum computing.

Technological applications of diamonds significantly outweigh their popularity as jewelry, and are increasingly widespread in industry. This is a motivation for researchers busy with elaboration of new diamond synthesis techniques. One of the problems they've addressed is production of needle- and thread-like diamond crystals. Such shaping of original natural and synthetic diamonds is possible due to polishing in the same way as in jewelry production. Other techniques include lithography and ion beam technologies, which help to separate fragments of desired shapes from large-sized crystals. However, such cutting techniques are quite expensive, and not always practical.

The researchers of the current study propose a technology that makes possible the mass production of small diamond crystals (or crystallites) of needle- and thread-like shapes. Their first results were published seven years ago in *Diamond & Related Materials*.

Alexander Obraztsov, physics professor at the Lomonosov Moscow State University, says, "The proposed technique involves determining formation of polycrystalline films from crystallites of elongate (columnar) shape. For instance, ice on a surface of a lake often consists of such crystallites, which can be observed while melting. Usually, during diamond polycrystalline films production, one strives for conditions that allow crystallites of columnar shape to tightly connect with each other, creating a dense homogeneous structure."



Example of diamond crystallites of different shapes, obtained with the help of the technology, worked out in the Lomonosov Moscow State University. There are electron microscopy images of diamond films' fragments after their oxidation in the air. The material left after the oxidation is represented by needle-like diamond monocrystals of pyramid shape. Credit: Alexander Obraztsov

Researchers have shown that low-quality diamond films consisting of separate, unconnected crystallites could be used for production of diamonds in the form of needle- or thread-like shapes. In order to achieve this, it's necessary to heat such films in an oxygen-containing environment. When heated, a part of the film material begins oxidizing and gasifies. Due to the fact that diamond crystallite oxidation requires maximum temperature, it's possible to adjust the temperature so that all the material except these diamond crystallites is gasified.

This relatively simple technology combines production of polycrystalline diamond films with specific structural characteristics via heating in oxygen. It enables mass production of diamond crystallites of various shapes (needle- and thread-like ones and others). The crystallites could be used, for instance, as high-hardness elements—cutters for high-precision processing, or indenters or probes for scanning microscopes. Such applications are described in an article published earlier by the team in the *Review of Scientific Instruments*.

During follow-up research conducted at the Lomonosov Moscow State University, the initial technology has been significantly improved, which allows scientists to diversify shapes and sizes of the needle-like crystallites and extend their applications. Researchers from the Lomonosov Moscow State University have drawn attention to optical properties that are of significant fundamental scientific and applied interest. The results of these studies are represented in a series of articles in *Journal of Luminescence*, *Nanotechnology*, and *Scientific Reports*. These developments represent the first example of genuine diamond field-emission (or cold) cathode realization. Many efforts have been made to obtain and study such cathodes for the last two decades.

More information: Victor I. Kleshch et al, Single Crystal Diamond Needle as Point Electron Source, *Scientific Reports* (2016). DOI: 10.1038/srep35260

Provided by Lomonosov Moscow State University