Physicists stretch diamond using an electric field

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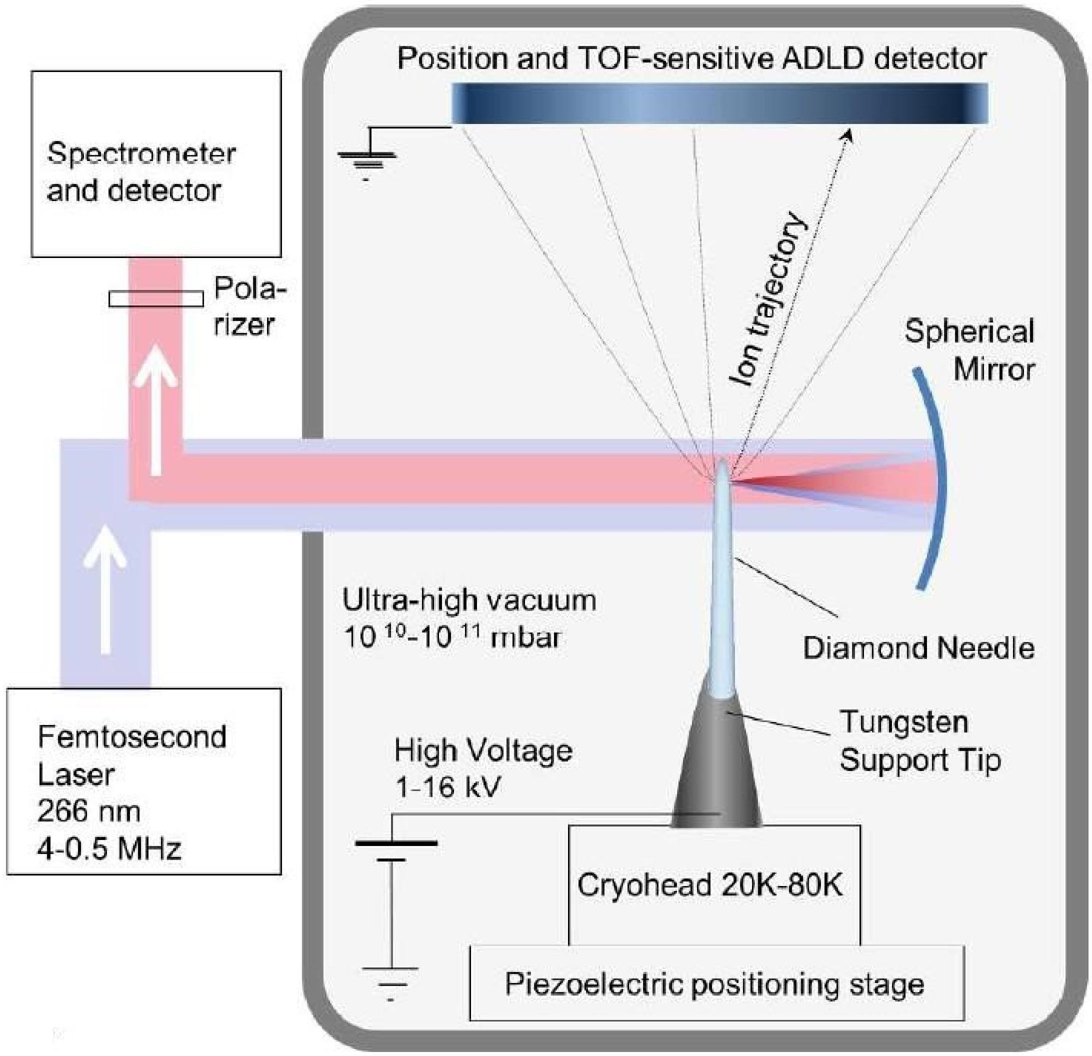

The scheme of the experiment (for practical use). Credit: Alexander Obraztsov

A research team from the Faculty of Physics of Lomonosov Moscow State University stretched acicular diamond crystallites using an electric field. Deformation occurring during the stretching causes changes in the luminescence spectrum. This effect can be used to develop electric field detectors and other quantum optic devices. The work was published in *Nano Letters*.

Similar to other crystals, diamonds always contain structural defects. Some of them cause changes in coloring (light absorption) or luminescence and are called color centers. Specific characteristics of some types of color centers in diamonds make them suitable for use in quantum optic devices such as qubits that are based on entanglement of the photons quantum states. For a diamond to be used in such devices, the distance between its individual color centers should be about 30 nm.

A research team headed by Alexander Obraztsov, professor of the Department of Polymer and Crystal Physics of the Faculty of Physics, MSU, has reported a method to mass produce diamond micro-needles in previous studies. This method includes the growth of diamond crystallites as a fraction of the films formed by chemical vapor deposition of methane and hydrogen. After that, all spare materials are removed from the films via heating in the air.

"In this new work, we tried to learn as much as possible about diamond needles that we produce, specifically about their color centers," said professor Obraztsov. In order to understand the location of color centers in the structure of the samples and to find out their properties, Russian scientists turned to their French colleagues, who used a unique methodology for the required analysis. "Our French colleagues apply it to study chemical composition and location of impurities in different materials," explained Obraztsov.

During the measurements, diamond needles were attached to an electrode placed into a high vacuum chamber. To achieve the stretching effect, high voltage was applied to the electrode causing electrical polarization of the dielectric diamond, as well as considerable mechanical stress stretching the needle. The stretching caused deformation of diamond's crystal structure.

According to the authors, this leads to changes in individual color centers, as well, and their quantum optic properties are altered along with the structure. Before that, scientists were only able to compress diamonds; this is the first time that diamond has been stretched.

During sample stretching, it was irradiated with a laser, and luminescence of the color centers was registered with a spectrometer. The experiment showed changes of shape and energy of the luminescence bands depending on the stretching force determined by the applied voltage. The team believes that similar diamond needles could be used to create detectors for contact-free measurement of electric fields with high spatial resolution.

"Detectors like this could be used not only to measure the fields created by high voltage in high vacuum, but those existing in biological molecules (DNA, RNA, etc.). Measurement of such fields is an important scientific issue today," said Obraztsov. The dimensions of diamond needles at their apex are of several to several hundred nanometers. Therefore, according to the scientists, measurements could be made with precision that corresponds to certain molecule fragments.

Diamond micro-needles produced with the use of the method developed by the MSU team would also be able to secure contact-free optical detection of magnetic fields, temperature, and other characteristics with nano- and microscopic spatial resolution.

More information: L. Rigutti et al, Optical Contactless Measurement of Electric Field-Induced Tensile Stress in Diamond Nanoscale Needles, *Nano Letters* (2017). DOI: 10.1021/acs.nanolett.7b03222

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