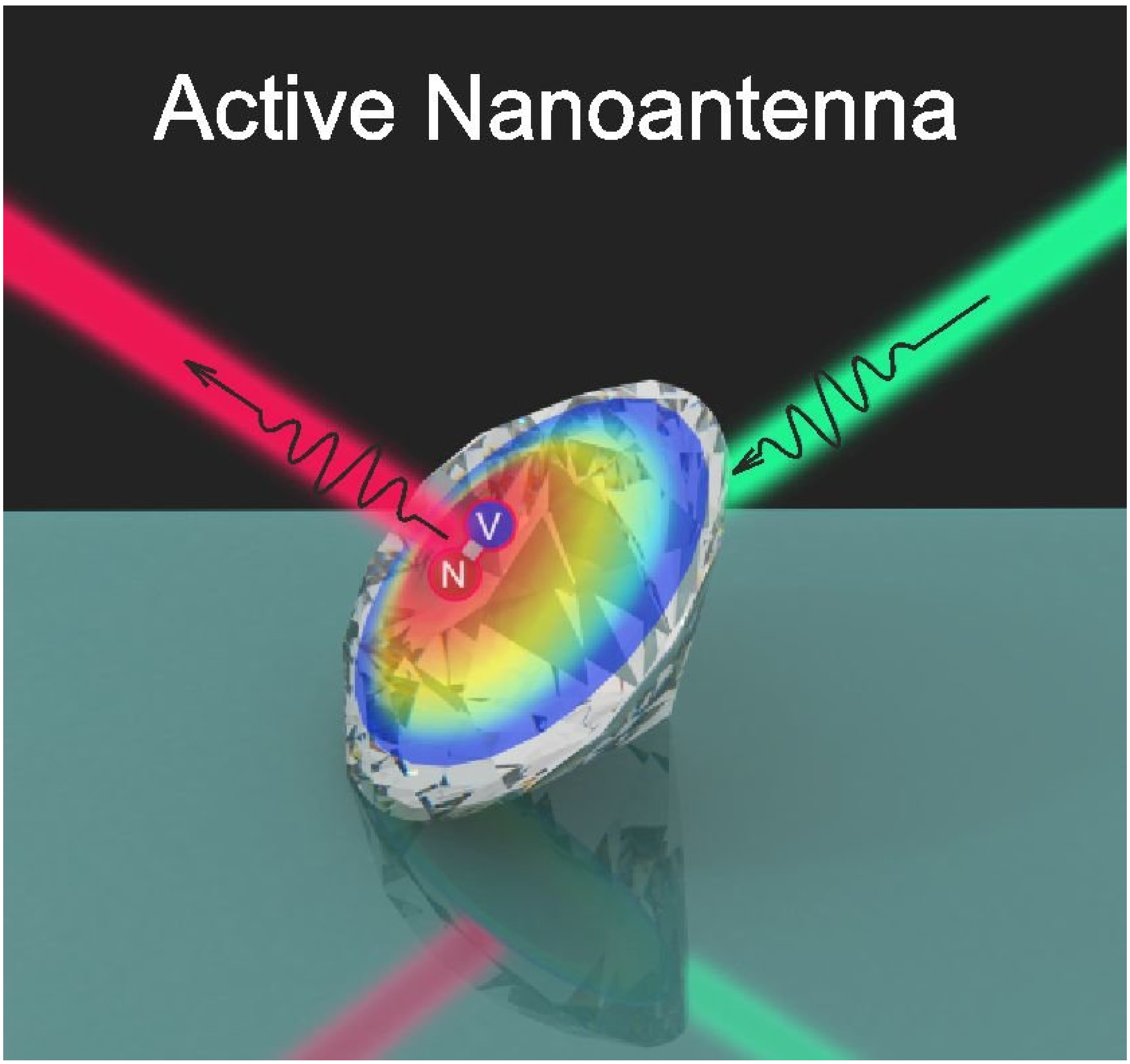
# Nanodiamond turns into controllable light source

May 2 2018




The scheme of active nanodiamond nanoantenna. Credit: ITMO University

A research group from ITMO University has developed a controlled light source based on nanodiamond. Experiments have shown that the diamond shell doubles the emission speed light sources and helps to control them without any additional nano- and microstructures. This was achieved due to artificially created defects in a diamond crystal lattice. Obtained results are important for the development of quantum computers and optical networks. The work is published in the *Nanoscale*.

One of the key areas of modern nanophotonics is the design of active dielectric nanoantennas or controlled photonic sources. As a base for nanoantennas, scientists usually use plasmonic metal nanoparticles. However, optical loss and heating of these particles encourages scientists to look for alternatives. For example, ITMO University researchers created nanoantennas based on perovskites and silicon. Recently, members of the International Laboratory for Nanophotonics and metamaterials of ITMO University developed a new concept of active dielectric nanoantennas based on nanodiamonds.

Nanodiamonds are carbon nanostructures with unique properties. They have a sufficiently high refractive index, high thermal conductivity and low interaction activity. The scientists used nanodiamonds with so-called nitrogen-vacancy centers (NV-centers) created artificially by removing carbon atoms from the diamond crystal lattice. Opened vacancies are then linked to implanted nitrogen atoms. The electron spin of such NV-centers is easily controlled by light, so that using that electron spin, researchers can record quantum information.

Scientists from ITMO University studied optical properties of nano-diamonds and found that their radiation can be enhanced by combining the NV-center luminescence spectrum with optical Mie resonances of diamond nanoparticles. This can be achieved at a certain position of the

NV-center and with the appropriate particle size. This increased the nanodiamond Purcell factor. This indicator is used to estimate how a diamond shell affects the rate of spontaneous emission of the light source. If the Purcell factor increases, the luminescence fading time reduces while the signal itself becomes stronger and much easier to read.

The scientists emphasize that this effect is achieved by using only properties of nanodiamonds. "Usually, to accelerate the radiation, one has to create a complex system of resonators. But we managed to achieve similar results without any additional structures. We showed experimentally that the luminescence fading can be speeded up at least two times, using just simple physics," says Dmitry Zuev from The International Laboratory for Nanophotonics and Metamaterials.

In fact, experiments were carried out on nanodiamonds with multiple NV-centers, even though the researchers also developed a theoretical model for the behavior of single photon sources in the diamond shell. Calculations showed that the speed of light emission can be increased by several dozen times. "Today, getting a single photon from one NV-center in a nanoantenna is a rather difficult task. In order to implement such an active nanoantenna in logic elements, for example, you need to manage their emission. In perspective, our concept will help to effectively manage single photon emission sources. It is very important for the development of quantum computers and optical communication networks," notes Anastasia Zalogina, lead author of the article, a member of the International Laboratory for Nanophotonics and metamaterials.

**More information:** A. S. Zalogina et al. Purcell effect in active diamond nanoantennas, *Nanoscale* (2018). DOI: 10.1039/C7NR07953B

Provided by ITMO University