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Toward 100% efficiency of photon extraction from single silicon vacancies in diamond

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Abstract

Color centers in diamond are considered as the most promising candidates for practical single-photon sources. However, it is still a challenge to achieve efficient single-photon emission under ambient conditions, which is required for many practical applications. Many of these emitters, such as silicon-vacancy (SiV) centers in diamond, demonstrate a remarkably sharp emission spectrum at room and higher temperatures, which cannot be achieved with other quantum optoelectronic systems. However, one of the major obstacles is the high refractive index of diamond, which limits the maximum collection efficiency to only a few percent, which is not sufficient for practical applications.

Here, we present a plasmonic nanoantenna that simultaneously enhances the quantum yield of the SiV center more than tenfold and greatly improves the directivity of single-photon emission from the vertically oriented SiV center so that it becomes possible to collect 87% of emitted photons. The developed design gives the possibility to emit all photons to a single waveguide-like quasinormal mode of the nanoantenna, which allows to obtain a highly directional far-field emission pattern. These directed photons can be easily collected by a conventional oil-immersion objective. It is important that the collection efficiency is not sensitive to the position of the SiV center. Although the quantum efficiency decreases as the distance from the SiV center to the metal nanoantenna increases, the collection efficiency exceeds 80% for distances up to 100 nm, which is highly beneficial for the practical implementation of the proposed nanoantenna concept.

The speaker

Dmitry Fedyanin is a senior research fellow at the Moscow Institute of Physics and Technology (MIPT). He received the M.Sc. degree in 2012 from MIPT and obtained his Ph.D. in 2013. In 2011 he was awarded the Medal of the Russian Academy of Science and in 2012 he received the European Material Research Society Young Scientist Award. His current research is focused on nanoscale and quantum optoelectronics for data-processing, communication, and sensing applications.