POPULAR SCIENTIFIC ABSTRACT

Danylo Komisar

Metasurface-enabled single-photon generation

The central building block of the rapidly developing field of quantum information technologies is a single-photon source. The quantum efficiency of the source, spectrum, and polarization of emitted photons are critical factors for progress of quantum communication and cryptography fields, as well as sensing and metrology.

The experimental studies outlined in this dissertation focus on achieving control over the polarization and directionality of single-photon emission by coupling quantum emitters to plasmonic metasurfaces. A comprehensive theoretical analysis is provided to describe the metasurface design and optimization, which builds up a framework for designing a single-photon source with any desired functionality.

First, a collimated radially polarized single-photon beam is demonstrated bycoupling a nitrogen-vacancy nanodiamond to a plasmonic bullseye antenna. On-chip 15 µm size antenna was fabricated using electron beam lithography around a nanodiamond. The single-photon emission was validated using second-order correlation function measurements. A subsequent theoretical investigation of the antenna design provides a set of rules that can be utilized for metasurface optimization.

Second, multichannel single-photon generation is discussed, which shows independent control over the direction and polarization state of each channel. The plasmonic metasurface implemented in this study was designed using a novel scattering holography approach. Furthermore, the channeling of single-photon emission into two beams of orthogonal polarizations was experimentally demonstrated by coupling a germanium vacancy center to holographic metasurface. The repeatability of the experiment was confirmed by coupling metasurfaces with multiphoton silicon vacancy nanodiamonds.

Experimental verification of a metasurface designed as a hologram pattern calculated with a surface plasmon polariton as a reference wave paves the way for designing metasurfaces that can generate any predefined emission intensity and polarization distribution in the far-field. Furthermore, the applicability of this method extends to a broad array of quantum emitters, establishing a new framework for single-photon source design.