Quantum and nano-optics with tunable microcavities

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Abstract

Optical microcavities are a powerful tool to enhance light-matter interactions. Consisting of microscopic reflective boundaries, they can concentrate, filter, and store light in wavelength-scale volumes. This enables applications ranging from spectroscopy and sensing to quantum information. To achieve large cavity enhancement on an accessible platform, we have developed microscopic Fabry-Perot cavities based on laser-machined optical fibers.

We employ such cavities to realize efficient readout of individual quantum emitters by means of Purcell enhancement of fluorescence emission. We study solid state quantum emitters such as color centers in diamond, aiming at applications in quantum cryptography, all-optical quantum computation, and efficient spin-photon interfaces.

In a different direction in the context of microscopy, we use microcavities for imaging and spectroscopy applications. We have developed scanning cavity microscopy as a versatile method for spatially and spectrally resolved maps of various optical properties of a sample with ultra-high sensitivity. We demonstrate the technique by quantitative imaging of the extinction cross-section of gold nanoparticles and measurements of the birefringence and extinction contrast of gold nanorods. Finally, we show that the Purcell effect can be used for cavity-enhanced Raman spectroscopy and hyperspectral imaging. Simultaneous enhancement of absorptive, dispersive, and scattering signals promises intriguing potential for optical studies of nanomaterials, molecules and biological nanosystems.