Thesis supervisor

Professor Sergey I. Bozhevolnyi

Author

Hamidreza Siampour Ashkavandi

A nanophotonic platform for quantum optical integrated circuits

Abstract

The evolution of the field of computing from electromechanical relay to vacuum tubes, electronic transistors and finally integrated circuits, where billions of transistors can be packed into a single chip, has exponentially sped up the power of information processing. As the age of miniaturization of semiconductor electronic devices is getting closer to the end, new opportunities appear with quantum computing that are not available in the paradigm of classical integrated circuits. This thesis explores new avenues for the implementation of nanoscale functional quantum devices by development of material platforms and nanofabrication techniques for monolithic integration of quantum light sources into chip-based optical circuitry. First, a top-down nanofabrication technique is developed for deterministic coupling of individual quantum emitters (QEs) into plasmonic waveguide modes. Secondly, a nanophotonic platform based on dielectric-loaded surface plasmon polariton waveguides (DLSPPWs) is demonstrated for investigation of the coupling of QEs embedded in nanodiamonds into plasmonic circuitry from the viewpoint of realizing bright and efficient single-photon sources integrated on a chip. Moreover, new atom-like QEs based on germanium-vacancy centers isolated in crystalline nanodiamonds is investigated, featuring bright zero-phonon optical lines with remarkable energy splitting in the ground state. The large energy split in the ground state implies a potentially longer spin coherence time due to the suppressed phonon-mediated transitions between the lower and upper branches. Finally, a chip-integrated DLSPPW-based cavity is demonstrated to enhance spontaneous emission rate of single photons at the zero-phonon line, opening thereby new perspectives for realizing on-chip quantum-optical networks.