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Quantum optical networks with diamond nanophotonics

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Scalable quantum optical networks require identical single photons from multiple quantum bits and high collection efficiency of these single photons. Nitrogen vacancy (NV) centers in diamond are a promising candidate for quantum information processing because they have quantum mechanical degrees of freedom that can be addressed optically and, as solid-state structures, can potentially be easily integrated into nanophotonic networks. In particular, they have a zero-phonon line (ZPL), which acts as an atom-like cycling transition that can be used for coherent optical manipulation. However, the ZPL only accounts for 3-5% of the total emission, and it is difficult to generate a high density of NV centers with stable ZPL. I will present progress toward gaining both spectral and spatial control over NV emission by coupling NV centers to nanophotonic devices. In particular, we have fabricated high quality factor (Q), small mode volume (V) photonic crystal cavities directly out of diamond, and have deterministically placed them around stable NV centers to enhance the spontaneous emission at the cavity resonance by a factor of 50-100. This emission is guided efficiently into a single optical mode, enabling integration with other photonic elements, as well as networks of cavities, each with their own optically addressable qubit. These nanophotonic elements in diamond will provide a building block for a variety of applications in quantum information processing, such as entanglement of distant NV centers and single photon transistors.