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Quantum Optics in the Solid State with Diamond Nanophotonics NATHALIE DE LEON, RUFFIN EVANS, KRISTIAAN DE GREVE, MICHAEL GOLDMAN, ALEX HIGH, Harvard University, MATTHEW MARKHAM, ALAS-TAIR STACEY, DANIEL TWITCHEN, Element Six Ltd, MARKO LONCAR, HONGKUN PARK, MIKHAIL LUKIN, Harvard University — Large-scale quantum networks will require efficient interfaces between photons and stationary quantum bits. Nitrogen-vacancy (NV) centers in diamond are a promising candidate for quantum information processing because they are optically addressable, have spin degrees of freedom with long coherence times, and as solid-state entities, can be integrated into nanophotonic devices. An enabling feature of the NV center is its zero-phonon line (ZPL), which acts as an atom-like cycling transition that can be used for coherent optical manipulation and read-out of the spin. However, the ZPL only accounts for 3-5% of the total emission, and previously demonstrated methods of producing high densities of NV centers yield unstable ZPLs. We have developed techniques to fabricate high quality factor, small mode volume photonic crystal cavities directly out of diamond, and to deterministically position these photonic crystal cavities so that a stable NV center sits at the maximum electric field. We observe an enhancement of the spontaneous emission at the cavity resonance by a factor of up to 100. Crucially, we are able to control the NV center precisely using both microwave and resonant optical manipulation. These nanophotonic elements in diamond will provide key building blocks for quantum information processing such as single photon transistors, enabling distribution of entanglement over quantum networks.

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