Purcell-Enhanced Single Photons at Telecom Wavelengths from a Quantum Dot in a Photonic Crystal Cavity

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Quantum dots (QDs) hold significant promise as single-photon sources for telecommunications due to their tunable emission across low-loss telecom bands, making them ideal for integration with existing fiber networks. The integration of QDs into photonic structures can further enhance their performance, particularly by increasing brightness through the Purcell effect—a phenomenon that boosts spontaneous emission rates when emitters are placed in optical cavities. This enhancement is crucial for advancing efficient quantum communication technologies that require reliable, high-brightness photon sources.

In our research, we focus on InAs/InP QDs, specifically engineered through droplet epitaxy metal-organic vapor-phase epitaxy (MOVPE) to operate within the telecom C-band. These QDs exhibit an impressively short radiative lifetime of 340 ps, a result attributed to a Purcell factor of 5, achieved by embedding the QD within a low-mode-volume photonic crystal cavity. By utilizing a phonon sideband pulsed excitation scheme and control of the QD-cavity detuning through in-situ temperature adjustments, we are able to measure a lifetime reduction as the quantum dot is tuned closer to resonance with a cavity mode.

We demonstrate that the QD emission not only remains stable but also retains single-photon purity up to 25K, indicating robust performance even at elevated cryogenic temperatures. These results underscore the feasibility of QD-based, single-photon sources operating in the C-band, a crucial step toward scalable quantum communication systems that integrate seamlessly into current telecom infrastructures.

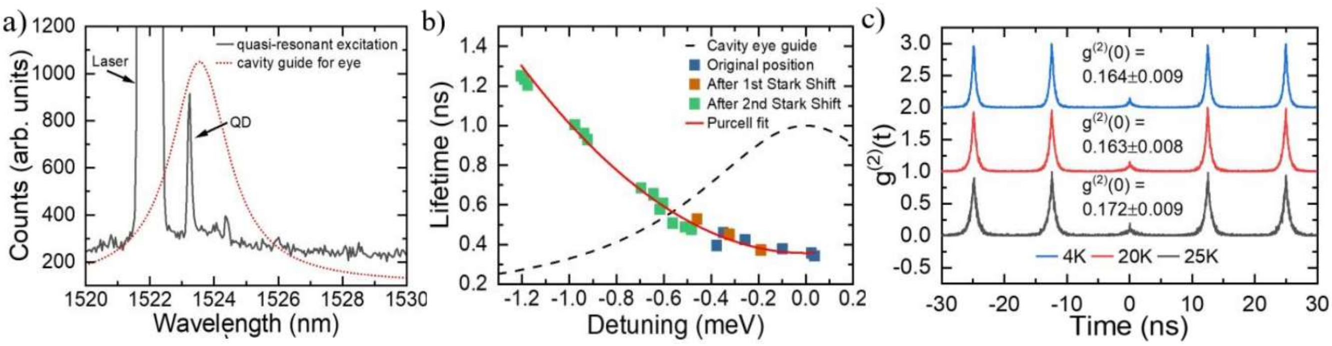

Figure 1: (a) PL spectrum of a QD in an L3 photonic crystal cavity excited through the LA phonon sideband. The red line shows the spectral position and width of the cavity mode. (b) The radiative lifetime of the QD plotted against cavity-QD detuning. The black line shows the shape of the cavity mode. (c) Temperature dependent single-photon purity measurements.

References

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