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

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Quantum dots are promising candidates for telecom single photon sources due to their tunable emission across the different low-loss telecommunications bands, making them compatible with existing fiber networks [1]. Their suitability for integration into photonic structures allows for enhanced brightness through the Purcell effect, supporting efficient quantum communication technologies.

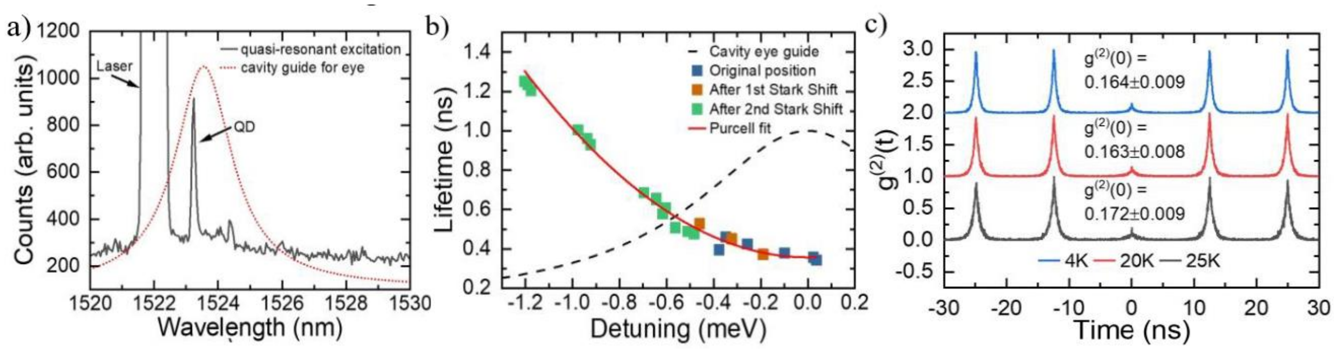

Figure 1: a) PL spectrum of a QD in an L3 photonic crystal cavity excited through the LA phonon sideband. The red line shows the spectral position and width of the cavity mode. b) The radiative lifetime of the QD plotted against cavity-QD detuning. The black line shows the shape of the cavity mode. c)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

Our work focuses on InAs/InP QDs created via droplet epitaxy MOVPE to operate within the telecoms C-band [2]. We observe a short radiative lifetime of 340 ps, arising from a Purcell factor of 5, owing to integration of the QD within a low-mode-volume photonic crystal cavity [3]. Figure 1a shows a PL spectrum of a QD in an L3 cavity where the QD is excited via a pulsed OPO through the phonon sideband of the QD at 1522 nm (labelled "laser"). The red line shows the spectral position and shape of the cavity mode. At 4K, shown here, the QD is blue detuned from the centre of the cavity at 1523.2 nm. Through in-situ control of the sample temperature we are able to tune the QD-cavity detuning. Figure 1b shows the radiative lifetime of the QD in the cavity is plotted against QD detuning from the centre of the cavity. The blue, orange and green points represent the temperature and excitation power dependent measurements performed for the three times the QD wavelength DC Stark shifted at 4K. The cavity mode wavelength dependence is shown as a guide for the eye (black dashed line). We also show a preserved single photon emission purity at temperatures up to 25K (Fig. 1c). These findings suggest the viability of QD-based, cryogen-free C-band single photon sources, supporting applicability in quantum communication technologies.

References

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