Telecom C-Band Quantum Dots: Purcell-Enhanced Single Photon Emission and Deterministic Charge Control

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Quantum dots (QDs) emitting directly in the telecoms C-band are an attractive prospect for single photon sources compatible with existing fiber networks [1]. To achieve the brightness and emission rates required for efficient quantum communication, the QD properties can be enhanced by integration into photonic structures. In this work, we focus on InAs/InP QDs grown by droplet epitaxy in a metal-organic vapor-phase epitaxy reactor, optimised for the telecom C-band [2].

First, we demonstrate Purcell-enhancement of the QD emission rate by integration into a low-mode-volume L3 photonic crystal cavity (Fig. 1a). Driving the QD via the LA-phonon sideband, we measure a radiative lifetime of 340 ps, corresponding to a Purcell factor of approximately 5. Furthermore, we demonstrate temperature tuning of the QD's emission wavelength and reveal a preserved single-photon emission purity at temperatures as high as 25 K, suggesting the viability of QD-based, cryogen-free C-band sources [3].

QDs can suffer from charge noise and spectral diffusion. To address this, we introduce a n-i-n gated structure to control the QD's electrostatic environment. Unipolar gating circumvents the issues associated with highly diffusive p-type dopants in InP. We demonstrate deterministic control over the QD charge state, and meV-scale Stark tuning with a continuous tuning range exceeding 2.4 nm (Fig. 1b). We observe high-purity single-photon emission, with a multiphoton emission probability of $g^{(2)}(0)=0.04\pm0.04$ [4].

Combining the key milestones of Purcell enhancement and charge and Stark control using n-i-n diodes has the potential to provide a complete platform for scalable, high-speed, and low-noise deterministic single-photon sources for long-distance quantum networks.

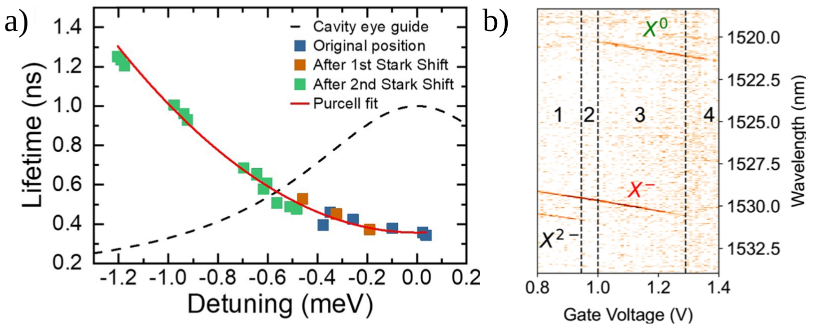

Fig. 1: (a) *QD radiative lifetime versus cavity-QD detuning (temperature-tuned).* ***(b)*** *Photoluminescence intensity map as a function of gate voltage for a single QD in an n-i-n diode.*

References

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