Bright Purcell enhanced single-photon source in the telecom O-band
based on a quantum dot in a circular Bragg grating

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In the field of quantum communication and quantum cryptography, the need for bright non-classical light sources remains a key requirement. Semiconductor quantum dots (QDs) have proven to be excellent candidates also being able to emit single-photons in the much sought after telecom bands. To overcome the high refractive index contrast between the semiconductor matrix and air, a main approach is to use cavity quantum electrodynamics (cQED). In this regard, circular Bragg gratings have achieved excellent results in the NIR regime [1][2]. Using the existing fiber network, especially single-photons in the telecom O-band are favorable not only because of zero wave-packet dispersion but also for wavelength division multiplexing with classical communication signals in the telecom C-band.

Here, we show the coupling of a QD emitting in the telecom O-band to a circular Bragg grating cavity. Comparing the decay time of the emission line spectrally matching the fundamental cavity mode to the mean decay time of emission lines spatially outside of the cavity yields a Purcell factor of $F_P = \tau_{res}/\tau_{ref} = 4.4$ (Fig. 1(a)). To investigate the single-photon emission capability, excitation power dependent second-order correlation measurements are performed. The background corrected $g^{(2)}(0)$ values can be seen in Fig. 1(b). A strong refilling can be seen with increasing pump power limiting the measured single-photon purity. However, this can be overcome with a more resonant pumping scheme in the future. In saturation a true single-photon count rate of 773 kcps (cps: counts per second) is measured on the detector (Fig. 1(c)). This corresponds to an end-to-end brightness of $\sim1\%$ and a first-lens brightness of $\sim20\%$ (setup efficiency: $\sim5\%$) of this single emission line.

Furthermore, we show another emission line which is spectrally off resonant, still with comparable count rate, highlighting the broadband geometric extraction enhancement of the circular Bragg grating, which was theoretically predicted but not measured yet.

The discussed measurements show the feasibility of using circular Bragg gratings in the telecom regime as bright single- or entangled-photon sources. Additionally even without spectral matching, a high extraction efficiency is ensured without Purcell enhancement facilitating the demanding requirement of perfect spectral matching. Finally, Purcell enhancement is demonstrated, opening the route to high repetition-rate sources with high degree of photon indistinguishability.

![Figure 1:](image)

| (a) decay time measurements | (b) background corrected $g^{(2)}(0)$ | (c) detected count rate |
|---|---|---|
| normalized counts | $g^{(2)}(\tau)$ | counts on detector (cps) |
| delay (ns) | at low pump power | at saturation |
| excitation power (µW) | | detected count rate |
| 0.0 | 0.1 | 0.0 |
| 0.5 | 0.25 | 0.0 |
| 1.0 | 0.50 | 0.0 |
| 1.5 | 0.75 | 0.0 |
| 2.0 | 1.00 | 0.0 |

References
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