High-Purity Single Photon Emission from InGaAs/GaAs Quantum Dots in the Telecommunication O-Band

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Semiconductor quantum dots (QDs) have been proven to be high-quality single photon emitters [1] and therefore promising candidates for applications in quantum information processing. However, for successful implementation of short-range quantum communication schemes, emission in the 1.3 μm-telecom band and high extraction efficiency are indispensable.

Here we report on single-photon emission of self-assembled InGaAs/GaAs QDs redshifted to 1.3 μm by applying low indium content InGaAs strain reducing layer [2]. Additionally, for enhancement of extraction efficiency microlenses were fabricated over the QD layer using electron beam lithography [3] with a design optimized by numerical modelling. In the case of a QD located near the center of the microlens, enhancement of emission is evidenced being a fingerprint of expected increased extraction efficiency.

In order to prove single photon character of emission we measured second order correlation function $g^{(2)}(\tau)$ in Hanbury Brown and Twiss configuration by using pair of superconducting single-photon counting detectors. Different excitation schemes were utilized to minimize the effect of background emission related mostly to neighboring QDs and other excitonic complexes. Under nonresonant excitation and quasi-resonant excitation into the wetting layer we obtained a clear photon antibunching with as measured values of $g^{(2)}(0) = 0.19$ (λ_{exc} = 787 nm) and $g^{(2)}(0) = 0.15$ (λ_{exc} = 850 nm), respectively. In both cases non-classical character of the emission was proven, but the probability of multiphoton events was relatively high: nonselective excitation results in a large number of carriers generated in the structure and therefore a significant background emission.

To minimize this effect, the first excited state (p-shell) of the selected bright QD was identified in microphotoluminescence (μPL) excitation spectroscopy experiment to be at 1256 nm corresponding to s-p splitting of 67 meV (in agreement with high-excitation PL measurements on the QD ensemble). Applying quasi-resonant pulsed excitation (Ti:Sa laser with 2 ps pulses at 76 MHz) into the *p*-shell we obtained the purest to our knowledge single-photon emission in the telecom O-band from a single QD: $g^{(2)}(0) = 0.03$ at $\lambda = 1.35$ μm (Fig. 1). Additionally, we observed power-dependent Rabi oscillations indicating on possible coherent control of the QD emission in such excitation scheme.

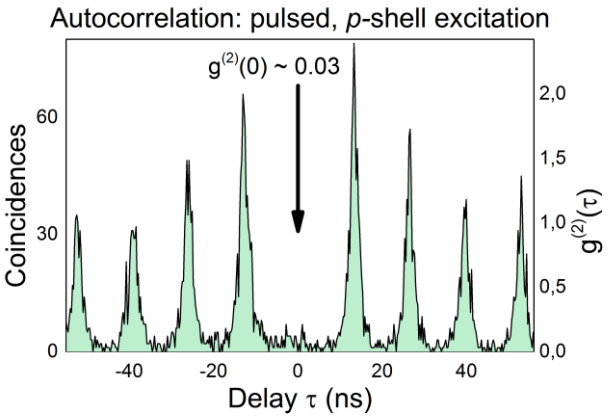

Fig. 1. Second order autocorrelation function under quasi-resonant (p-shell) pulsed excitation.

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