Extraction Efficiency Optimization for Telecom-Emitting GaAs-based Quantum Dots Deterministically Integrated into Photonic Confinement Structures

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Achieving high photon extraction efficiency (η_{ext}) for non-classical light sources remains still a challenging task and is the main limitation of reachable generation rates. Values of about 70% have been already achieved for quantum dots (QDs) in the near-IR spectral range <1 μm [1]. However, practical implementation of quantum computing systems and quantum communication protocols requires sources compatible with fiber networks. Till now η_{ext} =36% has been achieved at O-band emitting QDs, but obtained with a non-deterministic and spectrally narrow-band microcavity approach [2].

In this work, self-assembled $In_{0.75}Ga_{0.25}As/GaAs$ QDs covered with an $In_{0.2}Ga_{0.8}As$ strain reducing layer were grown on a distributed Bragg reflector by MOCVD epitaxy to assure high intensity single-QD emission at the O-band. Single QDs, selected using low-temperature in-situ electron beam lithography [3, 4], were deterministically integrated into cylindrical mesa structures with numerically-optimized geometry [5]. The emission was characterized via excitation-power-dependent and polarization-resolved photoluminescence in order to find the best candidates for further investigations and to identify excitonic complexes confined in the same QD. η_{ext} measurements have been carried out under non-resonant pulsed excitation using a calibrated setup with superconducting nanowire single-photon detectors. QD-mesas fabricated within both, non- and deterministic approaches, were fabricated and investigated. η_{ext} over 10% was achieved for the latter, exhibiting spectrally broadband enhancement (FWHM ≈ 30 nm) [5]. This relaxes the fabrication tolerances and need for precise control of individual QD wavelengths. The numerical optimization of mesa structures predicts the maximal η_{ext} of 40% to be achieved after further optimization, which is higher than reported so far in this spectral range [2].

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