Biexciton-exciton cascade in MOCVD-grown GaAs-based QDs emitting at 1.3 µm

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Self-assembled semiconductor quantum dots (QDs) are high quality quantum emitters suitable for optoelectronics and nanophotonics. They facilitate on chip integration and compatibility with well-developed semiconductor technology. MOCVD growth offers additional advantage in terms of low-cost mass production in comparison to MBE-grown QD structures. Strain engineering via application of InGaAs strain reducing layer [1] allowed to achieve emission of GaAs-based QDs at 1.3 µm beneficial for secure local quantum networks. Properties of the whole QD ensemble were extensively studied and were utilized as an active region of QD lasers [2], but the results on single QD level are rather limited [3].

We present study of single QDs, in particular a biexciton-exciton (XX-X) cascade. For single QD study sample was patterned with mesas of different diameter. A mesa of nominally 700 nm in diameter was chosen due to optimal number of QDs (spectral density of emission lines) vs. the influence of the mesa edges and related spectral diffusion broadenings. X and XX lines were preliminarly identified based on low temperature (5K) power- and polarization-resolved microphotoluminescence. They revealed X fine structure splitting of 70 µeV and XX binding energy of 3.1 meV. The origin of investigated emission lines was further confirmed in intensity correlation measurements in Hanbury-Brown and Twiss configuration setup equipped in two superconducting single photon counting detectors. The temporal resolution of 40 ps allowed for observation of both bunching and antibunching proving cascaded character of the XX-X emission and that they originate from the same QD.

Applied pulsed excitation seems to favor the formation of charged complexes as the relative intensities in the spectrum changed in comparison to continuous excitation and the emission lines originating from XX-X cascade diminished substantially in the whole excitation power range in agreement with rate equation model calculations. On the other hand, it occurs to be independent of the excitation wavelength in the wetting layer and SRL range. The emission from neutral complexes is strongly quenched with temperature in contrast to other emission lines in the spectrum. Additionally, the pulsed-pumping-induced excitation transfer is evidenced by strong relative changes in the intensities of groups of emission lines.

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