Magneto-Optical Properties of Single Symmetric InAs/InP Quantum Dots Emitting in the Telecom C-band

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Self-assembled epitaxial semiconductor quantum dots (QDs) have been the subject of study due to both – their interesting fundamental properties and potential practical applications. Discrete atom-like energy structure makes them ideal as an active region for non-classical light sources, e.g., single photon sources or sources of polarization entangled photon pairs [1, 2]. The latter require high in-plane symmetry of the nanostructure and/or external tuning to minimize the exciton fine structure splitting. Such sources can be utilized in quantum communication, e.g., to exchange cryptographic key or as building blocks of quantum networks, in particular, quantum repeater architectures. In this case, emission in the telecommunication windows, compatible with existing optical fiber infrastructure, is needed. QDs have also potential in spintronic applications, where individual spins of electrons and holes confined in the dots are used to store information (quantum memory) or as an active part of switching devices depending on the carrier g-factor. In this case, spin coherence properties are of interest.

Magneto-optical polarization-resolved measurements in Faraday and Voigt configurations enable to understand the nature of excitonic complexes in QDs. In particular, extension of the wave function can be deduced from the diamagnetic coefficient, g-factor of carriers/excitonic complexes can be determined based on the Zeeman splitting allowing also for observation of the fine structure of excitonic complexes and identification of emission lines in the single QD spectrum as originating from certain carrier configurations [3]. Finally, spin coherence time can be determined based on depolarization (Hanle) curve obtained with quasi-resonant excitation with circularly polarized laser beam [4].

In this study, we determine experimentally the fundamental magneto-optical properties of the new generation of symmetric, and low-density (2×10^9 cm^{-2}) InAs/InP QDs grown by ripening process-assisted molecular beam epitaxy [5]. These QDs fulfill the requirement of telecom spectral range emission (1.55 μm). Photon extraction efficiency was enhanced by growing the QDs on top of a distributed Bragg reflector, resulting in 6.8% photon extraction efficiency for planar sample [6] and 13.3% for QDs in cylindrical mesas [7]. High single-photon purity ($g^{(2)}(0) < 0.01$) [8] and low fine structure splitting makes them promising candidates for generating non-classical light.

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