Determination of the spin coherence time of carriers within single InAs/InP quantum dots using the Hanle effect

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Significant interest among researchers in exploring semiconductor spins through optical orientation techniques is caused by the potential of this area for the development of quantum information processing devices and spintronic devices. Quantum dots (QDs) stand out as particularly promising candidates for quantum spin memory due to their three-dimensional quantum confinement of carriers, which significantly suppresses spin relaxation processes. Consequently, spin relaxation times in QDs are expected to be considerably longer compared to those observed in bulk semiconductors or two-dimensional structures. [1] Long spin coherence time are crucial not only for spintronics application but also for entanglement photon pair generation. It was shown that the entanglement fidelity is limited by the spin coherence time of carriers within the QDs. [2]

This study explores the properties of symmetric, low-density InAs/InP QDs grown using ripening process-assisted molecular beam epitaxy and emitting within the telecom spectral range (1.55 μm). The QDs were grown on a top of a distributed Bragg reflector, resulting in 6.8% photon extraction efficiency for the planar sample and 13.3% for QDs in cylindrical mesas [3]. High single-photon purity ($g^{(2)}(0) < 0.01$) [4] and low fine structure splitting shows prospects for generating non-classical light. Such a material system can be used for optically driven spintronics, compatible with telecom infrastructure.

Our investigations involved magneto-optical polarization-resolved measurements in Voigt configuration. We observed the negative circular polarization (NCP) [4] under quasi-resonant excitation for emission lines identified as trions. The degree of circular polarization (DOCP) reaches up to 40%. Finally, the decrease of DOCP under the influence of external magnetic field, the so called Hanle effect, reveals the spin coherence time of carriers within the QD [1] which occurs to be in the range of recombination time of trions in these structures. Determining the factors causing decoherence will enable optimization of existing sources and verification of the application potential of the studied systems.

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