On the spin memory effect in InAs quantum dash emitting at 1.55 µm

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Recently, the InAs on InP QDash-based non-classical single photon emitter operating at 1.55 µm has been demonstrated [1] along with the possibility to diminish the confined exciton fine structure splitting [2]. While the former clearly shows QDash capabilities to generate single photons at a time, the latter can lead soon to demonstration of polarization-entangled photons at telecommunication wavelengths, essential for e.g. quantum repeater technology. Since epitaxial nanostructures as QDashes can be considered as a bridge platform between the solid-state quantum information storage/operation and the quantum state of light, it is crucial to investigate properties of the confined spin state that can mediate the exchange process of quantum information and constitute the spin memory element.

We demonstrate an impact of different spin-injection scenarios on the possibility to read-out the written exciton/electron spin state confined in a QDash. The spin initialization as well as read-out processes are realized by all-optical means. A properly polarized train of femtosecond or picosecond laser pulses creates the spin excitation in a QDash, whereas analysis of the photoluminescence signal (degree of polarization-DOP as a function of time or averaged in time) provides information about the confined spin state, e.g. existence of the spin memory and its storage time. First, we have focused on the possibility to observe an exciton spin memory (ESM) under non-resonant photo-injection. This revealed existence of a strong DOP “background” of ~27% that is not connected to population of a spin state but it is due to intrinsic properties of QDashes. The ESM is observed after the spin injection into the wetting layer as indicated by enhanced DOP in respect to the intrinsic one. This result shows partial preservation of the exciton spin state after relaxation process down to the QDash ground state, with the further possibilities to be recovered in the emission. The most pronounced ESM is obtained by utilizing a single longitudinal optical phonon-mediated process for the spin injection scheme. This led to further increase in the contrast between the “background” DOP and the actual one by ~35%, i.e. indicates on easy recovery of the spin memory state. Despite existence of the ESM effect the measured spin relaxation time reaches 1.7 ns that is comparable to the exciton decay time. It raises the question about possible spin relaxation mechanisms for such types of quantum structures. A high “background” DOP suggests that strong heavy-light hole mixing might be responsible for efficient relaxation channel of the spin state injected into such large nanostructures made of InAs on InP(001). In order to omit the above-mentioned limitation we propose to use a spin state of a resident electron that is addressed by utilizing the intermediate trion state. Initial results show a long spin memory effect that overcomes significantly the exciton spin lifetime.

[1] Ł. Dusanowski, et al. *Appl. Phys. Lett.* **105**, 021909 (2014).
[2] P. Mrowiński, et al. *Appl. Phys. Lett.* **106** 053114 (2015).
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