Exciton spin injection and relaxation in InAs/InP quantum dashes under quasi-resonant excitation

Ł. Dusanowski[1]*, M. Syperek[1], J. Misiewicz[1], A. Somers[2], J. P. Reithmaier[3], S. Höfling[2,4], G. Sęk[1]

[1]Laboratory for Optical Spectroscopy of Nanostructures, Department of Experimental Physics, Wrocław University of Technology, Wrocław, Poland, lukasz.dusanowski@pwr.edu.pl

[2]Technische Physik, Physikalisches Institut & Wilhelm-Conrad-Röntgen-Research Center for Complex Material Systems, University of Würzburg, Würzburg, Germany

[3]Institute of Nanostructure Technologies and Analytics, Universitaet Kassel, Kassel, Germany

[4]School of Physics and Astronomy, University of St Andrews, St Andrews, United Kingdom

* Corresponding Author

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Abstract

Quantum dashes (QDashes) are epitaxially grown nanostructures strongly elongated in one of the in plane directions. Their significant shape anisotropy and the non-uniform strain distribution result in strongly asymmetric confining potential for electron and hole. This consequently leads to the specific spin structure of an exciton [1] and a valence subband mixing pinning the polarization state of the emitted photons [2]. These unique properties open a route towards fundamental research concerning spin state in the anisotropic confinement including spin injection, control and relaxation.

We have examined exciton-spin dynamics within an ensemble of InAs/InP(001) QDashes emitting around 1.55 μm by means of polarization-resolved photoluminescence-excitation and time-resolved photoluminescence (TRPL) experiments at T = 4.2 K. Under non-resonant excitation (NRE) conditions we observed linearly polarized radiation pinned to the dash elongation axis (EA) with degree of linear polarization (DOLP) equal to around ~25 %, which stems from a strong valence band mixing [2]. In case of photon-polarization-controlled resonant injection of an electron-hole pair via the LO-phonon mediated scattering process we are able to selectively excite one of the two fine structure split bright exciton states. Consequently, we observe an increase in the value of DOLP (defined in respect to injected radiation polarization) of ~28 % and ~38 % along and perpendicular to the EA (in respect to the NRE case), respectively. Therefore, we demonstrate that the spin injection mechanism involving the LO-phonon scattering process is well realized in the investigated InAs/InP QDashes. Polarization-resolved TRPL experiment performed under the LO-phonon mediated excitation condition shows that for the both bright exciton spin states the DOLP decays with ~4 ns time-constant, which is 3-4 times longer than the exciton lifetime (~1.2 ns in case of those particular dashes). This observation clearly shows that injected exciton spin, confined in a QDash, is weakly affected by the spin relaxation mechanisms.

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