Non-classical photon emission at liquid nitrogen temperature from charged exciton confined in an (In,Ga)As/GaAs quantum rod

Ł. Dusanowski[1]*, M. Syperek[1], A. Maryński[1], L. H. Li[2,3] , J. Misiewicz[1], S. Höfling[4,5], M. Kamp[4], A. Fiore[2,6], 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]Ecole Polytechnique Fédérale de Lausanne, Institute of Quantum Electronics and Photonics Lausanne, Switzerland
[3]Currently at: School of Electronic and Electrical Engineering, University of Leeds, Leeds, United Kingdom
[4]Technische Physik, Physikalisches Institut & Wilhelm-Conrad-Röntgen-Research Center for Complex Material Systems, University of Würzburg, Würzburg, Germany
[5]School of Physics and Astronomy, University of St Andrews, St Andrews, United Kingdom
[6]COBRA Research Institute, Eindhoven University of Technology, Eindhoven, The Netherlands
* Corresponding Author

Keywords: *single photon source, charged exciton, quantum rod.*

Abstract

The rapidly evolving field of optical quantum communication requires utilization of efficient non-classical photon emitters. A possible realization of such an emitter, ie. single photon source (SPS) in a solid-state-system, integrable with today's complex electronic and photonic schemes, is based on a single semiconductor quantum dot (QD). Most of the implemented SPSs are based on the QD ground state neutral exciton, whose maximum achievable emission rate is limited by dark states existing along with bright states. Therefore, the charged exciton is potentially more interesting as an emitting complex, since it enables to achieve higher generation rates when compared to neutral exciton [1]. Nevertheless, deterioration of the emission efficiency due to enhanced non-radiative processes with increasing emitter temperature still prevents practical implementation of the near infrared QD-based SPS at ambient temperatures when based on some of the easily integrable III-V material systems, in spite of their very mature fabrication technology.

Epitaxially-grown single (In,Ga)As/GaAs quantum rods have been investigated in this context. Identification of a charged exciton complex has been performed by μPL studies in magnetic field. The registered set of optical transitions (cross-linearly polarized pairs of doublets) corresponds perfectly to the spin-dependent optical selection rules for the trion state under magnetic field in the Voigt geometry. In order to evaluate the non-classicality of the emitter auto-correlation statistics of the emission process has been registered. In the entire temperature range clear antibunching dip of the auto-correlation function at zero delay times has been recorded with the as-measured $g^{(2)}(0)$ values equal to 0.32 and 0.46 at temperatures of 10 and 80 K, respectively. After including the PL background counts correction, these values could be further reduced down to 0.26 and 0.29, respectively. Our experimental findings allow for predictions that such GaAs-based quantum rod structures are prospective for efficient single photon sources operating above the cryogenic temperatures.

[1] S. Strauf, N.G. Stoltz, M.T. Rakher, L.A. Coldren, P.M. Petroff, and D. Bouwmeester, Nat. Photonics 1, 704 (2007).