Towards a quantum emitter of linearly polarized or entangled photon pairs at telecommunication wavelengths utilizing InAs-InP based nanostructures

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Linearly polarized single photon source and entangled photon pair generation are both relevant elements for quantum communication protocols of secure data transmission (BB84, Ekert92). In this context, a deterministic quantum emitter based on a semiconductor platform and operating at telecommunication wavelengths of fiber-based transmission systems is strongly desired.

In that context, there have been investigated InAs/InGaAlAs/InP quantum dashes (QDashes) that emission wavelength overlaps with the 2nd and 3rd low-loss windows of silica fibers. Their application potential as non-classical emitters operated on both charged and neutral exciton and as a source of classically correlated photons from biexciton-exciton cascade has been demonstrated recently [1,2].

Optical properties of such nanostructures have been studied systematically showing their intrinsic properties like significant degree of linear polarization (DOLP) of emission and fine structure splitting (FSS) depending on the structures' morphology. The asymmetric confinement potential of QDashes involves both the valence band mixing and strong exchange interactions which give rise to well separated linearly polarized exciton transitions of unequal intensities. Further enhancement of DOLP up to 80% can be realized by a post-growth modification of the dielectric environment by forming asymmetric mesa structures. On the other hand, the exciton FSS tuning is feasible by the in-plane magnetic field in a range of ~300 μeV using 5 Tesla, reducing the zero-field value as large as ~220 μeV. Thus, the exciton bright-state crossing has been achieved in a range of 2-4 Tesla. Such tuning knob has a potential for obtaining a polarization entangled photons, as it was shown for inverted InAs/GaAs quantum dots [3]. The experimental data on high DOLP and reduced FSS has been collected for number of QDashes in a broad spectral range from below 1.3 to above 1.55 μm, and appeared to be a typical property of such nanostructures. Therefore, the single InAs QDashes might be considered as an active element of the future non-classical emission nanophotonic devices.

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