Excitonic fine structure splitting in type-II quantum dots

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The ability of the quantum dots to isolate and manipulate individual charge carriers and their integrability into more complex devices make them a candidate for various applications in field of quantum information processing. The source of entangled photon pairs, a crucial element of distinct quantum communication protocols, have been proposed [1] and later realised [2] using the biexciton-exciton radiactive cascade. For this it is important that the splitting of the bright exciton doublet (so called fine structure splitting, FSS) is lower than the transition linewidth. FSS of as-grown structures is usually by far too large and elaborate methods are employed in order to reduce it [3].

We focused here on InAs quantum dots covered by a thin GaAsSb layer. By adjusting the Sb content or the thickness of the layer the hole states can be driven out of the quantum dot volume (type II confinement) [4]. We study theoretically the effect of the structural parameters on FSS and on the emission wavelength and intensity. We show that in type II it is possible to tune FSS by changing the thickness of the GaAsSb layer. We reveal the underlying mechanism based on the vertical positioning of the hole wave function with respect to the piezoelectric field. Herewith we can compensate the contribution to the FSS induced by the piezoelectric field and to some extent also by the structural asymmetry. At the same time it is possible to keep a reasonably large emission rate and reach the telecommunication emission wavelength of 1.3 μm. This demonstrates a suitability of the structures under study for a practical realization of the source of polarization-entangled photon pairs.

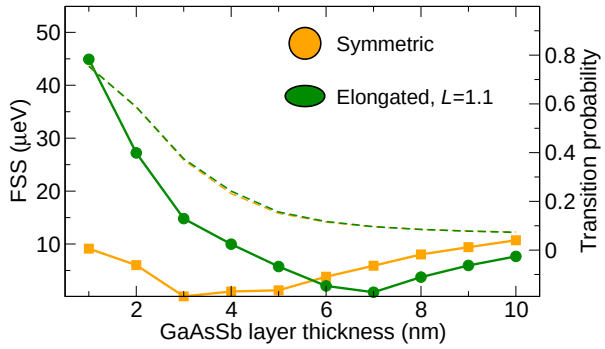

Figure: FSS (solid lines) and transition probability (dashed lines) in lens-shaped QDs (squares: circular base, circles: elliptic base) as functions of GaAsSb layer thickness.

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[4] P. Klenovský, V. Křápek et al., *Appl. Phys. Lett.* **97**, 203107 (2010).