Highly symmetrical droplet epitaxial quantum dots on GaAs(111)A

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Highly symmetrical quantum dots (QDs) with naturally low FSS can be achieved by self-assembled growth on (111) surfaces with C_{3v} symmetry. It is possible to obtain triangular and hexagonal droplet epitaxial (DE) QDs on singular GaAs(111)A with the FSS below 4 μeV [1, 2].

However, the epitaxial growth on singular GaAs(111)A is not straightforward due to the low growth rate and appearance of surface defects. We exploited a step-flow growth mode of a vicinal surface (1-2° miscut angle) to increase the growth rate on a (111)-oriented GaAs substrate and studied the formation of Ga and In droplets on that surface [3, 4]. The presence of the miscut also helps in the formation of thin (≈ 100 nm), smooth, and fully relaxed InAl(Ga)As metamorphic buffer layers (MMBL) on GaAs(111)A [5] in order to shift a photon emission of InAs QDs to a telecommunication wavelength range [6].

Additionally, we embedded such InAs/InAlAs QDs in a one-dimensional cavity based on AlGaAs/GaAs distributed Bragg reflectors (DBRs) [7]. It enabled us to meet the high-brightness and low-density criteria necessary for the spectroscopic investigation of single QDs (see Fig. 1a). We have quantified the FSS: approximately 50% show the value < 50 μeV with the minimum value of about 15 μeV (Fig. 1b). For the majority of emitters, we found that the dipoles are aligned along one preferential direction. The numerical simulations confirmed that the presence of the miscut modifies the spatial distribution of the electron and hole wave functions, leading to their elongation in the [1-10] direction [7,8].

With the collaboration of the Quantum Light Sources group at DTU, a single photon behavior of the InAs QDs was investigated. HBT measurements reveal the second-order autocorrelation function $g^2(0)$ below 0.01 (see Fig. 1c). Power-dependent time-resolved PL measurements indicate exciton lifetime of about 0.7 ns [9].

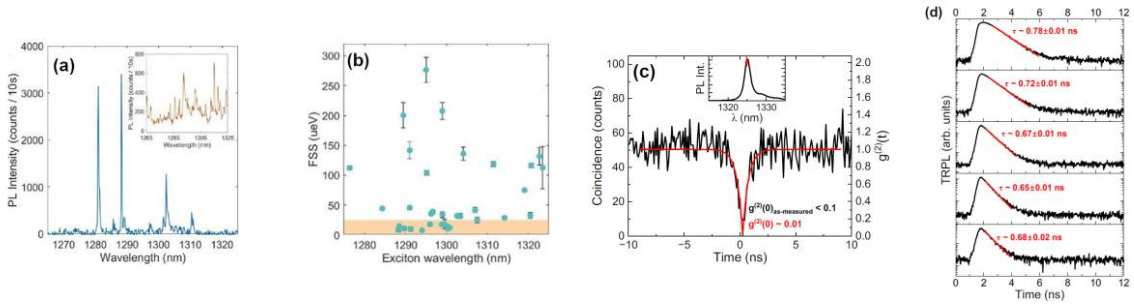

Fig. 1. (a) PL emission of an individual InAs QD. The inset shows an example of PL emission of InAs QDs without DBR cavity. (b) FSS statistical distribution. The orange area indicates the estimated resolution limit for a transition with 250 μeV linewidth. (c) Second-order correlation measurement of an individual InAs QD under CW excitation. (d) Power-dependent time-resolved PL of an individual InAs QD.

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