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Precise structure characterization of droplet epitaxial telecom-wavelength QDs for Quantum Information Technology

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Last decades the fabrication of self-assembly quantum dots (QDs) was attracted for photonic device application. QD can be used as an ideal source for the generation of entangled photon pairs, which are necessary building blocks for the long-distance fully secured quantum key distribution.
We present the fabrication and the precise structure characterization by means of HR-XRD mapping and AFM of telecom-wavelength droplet epitaxial (DE) InAs QDs with low fine-structure splitting (FSS) on a misoriented GaAs(111)A incorporated in a one-dimensional microcavity to improve the photon extraction efficiency. To shift a photon emission of InAs QDs grown on GaAs substrates to a telecom O-band, an InAlAs metamorphic buffer layer (MMBL) approach was used. A 100 nm thick InAlAs layer deposited on the vicinal surface is fully relaxed with a very flat morphology (see Figure 1a). The control of the growth kinetics, tuning both adatom diffusion length and step ejection probability from the bunches, permits a reduction of the InAlAs epilayer root-mean-square (RMS) surface roughness to ≈ 0.5 nm (see Figure 1b).
We embedded such InAs/InAlAs QDs in a one-dimensional cavity based on AlGaAs/GaAs distributed Bragg reflectors (DBRs). Combining the DE technique with the growth of a DBR microcavity enabled us to meet the high-brightness and low-density criteria necessary for the spectroscopic investigation of single QDs. We have quantified the FSS of cavity-enhanced InAs QDs: approximately 50% of them show FSS < 50 μeV. We also observed the presence of emitters with large FSS, which may originate from unexpected anisotropy in some of the QDs examined. For the majority of those emitters, we found that the oscillations of the energy offset display the first maximum for a similar half-wave plate (HWP) rotation, suggesting that the dipoles are aligned along one preferential direction. Excitonic doublets higher in energy tend to be polarized along [-1-12] direction – the miscut direction.

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