O-band telecom single photon emission from DE InAs QDs

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Abstract: DE InAs/InAlAs/GaAs(111)A QDs show high purity of single photon emission achieving g(2)(0) = 0.012 under CW and 0.069 under pulsed excitation. The average exciton lifetime is 0.98 ns and the extraction efficiency is 3.9%.

We present the growth and optical characterization of InAs QDs emitting in the O-band telecom range grown by droplet epitaxy (DE) on top of uniform InAlAs buffer layer grown on vicinal GaAs(111) platform [1,2]. The applied approach shows the possibility of shifting QDs emission up to second telecom windows with enough low-density QDs for application as single quantum emitters. Moreover, DBR-based top and bottom structures present a possibility for creating photonic structure, where straightforward growth on a uniform buffer layer gives simple access to create a λ/2 cavity for the planar sample.

The broad range of QDs' sizes promotes a wide distribution of emission energy from the quantum dots within the 1100 – 1350 nm range, where the increase in size is likely associated with a longer emission wavelength. Based on Atomic Force Microscopy (AFM) analysis, we observe an increase in asymmetry for larger quantum dots, linked to the crystallization step of QD fabrication and the presence of the miscut along [-1-12] direction. Statistical analysis of the QDs' asymmetry appears to confirm the correlation between the size and shape of the dot, with increasing shape asymmetry for larger QDs.

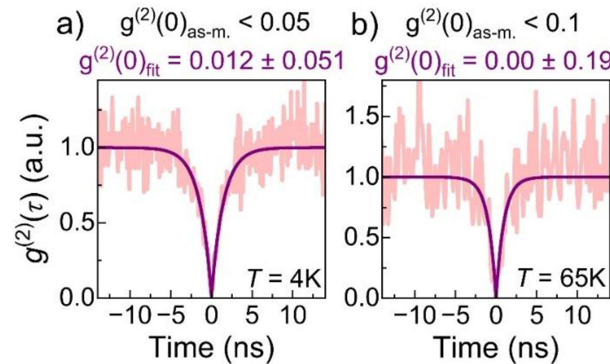

Fig. 1 The second-order correlation function under CW excitation at (a) 4K and (b) 65K.

Both continuous wave and pulsed excitation show purity on the level better than 90% for basic excitonic complexes, including also elevated temperatures (65 K) for CW excitation. QDs emission rate characterization showed increased value according to cavity-based planar photonic structure formed by bottom and top DBRs, where extraction efficiency of emission verification pointed a value close to 4% (NA = 0.8). Additional characterization of time-resolved PL showed a decay time at the level of 0.86 ns, where potential impact of cavity was rejected. Polarization-based measurements showed an increased value of degree of linear polarization connected to shape anisotropy for QDs shifted to longer wavelengths. Systematic characterization of single QDs emission in wide range from around 1200 nm to around 1350 nm showed lack of critical difference in optical parameters, especially in the case of decay time and linewidth of QDs PL suggesting lack of deterioration correlated with QDs wavelength shifting.

References

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