Theoretical modeling and fabrication of strain-free InGaAs/InAlAs QDs via LDE as C-band single photon emitter

Rabbia Tahir [1], **Pawel Wyborski** [2], **Artur Tuktamyshev** [1] , **Stefano Vichi** [1], **Richard Noetzel** [1], **Battulga Munkhbat** [2] **and Stefano Sanguinetti** [1]

[1] *L-NESS and Dipartimento di Scienza dei Materiali, Università di Milano-Bicocca, Italy*
[2] *Department of Electrical and Photonics Engineering, Technical University of Denmark, Denmark*

Semiconductor quantum dots (QDs) are considered as essential candidates to enable the single photon emission for the long-distance telecommunication application. In order to obtain telecom C-band emission at ~1550 nm, lattice matched $In_{0.7}Ga_{0.3}As$ quantum dots (QDs) were fabricated by local droplet etching on a $In_{0.7}Al_{0.3}As$ metamorphic buffer barrier layer realized on a GaAs(111)A substrate. The (111)A-orientation makes it possible to employ thin metamorphic buffers while maintaining intrinsic C_{3v} symmetry to promote highly symmetrical QDs [1]. Atomic force microscope (AFM) revealed the C_{3v} symmetry of the etched nanoholes through triangular pyramid shape. The nanoholes were then filled with $In_{0.7}Ga_{0.3}As$ to fabricate the targeted C-band QDs. The QDs dimensions, electronic structure and emission characteristics were theoretically optimized using **k.p** and envelope function models. The photoluminescence measurements made on the optimized sample show emission in 1388-1553 nm range, consistent with our theoretical predictions.

Second-order autocorrelation measurements show single-photon emission with measured $g^2(0)$ value of 0.141±0.027. Lifetime in the 1.3-1.9 ns range was revealed by time-resolved PL measurements. These results demonstrate the fabricated strain-free InGaAs/InAlAs QDs as state-of-the-art single photon emitters in the C-band window (i.e. ~1550 nm).

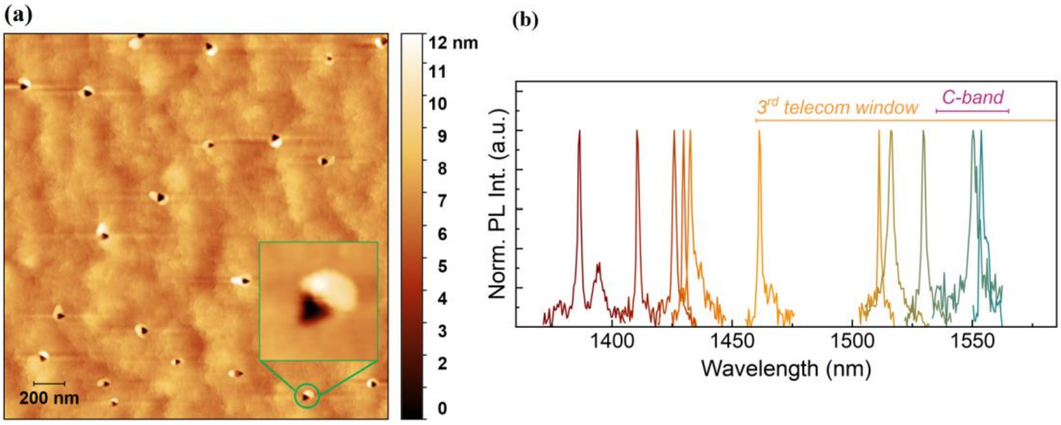

Figure 1 (a) AFM image of nanoholes with 1024×1024 resolution at 2.5×2.5 μm^2 scale, Inset: nanhole with C_{3v} symmetry (b) μ-PL measurements of the fabricated InGaAs/InAlAs QDs showing the emission in C-band

Reference:

[1] Tuktamyshev, A. et al. Appl. Surf. Sci, **669**, 160450 (2024).