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Quantum light emission from growth-tunable $GaAs_xP_{1-x}$ quantum dots in wurtzite GaP nanowires

Paolo De Vincenzi[1], Robert Andrei Sorodoc[2], Akant Sagar Sharma[1], Mario Roggi[1], Isabella Santanchè[1], Leonardo Perrini[1], Enrico Mugnaioli[3], Riccardo Rurali[4], Fabio Beltram[2], Lucia Sorba[2], Valentina Zannier[2] and Marta De Luca[1]

1. Department of Physics, Sapienza University of Rome, P.le A. Moro 5, 00185 Rome, Italy

2. NEST Istituto Nanoscienze-CNR and Scuola Normale Superiore, Piazza S. Silvestro 12, 56127 Pisa, Italy

3. Department of Earth Sciences, University of Pisa, Via S. Maria 53, 56126 Pisa, Italy

4. Institut de Ciència de Materials de Barcelona (ICMAB−CSIC), Campus de Bellaterra, 08193 Bellaterra, Barcelona, Spain

Abstract: We demonstrate growth-tunable single-photon emission from wurtzite $GaAs_xP_{1-x}$ quantum dots in GaP nanowires (630-700 nm), with $g^{(2)}(0) \approx 0.1$ at 5 K. These new emitters show strong potential as building-block for scalable, silicon-compatible photonic platforms.

Among III–V semiconductors, GaP has recently gained strong applicative relevance due to its wide transparency window (0.6–11 µm), minimal lattice mismatch with silicon, and, when synthesized as nanowires (NWs), its pseudo-direct bandgap in the wurtzite (WZ) phase (2.18–2.25 eV) [1]. In this framework, ternary $GaAs_xP_{1-x}$ alloys provide a powerful route for bandgap engineering across the green-to-red spectral range (550–780 nm), a highly attractive region for quantum technologies due to direct compatibility with cost-effective silicon-based single-photon detectors and with applicative relevance for free-space quantum communication, thanks to low atmospheric attenuation.

Building on these advantages, we introduce a novel platform for quantum light generation based on WZ $GaAs_xP_{1-x}$ quantum dots (QDs) embedded in defect-free WZ GaP NWs, as shown in STEM image reported in figure 1a, top panel. By controlling the QD composition (x = 0.7–0.9), we achieve deterministic emission tunability from ~630 nm to ~700 nm, as shown in the bottom panel of figure 1a.

Our emitters exhibit bright and spectrally narrow excitonic lines with linewidths below 2 meV up to 70 K. Spatially resolved micro-photoluminescence directly confirms localized recombination from single QDs, while power- and temperature-dependent measurements reveal well-defined quantum confinement and excitonic structure [2]. Electronic band structure calculations correlate quantum confinement with emission energy, providing key insight for material optimization. Second-order autocorrelation measurements demonstrate high-purity single-photon emission with $g^{(2)}(0) \approx 0.09$ under pulsed excitation, together with clear antibunching up to 40 K under continuous wave excitation, shown in figure 1b, and sub-nanosecond lifetimes [3].

These results position WZ $GaAs_xP_{1-x}$ QDs in GaP NWs as a new, tunable and scalable single-photon emitter platform with potential for integration in existing quantum devices operating under relaxed cryogenic conditions.

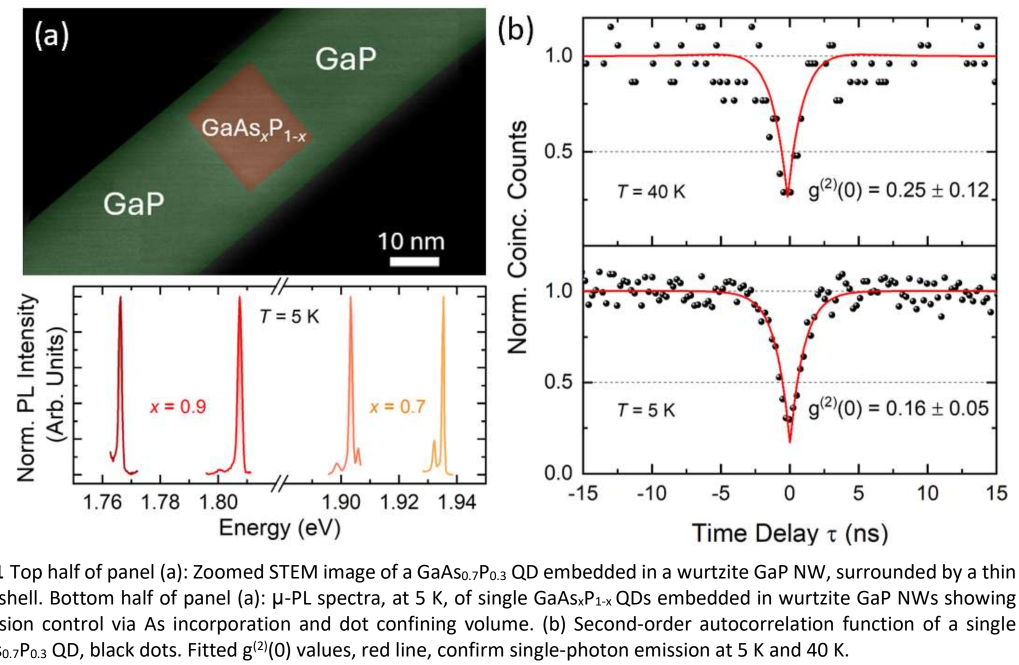

Fig. 1 Top half of panel (a): Zoomed STEM image of a $GaAs_{0.7}P_{0.3}$ QD embedded in a wurtzite GaP NW, surrounded by a thin GaP shell. Bottom half of panel (a): µ-PL spectra, at 5 K, of single $GaAs_xP_{1-x}$ QDs embedded in wurtzite GaP NWs showing emission control via As incorporation and dot confining volume. (b) Second-order autocorrelation function of a single $GaAs_{0.7}P_{0.3}$ QD, black dots. Fitted $g^{(2)}(0)$ values, red line, confirm single-photon emission at 5 K and 40 K.

References

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