Telecom Wavelength Single-Photon Sources Based on Semiconductor Nanowire Quantum Dots

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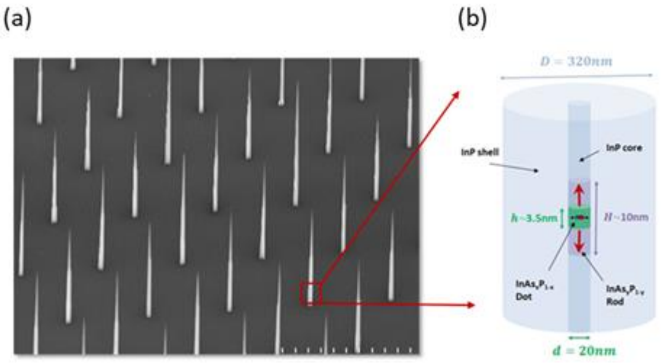
Single-photon sources with high purity and efficiency are key enablers of quantum information technologies, underpinning secure quantum communication and scalable photonic quantum computing. Among the various platforms, semiconductor nanowire quantum dot emitters have emerged as promising candidates for the deterministic generation of on-demand, high-purity, and indistinguishable single photons at high repetition rates. Their compatibility with silicon-based platforms further supports integration into photonic quantum circuits.

Here, we report recent progress in the deterministic growth and engineering of III–V semiconductor nanowires incorporating quantum dots, optimized for emission at telecom wavelengths. Using chemical beam epitaxy combined with selective-area growth and vapor–liquid–solid (VLS) mechanisms, we achieve position-controlled growth of InAsP/InP quantum dot-in-a-rod heterostructures embedded within InP nanowire waveguides [1]. This architecture enables bright single-photon emission at 1310 nm at 4 K, with saturation count rates reaching ~1.9 Mcps under 80 MHz pulsed excitation.

At sub-saturation excitation (~0.1 P_sat), we measure a second-order correlation value of $g^{(2)}(0) = 0.007$, confirming near-ideal single-photon purity. The system exhibits an end-to-end efficiency of 2.4% and a first-lens collection efficiency of about 28% [2]. Photon indistinguishability of 81.1% ± 3.7% with a temporal postselection of a 300 ps time window was achieved [3]. In addition, the device generates entangled photon pairs with a peak fidelity of 85.8 ± 1.1% and a concurrence of 75.1 ± 2.1% [4].



Counts (at 1st lens), cps	21 M
Efficiency (at 1st lens), η	0.28
Single photon purity, $g^{(2)}(0)$	0.007
Indistinguishability, V	0.811
Entangled photon pairs, F	0.858

Fig. 1. (a) Scanning electron microscopy image at 45° of an array of nanowires pitched at 7.5 µm. (b) Schematic drawing of the dot-in-a-rod structure. Table: Extracted performance at 4K of a single dot nanowire emitting at 1310 nm.

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[3] M. K. Alqedra, *et al.*, Applied Physics Letters 127, 164001 (2025).
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