Quantum Photonics with Strain-Engineered Site-Controlled Quantum Dots: From Scalable Deterministic Cavity Coupling to Telecom O-Band Emission

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Scalable quantum photonic technologies require deterministic, high-performance single-photon sources with precise spatial control, spectral tunability, and wafer-scale compatibility. Here, we present a unified platform based on strain-engineered, site-controlled quantum dots (SCQDs) that addresses both deterministic integration into nanophotonic resonators and telecom-wavelength emission.

Our approach employs a buried $AlAs/Al_2O_3$ stressor layer to induce a controlled tensile strain field, enabling site-selective nucleation without pre-localization techniques. This strain engineering simultaneously redshifts emission into the telecom O-band (~1.3 µm) while preserving optical coherence. We integrate SCQDs deterministically into circular Bragg grating (CBG) resonators using a marker-free, lithography-only process. A 6 × 6 SCQD–CBG array shows 100% device yield of optically active devices, with most emitters positioned within optimal radial tolerances. The best devices achieve photon-extraction efficiencies above 47%, high single-photon purity (~99.6%), and two-photon interference visibilities exceeding 80% [1]. In parallel, we demonstrate telecom O-band single-photon emission of SCQDs without the need of strain reducing layers, and with pure single-photon emission up to 77 K [2]. Our experimental results, supported by k·p and configuration-interaction modeling, reveal strain-induced band structure modifications and excitonic behaviour.

Our SCQD technology platform establishes a scalable route toward deterministic, high-performance quantum emitters for quantum communication and integrated photonic technologies.

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References

[1] K. Gaur et al., arxiv:2512.12300

[2] I. Limame et al., arxiv:2603.23392