2025 Conference on Lasers and Electro-Optics Europe & European Quantum Electronics Conference (CLEO/Europe-EQEC) | 979-8-3315-1252-1/25/$31.00 ©2025 IEEE | DOI: 10.1109/CLEO/EUROPE-EQEC65582.2025.11109120

Reliable fabrication of electrically tunable quantum dot emitters on SiN via micro-transfer printing

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Many applications in quantum communication and information processing demand integrated and tunable quantum emitters within a low-loss, scalable platform that can support multiple devices. While state-of-the-art In(Ga)As quantum dot devices have been realized in GaAs platforms[1], they suffer from significant propagation losses, typically on the order of 10 dB/mm. In this work, we integrate such electrically tunable p-i-n GaAs devices into a low-loss SiN platform. For this, we fabricated suspended GaAs devices, encapsulated in photoresist coupons on their native source wafer. Using a commercial micro-transfer printer, we reliably integrated these on the SiN platform. Afterwards, the photoresist encapsulation was removed prior to final metallization. This approach led to a high fabrication yield of 94.7%, with 36 out of 38 devices successfully integrated. After wirebonding the parallel-connected devices, the sample was mounted into a 4 K cryostat. Upon cooldown, the devices demonstrated consistent GaAs/SiN coupling efficiencies on the order of 1 dB, enabling the characterization of quantum dot emission using both GaAs and SiN grating couplers. In Fig. 1(b), when sweeping the voltage across the p-i-n diodes in forward bias under above-band excitation at 800 nm, the quantum dot spectral lines exhibit the expected quadratic response, which is consistent with the quantum confined Stark effect. After inserting an ultra-narrowband optical filter to select a single emission line, we characterized the emitted photon purity in second-order photon correlation measurements under p-shell excitation. In Figs. 1(c-d), we observe a clear antibunching dip, corresponding to a raw $g^2(\tau = 0)$ of $7.02 \pm 1.29\%$. At longer timescales, we observe a blinking effect that essentially disappears under low excitation powers, clearly demonstrating the supression of charge noise.

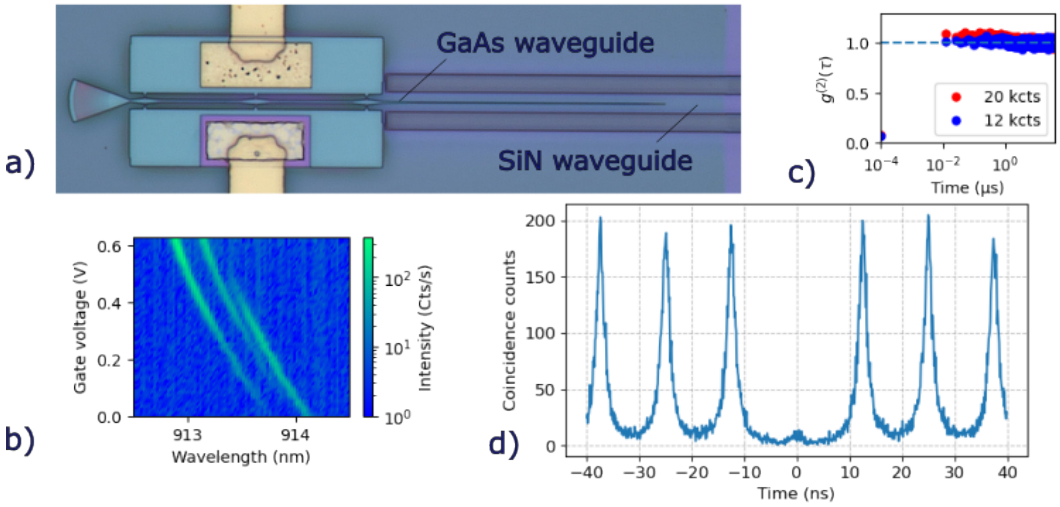

Fig. 1 (a) Microscope image of the micro-transfer printed GaAs/SiN device (b) Wavelength tuning of the quantum dot emission (c) Second-order photon correlation over long (inset: detector count rate/s) and (d) shorter timescales

This first integration including GaAs p-i-n layers clearly allows for proper charge control and tuning. It further opens up new opportunities for investigating nonlinear quantum photonics[2] and spin physics[3] in this platform.

We acknowledge the support by Fonds Wetenschappelijk Onderzoek (FWO) grant 1S69123N and by the QuantERA II Programme that has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 101017733.

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