Fabrication of a hybrid InAs/InP quantum-dot-based waveguides on SOI platform with micro-transfer printing

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On-chip photonics-driven quantum technologies represent a significant advancement in the processing and transmission of quantum information. Integrated quantum photonic circuits (IQPCs) incorporate semiconductor components such as emitters, waveguides (WGs), and detectors within a photonic chip and may provide the potential for enhanced performance and functionality when combined with silicon-based photonics and electronics.

Here, we show simulations, fabrication and experimental studies on a hybrid system of InP and Si waveguides with InAs/InP quantum dots (QDs) as single-photon emitters [1, 2]. The structure is integrated employing a micro-transfer printing technique where the InP nanobeam cavity is transferred on a dedicated silicon-on-insulator chip containing buried Si waveguides and outcouplers. Prior to fabrication, numerical optimization (3D FDTD simulations) identifies the most effective design for coupling between fundamental cavity mode and QD emission at 1.55 μm wavelength, as well as light transfer to Si/SiO_2 WG. Our study demonstrates a successful light coupling between printed InP and buried Si components by also investigating photons outcoupled through a grating system. This work shows the potential advantages of this method for heterogeneous integration, advancing the development of IQPC using single-photon sources of high purity and indistinguishability [3], which can also be combined with external fiber optic networks.

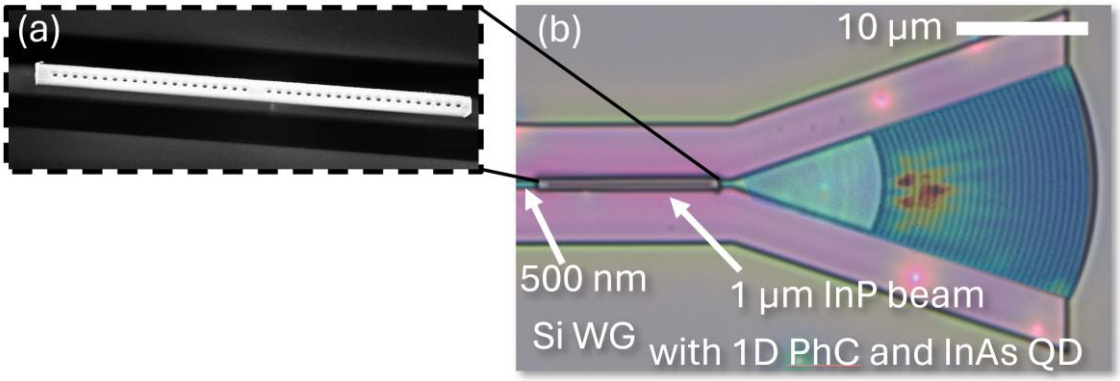

Figure 1. Images of the fabricated device. a) SEM of the analogous structure with InP nanobeam cavity waveguide integrated by micro-transfer printing with the on-chip waveguide. b) Microscope image of the examined structure with the nanobeam and the grating outcoupler – scattered QD emission collected on the 2D InGaAs camera is imposed on the image.

[1] P. Holewa et al., *Phys. Rev. B* **101**, 195304 (2020).
[2] M. Burakowski et al., *Opt. Express* **32**, 10874 (2024)
[3] P. Holewa et al., *Nature Communication (accepted)*, arXiv, 2304.02515 (2023)