Deterministic Integration of Quantum Photonic Devices Based on Quantum Dots with a SOI Chip Operating at 1.55 µm

M. Burakowski[1], P. Mrowiński[1], P. Holewa[1, 2, 3], Y. Ding[2], K. Yvind[2, 3], E. Semenova[2, 3], M. Syperek[1]

[1] *Department of Experimental Physics, Faculty of Fundamental Problems of Technology, Wrocław University of Science and Technology, Wyspiańskiego 27, 50-370 Wrocław, Poland*
[2] *DTU Electro, Technical University of Denmark, Kongens Lyngby 2800, Denmark*
[3] *NanoPhoton-Center for Nanophotonics, Technical University of Denmark, 2800 Kongens Lyngby, Denmark*

Quantum technologies based on on-chip photonics could significantly advance information processing and transmission. Integrated quantum photonic circuits (IQPC) using semiconductor components such as emitters, waveguides (WGs) and detectors that compose a photonic chip can offer improved performance and enhanced functionality when combined with silicon-based photonics and electronics.

We present modelling, 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 placed on a separate silicon-on-insulator chip containing buried Si waveguides and outcouplers. Prior to fabrication, numerical optimization (3D FDTD simulations) identifies the most effective architecture 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 showcases successful light coupling between printed InP and buried Si components by also investigating photons outcoupled via a grating system. We show the potential benefits of this approach for heterogeneous integration, advancing the development of IQPC using single-photon sources of high purity and indistinguishability [3], which can also be easily combined with external fiber optics networks.

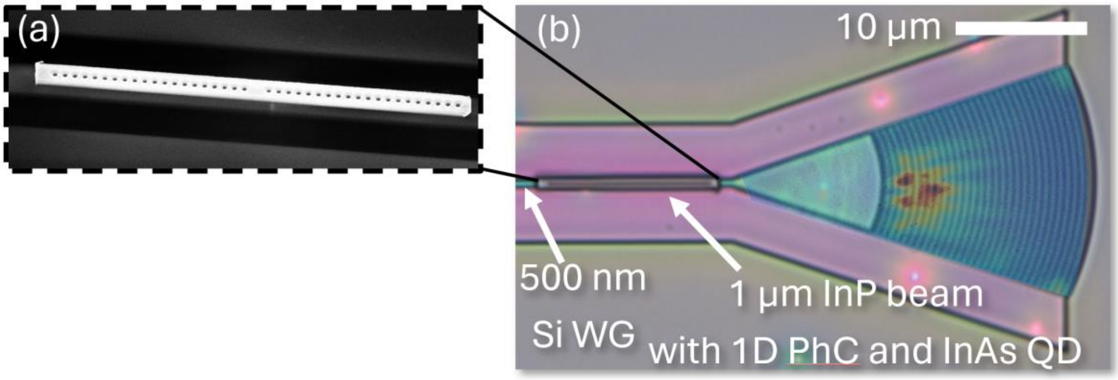

Figure 1. Images of the fabricated device. a) SEM of the analogous structure with InP nanobeam cavity waveguide integrated by micro-transfer printing with on-chip waveguide. b) Microscope image of the examined structure with the nanobeam and the grating outcoupler – scattered QD emission collected on 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**, 10874-10886 (2024).
[3] P. Holewa et al., arXiv, 2304.02515 (2023).