Heterogeneously Integrated InAs/InP Quantum Dot Single-photon Emitter with the Si Platform for On-chip Quantum Photonics

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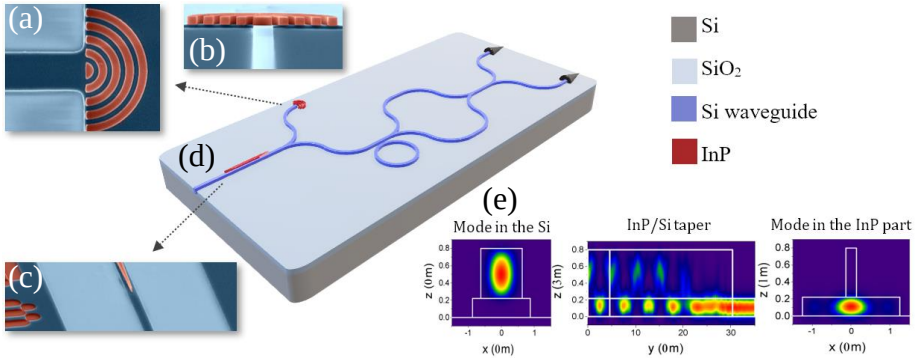
Photonics-based quantum technologies would remarkably advance the processing and transfer of information. Photonic integrated circuits (PIC) in which semiconductor-based components, like emitters, waveguides (WGs), and detectors, can all be integrated on a compact photonic chip, provide a better performance, and increase their functionality when assembled with silicon-based electronics.

We present modelling, fabrication, and experimental studies on a hybridized InP/Si WG system with InAs/InP quantum dots (QDs) as single photon emitters [1]. The structure is fabricated via the direct wafer bonding technique of InP and silicon-on-insulator chips, followed by the e-beam lithography and inductively coupled plasma etching steps resulting in the InP WGs formation. Before fabrication, the structure was optimized numerically, revealing the optimal architecture for the most efficient coupling between QDs and propagating modes in the InP/Si WG and, further, along the the Si/SiO_2 WG. A linear taper structure achieves the efficient light field coupling between the InP/Si and Si/SiO_2 WGs [2]. We demonstrate the light coupling between InP and Si parts and examine the quantum nature of photons generated by a QD and propagating through WGs. The Hanburry-Brown and Twiss interferometric experiment on photons emitted by a QD and collected at the cleaved facet of the Si/SiO_2 WG revealed a good suppression of multiphoton emission events with $g^{(2)}(0) < 0.2$. The outcomes of our study underscore the potential benefits of this technological approach for advancing the development of quantum on-chip photonics using single-photon sources which can be easily combined with external fiber optics networks.



Scanning electron microscope images of the fabricated outcoupler (a, b) and taper (c). Conceptual illustration of the PIC with a heterogeneously integrated QD emitter (d). Modes of transmission for the calculated waveguide (e).

[1] P. Holewa *et al.*, *Phys. Rev. B* ***101***, 195304 (2020).
[2] P. Mrowiński *et al.*, *Opt. Express* **31**, 1541-1556 (2023)