# Abstract

This thesis presents results of heterogeneous integration of InAs/InP semiconductor quantum dots (QDs) with photonic structures (waveguides, photonic crystals, and optical fibers) and their optical characterization for the purpose of quantum information processing realized on-chip. The characterization of devices fabricated using a large-area direct bonding technique allowed proving the successful hybrid integration of the InP and silicon-on-insulator (SOI) platforms, enabling the coupling of single photons emitted by QDs into the interior of the SOI chip. This approach offers a scalable and cost-effective solution for creating dense multi-source on-chip environments within complex quantum photonic circuits. Fabrication and characterization were focused on the telecom C-band for compatibility with fiber networks. Experimentally demonstrated light coupling between the InP and SOI platforms was evidenced by the observation of photons outcoupled at both the InP outcoupler and the cleaved facet of the SOI waveguide with a determined on-chip coupling efficiency of 5.1 % between the QD source and the SOI waveguide, with a high single-photon purity operation at the level of 98 %.

In addition, this thesis presents the development and characterization of an integrated quantum light source for long-haul fiber-optic quantum communication. Designed, fabricated, and optically characterized, a single-photon emitter was based on InAs/InP quantum dots embedded within an InP H1 point defect 2D photonic crystal cavity. For this device, a micro-transfer printing process was developed to transfer the photonic crystal with QDs to standard single-mode fiber. The integrated source was then characterized within a cryocooler at 15 K, demonstrating high-quality single-photon emission with a second-order autocorrelation function with purity of 86 % and stable operation. To validate the system's performance in a realistic setting, an all-fiber optical channel was established between two laboratory nodes. This fabrication and experimental investigation allowed for demonstration of a robust and plug-and-play single-photon source operating in the third telecom window, paving the way for practical and scalable quantum communication networks utilizing fiber-optic infrastructure.

A developed micro-transfer printing process enabled highly accurate, precise, and deterministic transfer of individual InP nanobeams with InAs/InP quantum dots within 1D photonic crystal cavities. With this advanced method, transfer with exceptional control given by sub-100 nm (1-sigma) accuracy and precision was achieved. It allowed the integration of these nanobeams into diverse configurations (also automatically with high throughput) and on various material platforms, including Si, SiN, InP waveguides, and metal contacts. The research presented in this thesis features direct bonding and especially micro-transfer printing as a universal integration technique for the development of quantum photonic integrated circuits.