Heterogenous Photonic Integration for Quantum Optical Communication

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Photonic integrated circuits (PICs) play an important role in telecom and datacom applications. While in the past integrated transceivers were the main driver for technological advances in integrated photonics, nowadays PICs are emerging in various other fields, such as sensing, high-performance computing, quantum technologies, and more [1]. Various material platforms for PICs have been developed and successfully utilized, like III-V semiconductors (InP, GaAs), silicon-based materials (Si, Si_3N_4, SiO_2), lithium niobate ($LiNbO_3$), polymers and others.

In our work we present an approach of developing a versatile photonic integration platform for quantum applications. So called quantum photonic integrated circuits (QPICs) require the integration of several diverse device functions on the same base platform to drive the miniaturization process and multiply quantum performance [2]. We will present the ambition and first results of the Quantera project entitled "A versatile quantum photonic IC platform enabled by micro-transfer printing – uTP4Q". In the project, the micro-transfer printing (uTP) technique is employed [3] for heterogeneous integration of different quantum components fabricated on their primary technology platforms into one QPIC. This approach enables us to use high-performance components, such as In(Ga)As single-photon sources, $LiNbO_3$ modulators and switches, NbN superconductive nanowire single-photon detectors and low-loss Si_3N_4 connections and passive components for high performance QPICs. The goal of the project is to demonstrate the advantages of this approach for the case of an integrated solution of device-independent quantum key distribution (DI-QKD) in optical communication. The uTP process is used for heterogeneous integration of InAs quantum dot emitters, lithium niobate modulators and switches, and superconducting detectors on a mature foundry-based low-loss silicon nitride waveguide interposer (Fig. 1). In the presentation we will present selected results of the project, highlighting the approaches to achieve efficient optical coupling of components to the SiN platform and optical fibers. Requirements for using QPICs in optical access networks will be discussed.

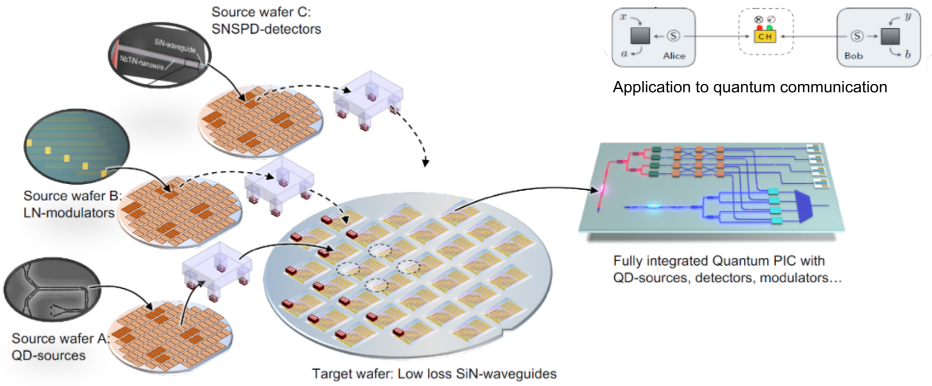

Fig. 1: Micro-transfer printing of different components to SiN interposer to obtain high performance QPICs for quantum applications.

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