A low-loss 200 mm SiN quantum photonics platform for quantum computing

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Practical quantum computing based on photonic qubits requires a set of key chip-based components with minimal optical losses for quantum light manipulation, in order to ensure large quantum computing depth with minimal errors.

While we have previously developed an ultra-low loss SiN platform in a 200 mm CMOS-compatible fabrication line at CEA-LETI, suited for both conventional and quantum applications at 1550 nm telecom wavelength [1], we focus here on a low-loss SiN photonic platform operating at 900-950 nm wavelength range, compatible with on-demand single photon sources based on III-V quantum dots [2]. This platform features both tunable passive components for programmable quantum processing and superconducting nanowire single photon detectors (SNSPDs). SNSPDs arrays can be seamlessly integrated on-chip or densely packaged separately with a fiber array.

The platform is optimized to provide the best compromise between low waveguide propagation losses and compact bends in order to minimize the footprint and total loss budget of functional processing circuits. Propagation losses are 0.5 dB/cm and 1.2 dB/cm for multimode and single-mode waveguides respectively and 90° bends have negligible loss for radii down to 40 µm. Hence directional couplers can be very compact. Thermo-optical phase shifters have insertion loss below 0.05 dB. Fiber-to-chip coupling loss is currently 2 dB and is expected down to 0.25 dB from simulations of optimized designs.

Single photon detection is based on evanescent coupling between an absorbing superconductiong NbN nanowire placed atop a SiN waveguide [3]. After material optimization [4], we measure on-chip detection efficiency of 72% for a dark count rate limited to 100 Hz, a maximum count rate up to 143 MHz and a timing jitter below 50 ps.

This platform is further being extended with the development of low-loss high-speed phase shifters based on the direct bonding of LNOI wafers onto the SiN wafers.

Our work paves the way towards an industrial-grade integrated photonic platform offering the key building blocks for on-chip quantum processors enabling advanced photonic quantum computing schemes.

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References

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Figures

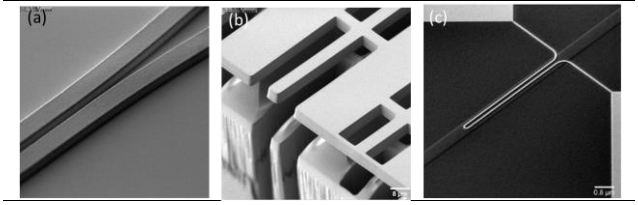

Figure 1: Directional coupler, suspended fiber-to-chip coupler and SNSPD integrated in a 200 mm SiN platform and operating in the 900-950 nm wavelength range