High-efficiency NbN Waveguide-Integrated Superconducting Nanowire Single-Photon Detectors at 1550 nm on 200-mm SOI Wafers

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Superconducting nanowire single-photon detectors (SNSPDs) integrated on top of photonic waveguides combine high detection efficiency, low dark count rate, low timing jitter and faster reset time than their normal incidence counterparts [1]. These features make them highly suitable for chip-based quantum communications and networks or for quantum computing using photonic qubits.
We report on the development of telecom wavelength waveguide-integrated SNSPDs using a CMOS-compatible process on 200-mm diameter SOI wafers, thus offering a strong scalability potential. In addition, the fabrication process is fully compatible with other components of the SOI platform such as nonlinear sources of entangled photon pairs and generic components for light routing, filtering and modulation.
The SNSPDs are fabricated using a 5-nm NbN superconducting layer, which critical temperature is optimized above 8K through the prior deposition of a 10-nm AlN texturing layer [3]. Nanowires are then patterned with a 100 nm width and various lengths of 10, 40 and 80 µm, encapsulated with SiO_2 so as to ensure stable performances, and metallized using a planar process.

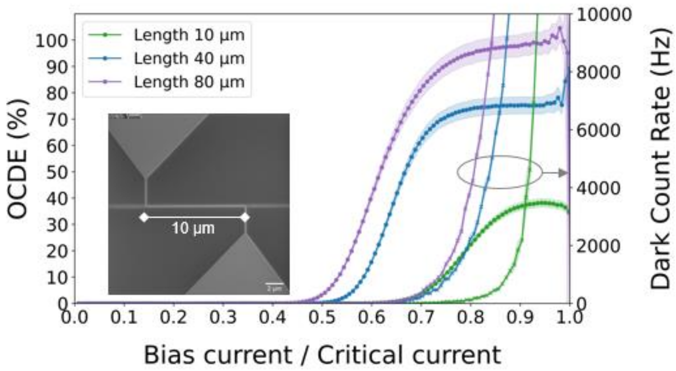

Fig. 1: *On-chip detection efficiency (OCDE) and dark count rates of 10, 40 and 80 µm waveguide-integrated SNSPDs as a function of the normalized bias current.*

Inset : scanning electron micrograph of a 10-µm long SNSPD.

SNSPD chips are then packaged and mounted in a closed-cycle helium cryostat for characterization at 2.4 K. As shown in Fig. 1, the on-chip detection efficiency (OCDE) of the three SNSPDs, plotted as a function of the bias current (normalized with respect to the critical current), features a clear saturated detection efficiency, increasing with the absorption length of the NbN nanowires. The detector OCDE at 1550 nm reaches maximum values of 38.2 ± 1.6 %, 75.2 ± 3.2 %, and 98.6 ± 4.3 % for 10, 40 and 80 µm length respectively. A detection efficiency above 90% is therefore achieved for detectors as short as 80 µm (compatible with > 200 MHz counting rate), with a dark count rate limited to 1000 Hz. This work paves the way to the future industrial deployment of high-efficiency SNSPDs integrated into quantum communication receiver circuits or quantum computing processors.

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References

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