Integrated Superconducting Single Photon Detectors on Thin-Film Lithium Niobate at High Operating Temperatures

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The generation, control, and detection of single photons are fundamental to quantum photonic applications, as they enable the implementation of protocols such as quantum communication, quantum computing, and quantum sensing, where information is encoded and processed at the level of individual quanta of light. Integrated platforms, such as silicon photonics, have already enabled efficient single photon generation and control [1]. Emerging platforms such as thin-film lithium niobate (TFLN) are particularly interesting due to the possibility of fast electro-optic control and photon-pair generation via spontaneous down-conversion [2]. However, the missing co-integration of single photon detectors remains critical to reduce coupling losses and enable fast feed forward. Superconducting nanowire single photon detectors (SNSPDs) offer high efficiency, low timing jitter, and low dark counts, making them a leading solution. SNSPDs have been integrated on optical waveguides [3], however their co-integration with single photon sources and scalable photonic circuits remains a fabrication challenge. Maintaining the patterned detector's performance through subsequent processing steps required for optical components, such as periodically poled waveguides, thermo-optic modulators, and other components is nontrivial. Here, we demonstrate NbTiN SNSPDs directly integrated on TFLN waveguides (device shown in Fig.1a), achieving high critical currents and operation at elevated temperatures up to 5 K, well above the typical 1–2 K reported in the literature. By optimizing deposition, nanowire design, and fabrication processes to preserve material integrity [4], we obtain critical current densities up to $6.4\,\mathrm{MA/cm^2}$ (see Fig.1b), low dark count rates (<10 Hz at 90 % of I_c, seen in Fig.1c), and fast reset times on the order of 1 ns. The reported high critical temperatures (subsequently high critical currents at 5 K) enables operation with standard He-4 cryostats and provides a solid foundation for further integration with complex photonic components.

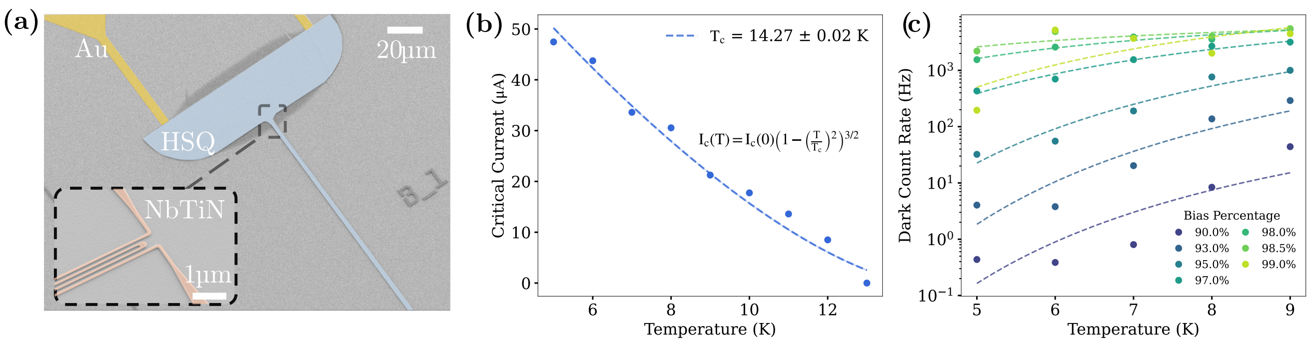

Figure 1: (a) False colored SEM image of device. (b) Critical current of a device in 10 nm-thick NbTiN chips as a function of temperature. (c) Dark count rate at different temperatures for a 10 nm-thick device. Data is fitted (dashed lines) with an exponential equation.

References

[1] Stefano Paesani et al. "Generation and Sampling of Quantum States of Light in a Silicon Chip". In: *Nature Physics* 15.9 (Sept. 2019), pp. 925–929.

[2] Di Zhu et al. "Integrated Photonics on Thin-Film Lithium Niobate". In: *Advances in Optics and Photonics* 13.2 (2021), pp. 242–352.

[3] Emma Lomonte et al. "Single-Photon Detection and Cryogenic Reconfigurability in Lithium Niobate Nanophotonic Circuits". In: *Nature Communications* 12.1 (2021), p. 6847.

[4] Sjoerd Telkamp et al. "High-Temperature Growth of Ultra Thin NbTiN Films on Lithium Niobate for Integrated Single Photon Detection". In: *arXiv preprint* (2025). arXiv: 2509.07870.