Atomic-layered deposited mid-IR sensitive Superconducting Nanowire single photon detectors

Nidhi Choudhary[1*], Dmitry Morozov[1], Daniel Kuznesof[1], Vikas Vikas[1], Ciaran T. Lennon[2], Ian Maclaren [3], Robert H. Hadfield[1]

[1]*James Watt School of Engineering, University of Glasgow, Glasgow G12 8QQ, United Kingdom*

[2]*Oxford Instruments Plasma Technology, Govier Way, Bristol BS35 4GG, United Kingdom*

[3]School of Physics and Astronomy, University of Glasgow, Glasgow G12 8QQ, United Kingdom

Superconducting nanowire single-photon detectors (SNSPDs) are prized for their excellent sensitivity and performance across a wide wavelength range, from UV to mid-infrared [1]. SNSPDs are important advancements that enable quantum technology applications, such as quantum key distribution and single-photon LiDAR [2,3]. Advances in materials science, particularly with refractory metal nitride thin films such as niobium nitride (NbN) and niobium titanium nitride (NbTiN) [4], are crucial in enhancing SNSPD performance. Plasma-enhanced atomic layer deposition (ALD) is an advanced method that ensures exceptional film uniformity, making it ideal for a variety of applications. In this study, we present the fabrication and characterisation of NbTiN-based SNSPDs for the near and mid-infrared wavelength range. The detectors were patterned on NbTiN films and operated in a closed-cycle cryostat at 0.9 K. Figure 1 below shows the current Photon count rate (PCR) and dark count rate (DCR) vs bias current at 1.55 and 2.3 µm of the fabricated detector on a 5 nm NbTiN ALD-deposited film at 0.9 K. Photon detection rate and timing jitter were measured at different wavelength ranges, 1.5-4.4 µm under low dark count conditions, revealing high sensitivity across the measured wavelength bands. The combination of wide spectral coverage and high efficiency of our detectors based on ALD superconducting films indicates suitability for high-precision photon timing applications.

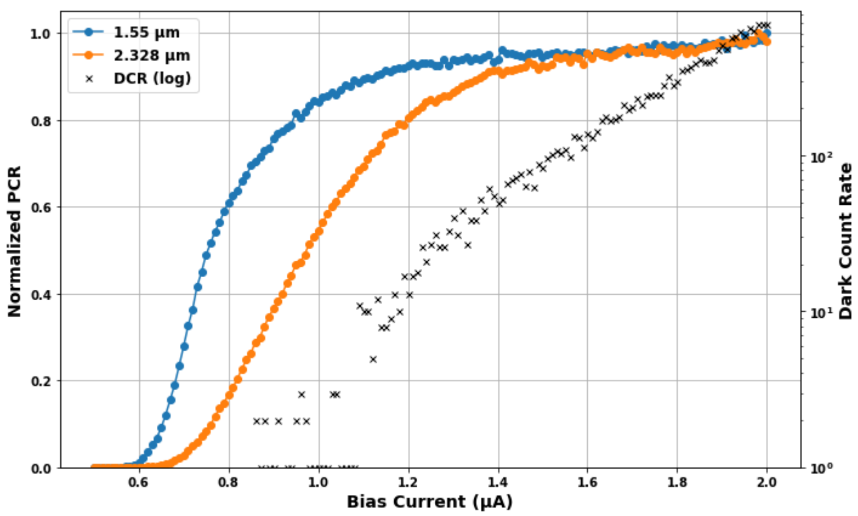

Figure 1: *The normalised PCR data recorded at different wavelengths as a function of bias current, along with the dark count rate (DCR) on the right side at a base temperature of 0.9 K.*

Funding acknowledgement

N. C. thanks the University of Glasgow for support through the Mary Gibb postgraduate research scholarship

R.H.H. gratefully acknowledges funding from UK Research and Innovation (UKRI) under Grants ST/T005920/1, EP/T00097X/1, and EP/S026428/1. R. H. H. and Y. C. gratefully acknowledge support from the National Research Foundation of Korea JOSEON project.

References

[1] Morozov D V, Casaburi A and Hadfield R H 2021 Superconducting photon detectors *Contemporary Physics* **62** 69–91

[2] Taylor G G, MacKenzie E N, Korzh B, Morozov D V, Bumble B, Beyer A D, Allmaras J P, Shaw M D and Hadfield R H 2022 Mid-infrared timing jitter of superconducting nanowire single-photon detectors *Applied Physics Letters* **121** 214001

[3] Steinhauer S, Gyger S and Zwiller V 2021 Progress on large-scale superconducting nanowire single-photon detectors *Applied Physics Letters* **118** 100501

[4] Choudhary N, Peeters S A, Lennon C T, Besprozvannyy D, Knoops H C M, Maclaren I and Hadfield R H 2025 Transmission electron microscopy analysis of atomic layer deposited NbTiN/NbN superconducting thin films *APL Materials* **13** 111104