Mid-infrared quantum sensing with an efficiently fibre-coupled superconducting nanostrip single-photon detector

Daniel Kuznesof [1], Ioana Craiciu[2], Jason Allmaras[2,] Bruce Bumble[2], Devendra K. Namburi[1], Harry Nimbley[1], Daniel N. Shanks[2], Beomgyu Choi[4,1], Sahil R. Patel[2], Dmitry V. Morozov[1], Nidhi Choudhary[1], Vikas Vikas[1], Gregor G. Taylor[2,3], Yonuk Chong[4], Emma E. Wollman[2], Matthew D. Shaw[2], Robert H. Hadfield[1]

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

[2]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Dr., 91109, California, United States

[3]Advanced Quantum Architecture Laboratory (AQUA), École polytechnique fédérale de Lausanne (EPFL), Neuchâtel 2002, Switzerland

[4]SKKU Advanced Institute of Nano Technology, Sung Kyun Kwan University (SKKU), Suwon, 16419, Republic of Korea

The ability to sense individual photons is critical in quantum cryptography, quantum information processing, quantum imaging, and quantum metrology [1]. Superconducting nanostrip single-photon detectors (SNSPDs) offer exceptional performance in terms of sensitivity [2], spectral range [3] and timing resolution [4] and make these applications possible. Whilst high performance SNSPDs operating at near-infrared and telecoms wavelengths are commercially available, extending performance into the mid-infrared (3 - 15 μm) is a major challenge. Building upon previous advances in mid-infrared time-correlated single photon counting with SNSPDs [5], this work presents an efficiently optical fibre-coupled superconducting nanostrip single-photon detector (SNSPD) with blackbody-limited performance and low timing jitter in the mid-infrared region. We present the complete characterisation of system detection efficiency, timing jitter and polarisation extinction ratio from 1.06 – 3.8 μm of the SNSPD and discussion of the system limitations. Moreover, we present a proof-of-principle application of the device for single-photon multispectral depth imaging of small targets in this wavelength range, clearly resolving sub-millimetre features and showing potential for nondestructive testing and materials identification capability. This technology out-performs existing mid-infrared photon detectors and would be well suited for mid-infrared sensing in photon starved environments such as astrochemistry, covert/long-range depth-imaging through turbulent media and obscurants, and remote non-destructive testing.

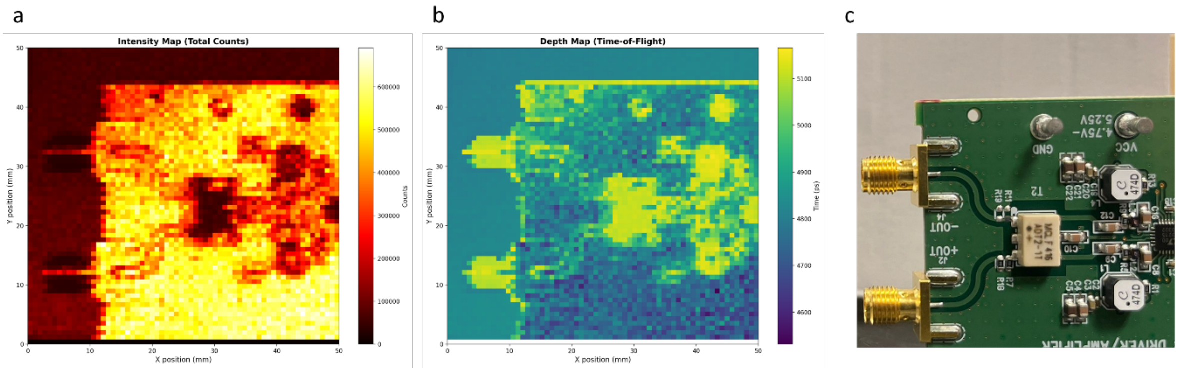

Fig. 1: Single-pixel imaging of an evaluation circuit board at 2.3 μm wavelength with 100 ms dwell time 22 μW power a.) Intensity image of the board b.) depth map of the board c.) photograph of the board.

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