Infrared single photon detection with superconducting nanowires

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***Abstract*—Single photon detectors based on superconducting nanowires have emerged as a highly promising alternative for single-photon detection. These devices offer single photon sensitivity from visible to mid infrared wavelengths with high efficiency, low dark counts and tens of picoseconds timing resolution. We discuss recent advances in device design, integration and miniaturized cooling systems. We give an overview of applications where these devices are now being deployed, including optical quantum information processing, single photon remote sensing and dosimetry for laser medicine.**

Keywords—superconducting detector, superconducting nanowire single photon detector, photon-counting, infrared detection

I. Introduction

The ability to detect single photons underpins a host of emerging 21st century scientific and technological applications. Over the past decade, superconducting nanowire single photon detectors (SNSPDs) [1] have emerged as a practical alternative to off-the-shelf photon counting technologies such as photomultipliers (PMTs) and semiconductor single-photon avalanche diodes (SPADs).

II. Next Generation SNSPDs

The canonical SNSPD device consists of a narrow superconducting wire patterned via electron beam lithography in a thin superconducting film. The device is cooled below the superconducting transition temperature and biased close to the critical current. When an infrared photon (energy ~1eV or even lower) strikes the wire, the current distribution is perturbed triggering a fast voltage pulse which can be rapidly read out with room temperature electronics. Major avenues of development include scale up from single pixel SNSPDs to large area arrays [2], integration with optical waveguides [3] and nanoantennas [4]. At the University of Glasgow we are employing novel superconducting materials and advanced nanofabrication techniques to realize these designs [figure 1 (a),(b)]. We are using a suite of advanced characterization tools, including low temperature photoresponse mapping to characterize these devices from near to mid infrared wavelengths.

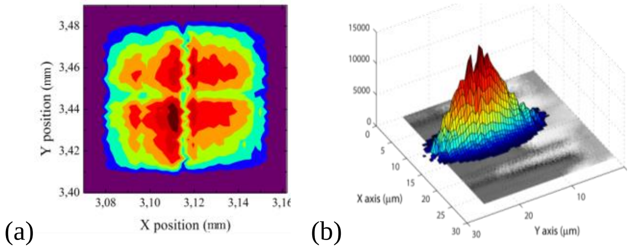

Figure 1 SNSPD development at Glasgow (a) photoresponse map of 60 µm x 60 µm area four-pixel SNSPD array with peak detection efficiency >40%. (b) waveguide integrated SNSPD [3].

III. Advances in Practical Cryogenics

In tandem our group is addressing the challenge of practical device operation at cryogenic temperatures. We have recently partnered with STFC Rutherford Appleton Laboratory to realize a miniaturized 4 K Stirling/Joule-Thompson cooling platform for SNSPDs [figure 2].

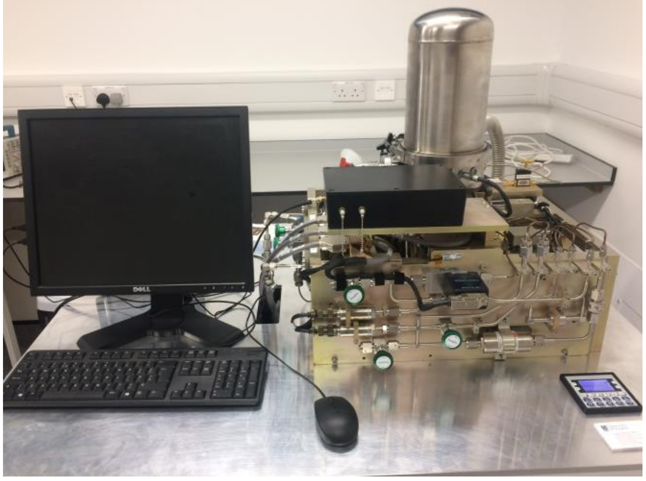

Figure 2 Miniaturized 4 K cooler for SNSPDs developed in partnership with STFC Rutherford Appleton Laboratory.

IV. Outlook: Advanced Photon Counting Applications

In collaboration with UK and international partners we are deploying SNSPDs in a wide range of advanced photon counting applications. Recent examples of groundbreaking implementations include quantum communication networks [5], on-chip quantum information processing [6], single photon remote sensing [7] and singlet oxygen luminescence dosimetry for photodynamic therapy in the treatment of cancer [8].

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