Superconducting nanowire single-photon detectors based on amorphous superconductors

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Introduction

Goal: develop SNSPDs with:
- High intrinsic quantum efficiency (e.g. 90% at 1550 nm)
- Low dark count rates (<10 Hz)
- No afterpulsing effects
- High count rates (20 MHz)
- Low intrinsic jitter (<70 ps)

Amorphous superconductors are highly promising [1].

Devices characterisation

System detection efficiency

Broadband spectral response

Counting rate

Jitter

Measurements at 0.8K show:
- >70% maximum system detection efficiency
- Large spectral response [2]
- 50 ns deadtime
- Jitter as low as 55 ps
- Saturated efficiency, which is the first requirement for high overall system efficiency and higher temperature usability
- Dark count rate can be reduced to few counts per second using filters

Amorphous SNSPDs for space quantum communication

Optical coupling to large telescopes : requires a large collection area
- Free-space coupling in fixed cryostat with Coudé path (best overall efficiency, but more noisy)
- Large core optical fibres (e.g. 200 μm-core multimode fibres) from focus of telescope to SNSPD detector

Large collection area using a 2D array of detectors
- Up to 64 pixels was demonstrated using WSi (320 μm diameter area) [3]
- A large yield of the fabrication process is essential to create large arrays. We currently have a yield higher than 80% (working detectors) with our MoSi process. Higher yield is within reach.

Readout strategy
- A readout strategy is needed to read all the pixels simultaneously.
- Flex coaxes can be used to connect to all pixels, from 0.8K to room temperature
- We have implemented cryogenic amplification at 40K
- A multiplexing scheme can be implemented on the array itself, with some compromise on the fill factor and the efficiency per pixel. [3]

Time tagging
- WSi arrays have been shown to count up to 1.2 Gcounts per second [3]
- Tests with a new time tagger from IDQ (25 MHz counting rate per channel, 4 channels) are planned

Operation and optimisation

Optical coupling to optical fibre
- Devices are detached from the wafer and aligned in a zircon mating sleeve
- An optical fibre in a ferrule is automatically aligned with the sensitive area of the detector
- Any kind of fibre can be used

Efficiency optimisation
- Optical stack to optimise absorption in the nanowire, from UV to Mid-IR

Temperature behaviour
- Plateaued efficiency up to 1.9 K
- Further optimisation of thickness and critical current can lead to operation at 2.3 K [4]