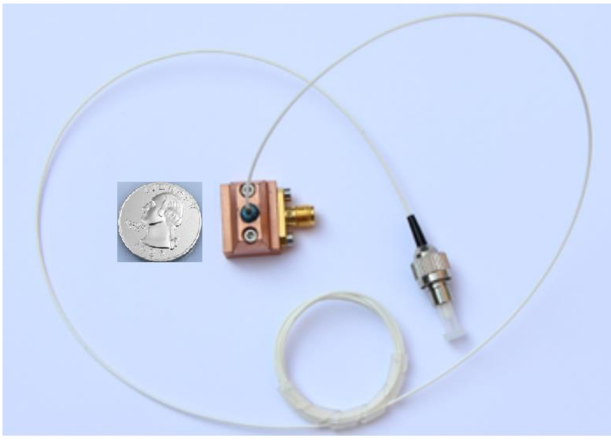
CA-SNSPD Superconducting Nanowire Single Photon Detector

Overview

Advanced Lab Instruments' single-photon detectors based on superconducting nanowires single photon detector (SNSPDs) have rapidly emerged as a highly promising photon counting technology for infrared wavelengths. These devices offer high efficiency, low dark counts and excellent timing resolution. In this datasheet, we consider the basic SNSPD operating principle and models of device behaviour. We give an overview of the evolution of SNSPD device design and the improvements in performance which have been achieved. We also evaluate device limitations and noise mechanisms. We survey practical refrigeration technologies and optical coupling schemes for SNSPDs. In the datasheet we also summarise promising application areas, ranging from quantum cryptography to remote sensing.



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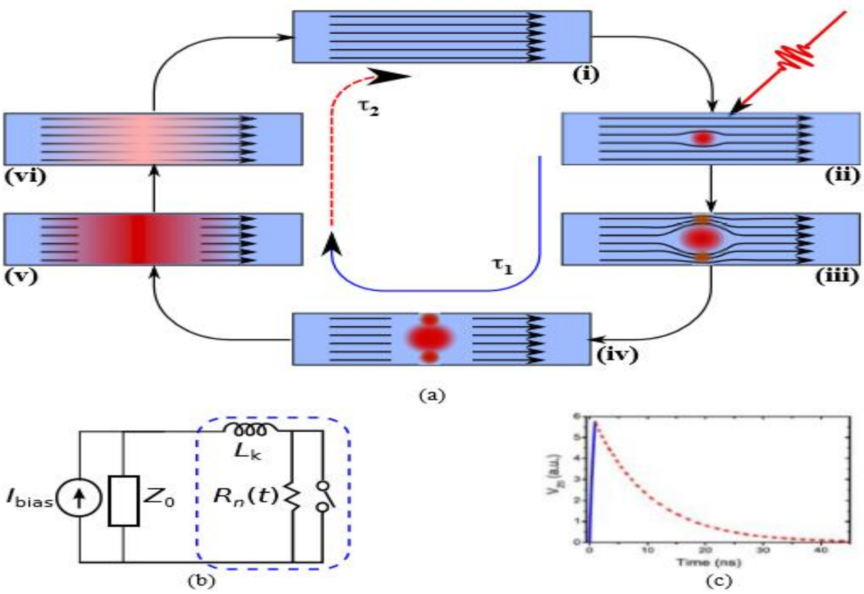
The Basic Operation Principle



The basic operation principle of the superconducting nanowire single-photon detector (SNSPD)

(a) A schematic illustrating the detection cycle.

(i) The superconducting nanowire maintained well below the critical temperature is direct current (DC) biased just below the critical current.

(ii) When a photon is absorbed by the nanowire creating a small resistive hotspot. (iii) The supercurrent is forced to flow along the periphery of the hotspot. Since the superconducting nanowires are narrow, the local current density around the hotspot increases, exceeding the superconducting critical current density.

(iv) This in turn leads to the formation of a resistive barrier across the width of the nanowire .

(v) Joule heating (via the DC bias) aids the growth of resistive region along the axis of the nanowire until the current flow is blocked and the bias current is shunted by the external circuit.

(vi) This allows the resistive region to subside and the wire becomes fully superconducting again. The bias current through the nanowire returns to the original value.

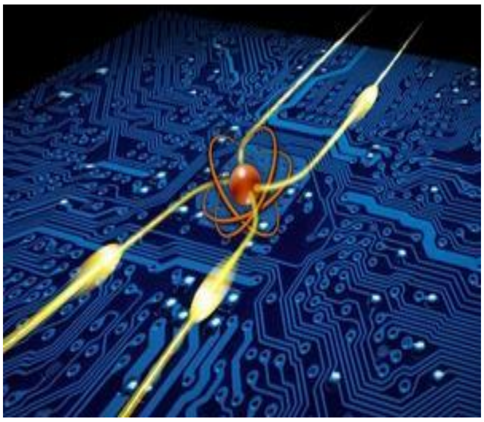
(b) A simple electrical equivalent circuit of a SNSPD.

Lk is the kinetic inductance of the superconducting nanowire and Rn is the hotspot resistance of the SNSPD.

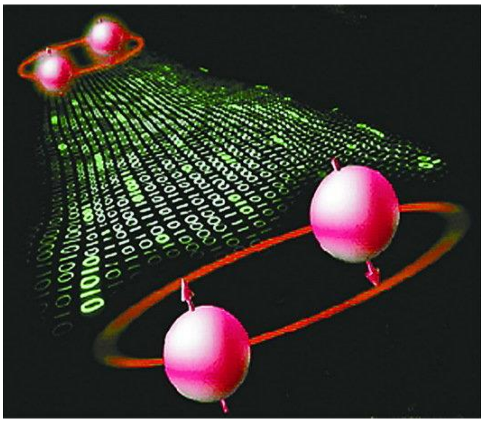
The SNSPD is current biased at Ibias. Opening and closing the switch simulates the absorption of a photon. An output pulse is measured across the load resistor.

(c) A simulation of the output voltage pulse of the SNSPD (approximating the pulse shape typically observed on an oscilloscope after amplification). Values of Lk and Rn have been used for this simulation (for simplicity the Rn is assumed fixed, although a more detailed treatment. The solid blue line is the leading edge of the SNSPD output pulse, whilst the dotted red line is the trailing edge of the output pulse. The time constants relate to the phases of the detection cycle.

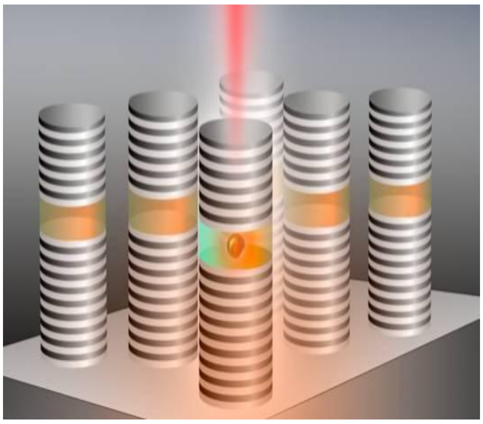
Applications



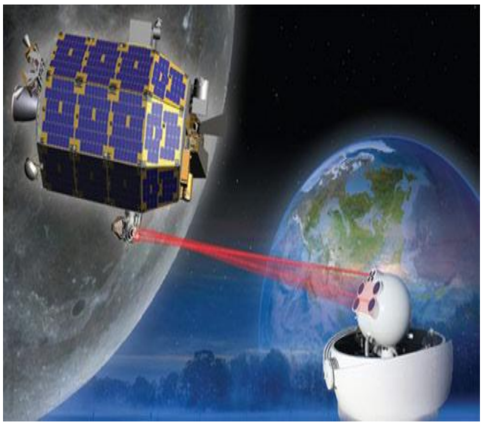
Optical Quantum Computation



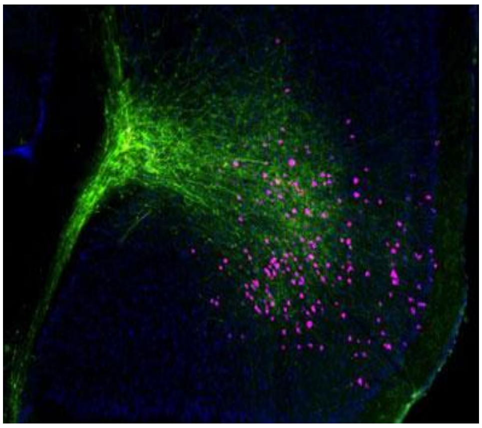
Quantum Communication



Quantum Light Source Characterization



Laser Communication



Biological Fluorescence Detection

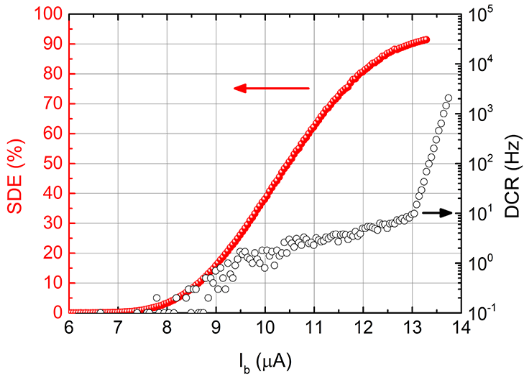
Non-Destructive Chip Testing

Specification

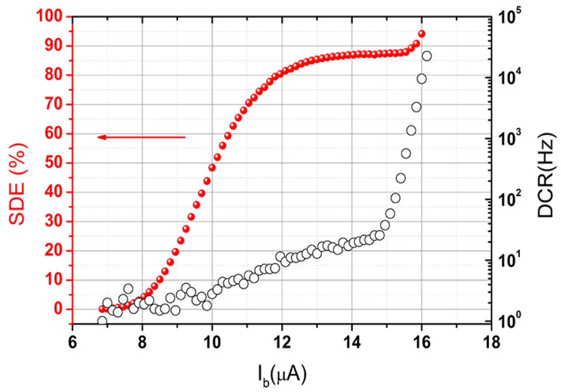
Parameters		Typical*	Optimum
Detection Efficiency	1550 nm	≥70%	≥90%
	1064 nm	≥70%	≥80%
	850 nm	≥70%	≥80%
	532 nm	≥70%	≥80%
Dark count rate		≤100 Hz	≤1 Hz
Timing jitter		40-70 ps	≤20 ps
Counting rate		≥20 MHz	≥100 MHz
Dimension		??	
Weight		??	

*① All the resulsts were tested at 2.2 K; ② Customerization is available.

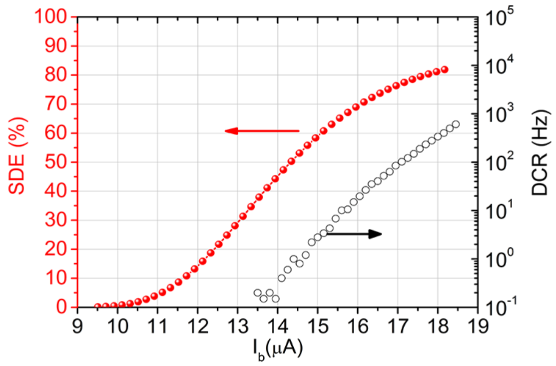
SDE and DCR Curve



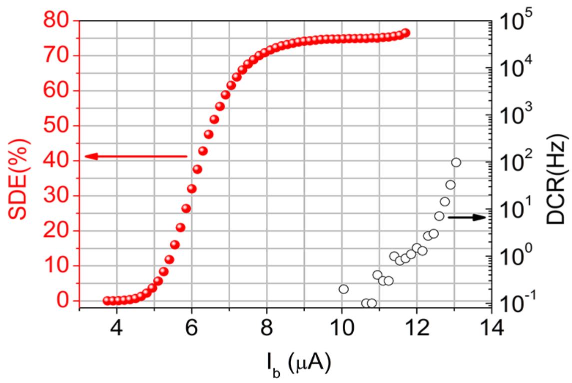
1550nm



1064 nm

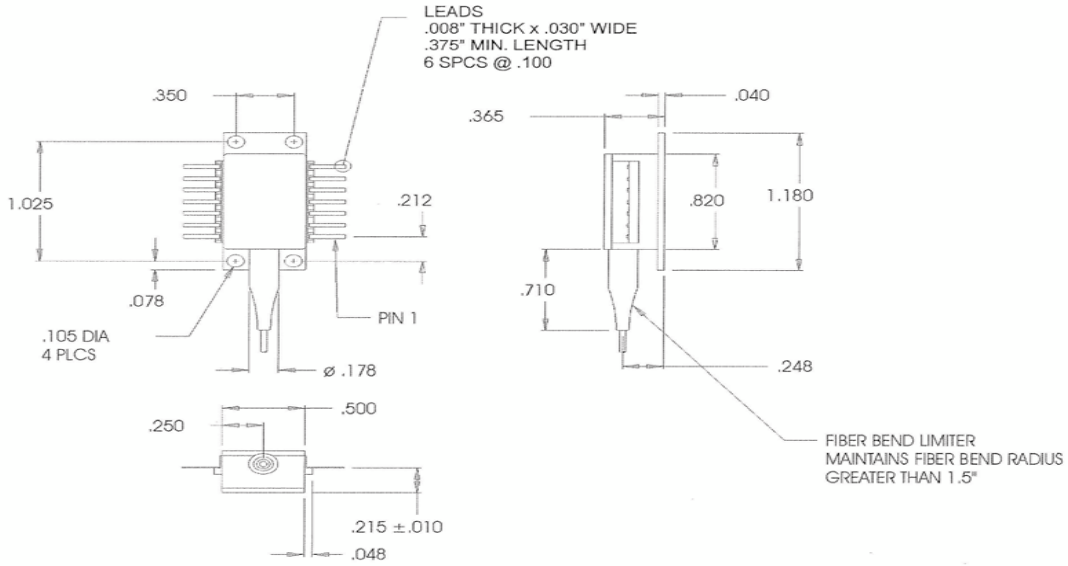


850 nm



532 nm

Outline Drawing



Package Schematic

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