# Superconducting Nanowire Single-Photon Detectors

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Description:
OBJECTIVE: To develop nanowire single-photon detectors of shortwave infrared light with high system efficiency (>90%) and bandwidth (~1 GHz), high fabrication yield, and with compact (~5U) packaging and turnkey operation. DESCRIPTION: Single photon sensitive detectors have many applications including active and passive imaging, traditional and upcoming quantum optical communications, and quantum information processing. For quantum key distribution in fibers, for instance, the noise properties of the detectors limit the distance over which one can establish a secure key. Similarly, for 3D imaging via LADAR, longitudinal resolution is limited by the detector jitter while the detector sensitivity dictates the trade-off between illumination power and maximum range. Therefore, a high-bandwidth, high-sensitivity, compact and readily available photon-counting detector is a key technology for many future scientific developments and improved DoD application capabilities. Technologies for detecting single photons in the telecom band include semiconductor devices such as Geiger-mode InGaAs avalanche photodiodes (APDs) and superconducting devices like the transition edge sensor (TES). The InGaAs APDs can be operated at temperatures accessible via thermoelectric cooling, making them ideal for applications requiring compact photon-counting solutions. InGaAs APDs, however, are typically plagued by after-pulsing effects, making them ill-suited for applications requiring high duty-cycle and high-rate detection [1]. Extremely high efficiency and low dark counts can be achieved with superconducting TES detectors, but the rates are limited to less than 10 MHz and the systems must be operated in the 100 mK regime requiring an extensive cooling overhead [2]. New results in superconducting nanowire devices [3] have shown that high detection rates, low dark-count rates (DCRs), and high efficiency are all possible simultaneously with operating temperatures between 1 and 4 K. Despite these results, further

performance improvements are needed. For example, detection efficiency (DE) above 90% and bandwidth (BW) approaching 1 GHz has yet to be achieved simultaneously. In addition, innovations leading to a reduction in the system footprint and improved operability will provide better accessibility of such technologies to the relevant scientific and engineering communities. The goal of this SBIR project is to further improve upon the current state-of-the-art in nanowire single-photon detector performance while advancing the supporting technologies to allow for a compact, turn-key commercial system. The final system should provide multiple (>2), independent single-pixel detectors with performance superior to all current commercially available options (DE>90%, BW~1GHz, DCR