NASA SBIR/STTR Technologies

NFAD Arrays for Single Photon Optical Communications at 1.5 µm

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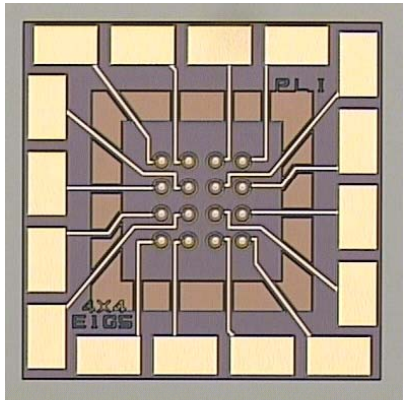
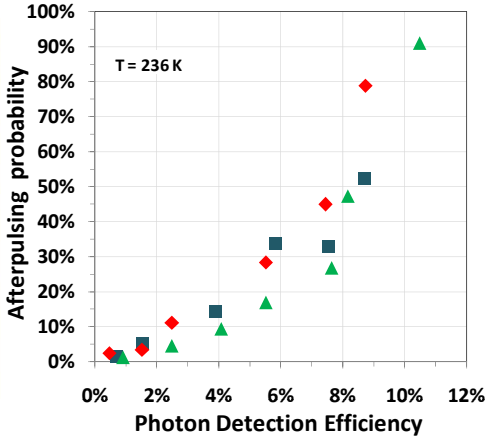
Identification and Significance of Innovation

We propose to develop large-format 128 x 128 single photon counting detector arrays suitable for deployment in spacecraft terminal receivers supporting long-range laser communications. We will leverage initial success in monolithically integrating "negative feedback" elements with state-of-the-art single photon avalanche diodes to realize large-scale negative feedback avalanche diode (NFAD) arrays in which array pixels have good detection efficiency, low dark count rate, low afterpulsing, low timing jitter, and high counting rate. Since NFADs self-quench and self-arm, they can be implemented with greatly simplified back-end circuitry and enable single-photon sensitive focal plane arrays with vastly reduced complexity relative to the state-of-the-art. *NFAD arrays have significant promise for enabling space-qualifiable focal plane arrays that serve applications requiring 1.5 µm single photon detection.*

Expected TRL at start and end of Contract: TRL 2 → TRL 4





Photograph of proof-of-concept 4 x 4 NFAD array to be scaled to 128 x 128 in proposed program and Phase 1 data for self-quenching NFAD integrated afterpulsing at detection efficiencies of up to ~10%.

Phase I Technical Objectives

I. Optimize pixel-level NFAD design
II. Implement optimized pixel-level NFADs into large-format arrays
III. Develop characterization capability for testing large-format NFAD arrays (i.e., 128 x 128 x 100 µm pitch)

Phase I Work Plan

A.1 NFAD wafer epitaxial design and fabrication
A.2 NFAD 32 x 32 array-level design and photomask fabrication
A.3 NFAD 32 x 32 array wafer processing and wafer-level testing
A.4 Design of fan-out board test platform
A.5 Test electronics development, including FPGA and test code
A.6 NFAD 32 x 32 array prototype characterization
B.1 – B.5 Second iteration of A.1 – A.6 for 128 x 128 NFAD format
B.6 Summarize results and define inputs for full FPA development

NASA Applications

- Free-space optical communications, including space-based laser communications links.
- Active remote sensing optical instruments (lidar)

Non-NASA Applications

- Range-finding and ladar applications
- Commercial lidar systems
- Free space optical (satellite) communications
- Single photon counting for fluorescence, photoluminescence and photoemission applications

Firm Contact

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NON-PROPRIETARY DATA