NASA SBIR/STTR Technologies

High Performance Avalanche Photodiodes for Photon Counting at 1064 nm

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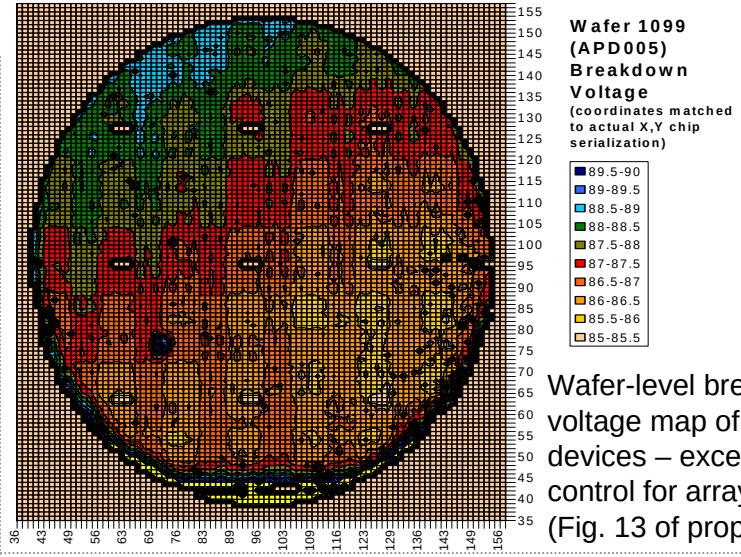
Identification and Significance of Innovation

Progress in InP-based single photon avalanche diodes (SPADs) has not paralleled advances in avalanche photodiode "linear mode" operation. Innovation for photon counting operation is required through device modeling and materials characterization. Very little work has focused on SPAD use at 1064 nm devices, and there are not yet large diameter devices (e.g. 500 um) in the InP material system.

We will implement (i) innovative bandgap and E-field engineering, (ii) simulation platforms developed during Phase I, and (iii) advanced materials characterization to greatly advance photon counting performance for 1064 nm SPADs. Excellent wafer-level yield and uniformity will allow us to also deliver unprecedented SPAD arrays.



Wafer-level breakdown voltage map of Phase I devices – excellent fabrication control for arrayed devices (Fig. 13 of proposal)

Technical Objectives

I. Meet NASA 1064 nm photon counting targets:

- gain > 1000, detection efficiency > 50%, saturation > 50Mcounts/s, 0.5 mm device diameter, 500 MHz bandwidth, non-gated operation

II. Performance comparison between bandgap-engineered, E-field-engineered, and bulk multiplication regions

III. Linear SPAD arrays with photon counting electronics

Work Plan

Five (5) primary program Tasks per design iteration:

1 – analysis; 2 – materials characterization; 3 – simulation; 4 – final device design; 5 – fabrication and characterization

Execute three (3) iterations of the 5 program Tasks; learnings from each iteration serve as input for subsequent iterations

Dedicated Task for developing prototype linear SPAD arrays

NASA Applications

- Free-space optical communications, including space 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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