Department of the Navy SBIR/STTR Transition Program

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NAVSEA #2018-0517

Topic # N15A-T011

Ultra scaling of SPAD arrays for high-speed laser ranging

LightSpin Technologies, Inc.

WHO

SYSCOM: NAVSEA

Sponsoring Program: PEO IWS 2.0 Above Water Sensors

Transition Target: Working to identify potential Transition Targets

TPOC:
(812)854-4694

Other transition opportunities: Free Space Optical Communications
Laser Ranging and Tracking
Quantum Key Distribution

Notes: Current photon detector technologies have either low sensitivity/high bandwidth or high sensitivity/low bandwidth. This can be characterized by a gain-bandwidth product. Most photodetector technologies exhibit a gain bandwidth product of about 0.1 THz, with single photons only being detectable when the bandwidth is below 1 MHz. Newly developed SPAD array devices (LightSpin and SiPM) achieve single photon sensitivity with high gain-bandwidth product, laying a foundation for detecting single photons at GHz bandwidth!

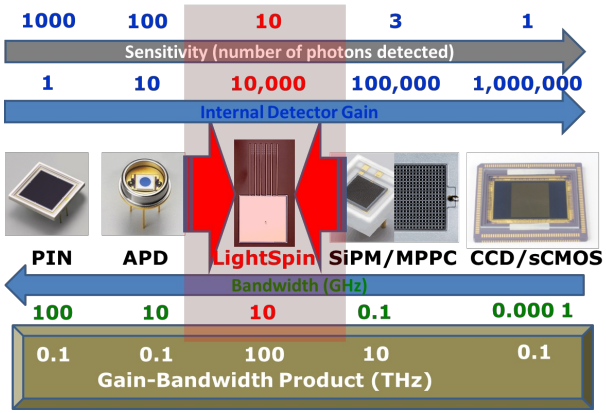

Image courtesy of LightSpin Technologies, Inc., Copyright 2018

WHAT

Operational Need and Improvement: Solid-state photon detectors for ship-to-ship free space optical communications and precision localization, improving the ability of multiple ships to act in concert and combine shipboard sensor data. Visible wavelengths were chosen because low-cost lasers are readily available and these wavelengths do not interfere with shipboard sensors (LADAR and tracking systems). Currently available photodetectors are either high-speed/low-sensitivity or low-speed/high-sensitivity. There is a strong need for detecting single-photons and multiple-photon signals with bandwidths exceeding 1 GHz.

Specifications Required: Single Photon Sensitivity Visible Wavelengths (400 - 650 nm)
1 GHz @ 1.0 mm^2 area (CW bandwidth)
4 GHz @ 0.5 mm^2 area (CW bandwidth)
10 GHz @ 0.5 mm^2 area (pulsed bandwidth)

Technology Developed: Compound semiconductor Single Photon Avalanche Diode (SPAD) arrays Similar to Silicon Photomultipliers (SiPMs), which are silicon SPAD array devices.
Analogous to Microchannel Plate (MCP) vacuum tube photodetectors, where the photocathode and array of channels is replaced by an array of SPAD devices.

Warfighter Value: LightSpin's Photomultiplier Chip provides a unique capability to fill the gaps in competing technologies, increasing the bandwidth for free space optical communications by at least an order of magnitude, and improving the range and precision of targeting/tracking applications.

(1) Higher bandwidth. Due to LIghtSpin's proprietary process and the use of high performance compound semiconductors, LightSpin is developing Photomultiplier Chips to achieve single photon detection with bandwidths in excess of 1 GHz, about an order of magnitude larger than currently available SiPMs

(2) Wavelength customizable: LightSpin's technology can be targeted to specific applications:.
GaInP for highest sensitivity in visible wavelengths, with low noise and improved radiation hardness.
Silicon for lowest cost, while maintaining GHz bandwidths and high sensitivity.
InGaAs for operation at wavelengths between 900 nm and 2500 nm.

WHEN

Contract Number: N00253-17-C-0003 **Ending on:** May 18, 2019

Milestone	Risk Level	Measure of Success	Ending TRL	Date
5 micron pitch SPAD arrays	Low	Laboratory Demonstration	TRL-4	September 2018
0.5 GHz CW Bandwidth	Low	Laboratory Demonstration	TRL-4	September 2018
2.0 GHz pulsed Bandwidth	Med	Laboratory Demonstration	TRL-3	January 2019
1.0 GHz CW Bandwidth, 30 dB DNR	Med	Laboratory Demonstration	TRL-5	May 2019
4.0 GHz pulsed Bandwidth, 5 dB DNR	High	Laboratory Demonstration	TRL-3	May 2019
Prototype Quadrant detector	Med	Laboratory Demonstration	TRL-5	May 2019

HOW

Projected Business Model: LightSpin Technologies, Inc. (LTI) was founded in 2001 to develop and commercialize high performance compound semiconductor components. Through a systematic development approach, LTI has demonstrated superior III-V photodetector technology. LTI has an excellent track record with the SBIR program and other R&D initiatives working across multiple government agencies. For this specific SBIR effort LTI anticipates outsourcing fabrication to commercial foundries but retain testing and validation In-House. LTI plans to sell the finished Photodetector Module to various Primes.

Company Objectives: LTI is developing a new, ultimate sensitivity photodetector technology called the Photomultiplier Chip. Photomultiplier chips detect optical signals with high internal gain, low noise, and multi-GHz bandwidths, allowing precise timing of signals as small as single photons. This technology enables improved remote sensing and free space optical communications, improved radiation hardness for high energy physics applications, higher sensitivity imaging for medical imaging applications, and improved detection of illicit radioactive material.

Potential Commercial Applications: DoD: Free Space Communications, tracking, and positioning
Healthcare: Critical component for high performance positron emission tomography (PET) imaging
Automobile: autonomous navigation sensors

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