

Department of the Navy SBIR/STTR Transition Program

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Topic # NM12-158

Development of CMOS-based APD Arrays with Si-Ge-C Materials

Quantum Semiconductor LLC

WHO

SYSCOM: ONR

Sponsoring Program: Surface Warfare Division (N96)

Transition Target: Program Executive Office (PEO) Integrated Warfare Systems (IWS)

TPOC:

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Other transition opportunities:

Quantum Semiconductor technology is applicable to any application that uses conventional image sensing or Light Detection and Ranging (LIDAR). Other branches, such as the Army and Special Forces, could benefit from the technology.

Notes: Quantum Semiconductor technology can be used in submarines, unmanned aerial vehicles (UAVs), tanks, helicopters, planes, hand-held devices and more - wherever sensitive day or night imaging or LIDAR would benefit the warfighter. Our technology platform consists of Complementary Metal-Oxide-Semiconductor (CMOS) Avalanche Photo-Diode (APD) arrays which operate using a highly sensitive gain mechanism with low dark current at low voltages.



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WHAT

Operational Need and Improvement: Ultra-sensitive imaging in visible and infra-red is a topic of ongoing research and development. LIDAR systems are used to acquire a 3D map of a field of view, which can be then used to track the motion of objects. Typically this is done by the Time-of-Flight (ToF) method through the sensing and recording of the time of arrival of reflected photons from Light Amplification by Stimulated Emission of Radiation (LASER) pulses. The sensing part of the LIDAR system should have the highest light sensitivity possible and cover specific wavelength ranges that are eye-safe and for which efficient and low-cost lasers exist. LIDAR with improved performance, form, fit and function at lower cost, is the objective.

Specifications Required: The sensing part of the LIDAR system should consist of a large 2D array of pixels, capable of single-photon detection/counting, with a very high probability of detection, and capable of operating at a high frame rate. Ideally the new image sensor can be backwards compatible with, and enable retrofitting of, existing LIDAR systems.

Technology Developed: Quantum Semiconductor is developing a new CMOS Image Sensor technology, with photo-diodes incorporating epitaxial SiGeC films, capable of single photon-detection at low voltages, compatible with standard CMOS devices and circuitry. Technology development and manufacturing is at a US-based CMOS foundry, for high-yield and low-cost. Quantum Semiconductor is developing new CMOS-compatible materials for extending the wavelength range of detection for our sensors.

Warfighter Value: Future passive image sensing and LIDAR systems based on the new technology, will offer unprecedented performance for low light sensing, compactness, power consumption, and low cost manufacturing. For the first time, such systems can be "hand-held", opening up completely new ways in which such systems are used, including platforms that currently cannot incorporate LIDAR systems, such as light-weight drones, due to size, weight, power consumption, etc., of conventional LIDAR systems.

WHEN

Contract Number: N00014-15-C-5194 **Ending on:** October 3, 2018

Milestone	Risk Level	Measure of Success	Ending TRL	Date
Ab-initio Simulation of Superlattices	N/A	Discover compositions with desired Coefficient of Absorption	3	June 2016
Design, Manufacture and Test of Test-Chip 1 and 2	N/A	Verification of new gain mechanism in APDs	3	November 2016
Design, Manufacture and Test of Engineering Test-Chip	Med	Optimized design flow for single-photon detection	4	December 2017
Experimental demonstration of Superlattices	Med	Electronics and photonic properties validated	4	April 2018
Integrated data package for new sensor	High	Yield of APDs above 80%	5	July 2018

HOW

Projected Business Model: Quantum Semiconductor intends to make image sensors, camera sub-assemblies and packaged LIDAR systems for system integrators serving military and commercial markets. As a fabless semiconductor company, Quantum Semiconductor performs the design, test and assembly, and uses a foundry partner for manufacturing. Quantum Semiconductor's goal is to make products based on our proprietary, patented technology for imaging and LIDAR applications. Restricted Licensing of certain proprietary materials and designs to strategic development partners for Si photonic and photovoltaic products may be considered.

Company Objectives: Quantum Semiconductor is looking for partnerships with prime contractors that integrate systems for imaging and LIDAR to all branches of the DOD. Our technology platform development roadmap encompasses visible imaging, Short-Wavelength Infra-Red (SWIR) and Mid-Wavelength Infra-Red (MWIR). The development of CMOS-based IR imagers and LIDAR systems will bring huge enhancements in safety, performance, as well as form, fit and function at lower cost than existing solutions.

Potential Commercial Applications: The Quantum Semiconductor technology platform combines new Silicon-based materials with new CMOS device structures to produce large imaging arrays with high sensitivity in the wavelength range of choice, from Visible to Infra-Red. Applications that need passive image sensing at extremely low light levels, with multi-megapixel resolution, covering the Visible and/or Near Infra-Red (NIR), would benefit from the technology. Future capabilities include extending the wavelength range to beyond 1.6µm. The Silicon-based materials that efficiently absorb light in infra-red wavelengths also can be made to efficiently emit light at those wavelengths. Applications include imaging arrays for cell phone cameras, scientific and biological imaging, passive and active LIDAR for autonomous and manned vehicles, Si photonics for optical communications, and photovoltaics.

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