Department of the Navy SBIR/STTR Transition Program

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Topic # NM12-158
Development of High Gain SiGeC CMOS Imaging Arrays for Visible Sensing
Quantum Semiconductor LLC

WHO

SYSCOM: ONR

Sponsoring Program: Code 32

Transition Target:

TPOC:
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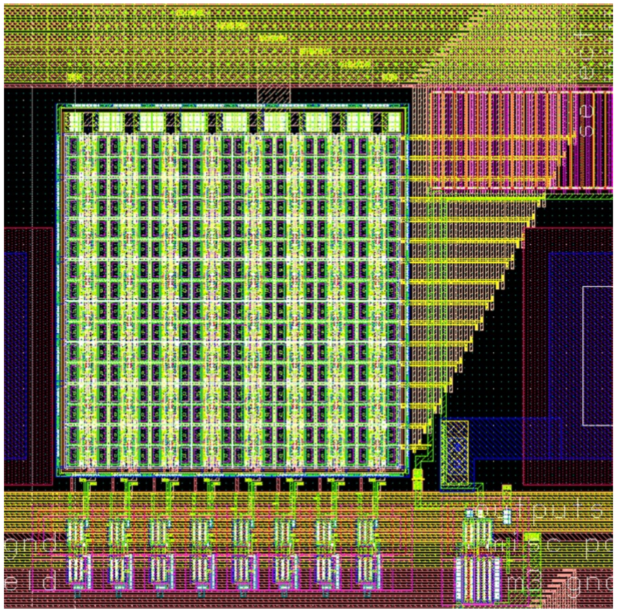
Other transition opportunities: The DoD, as well as NASA, could benefit from the technology, specifically platforms that need new, enhanced performance LiDAR systems for land, sea and air. Quantum Semiconductor's technology can be used in submarines, unmanned aerial vehicles (UAVs), tanks, helicopters, planes, hand-held devices and more - wherever sensitive day or night imaging or LIDAR would benefit the warfighter.

Notes: The Quantum Semiconductor technology platform combines CMOS circuitry and new SiGeC Photo-Diodes to produce large imaging arrays with high sensitivity covering the Visible and Near-Infra-Red (NIR).



WHAT

Operational Need and Improvement: Ultra-sensitive imaging in visible and near-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 LASER pulses.The light-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 very large noiseless gain, enabling single photon-detection, at low voltages compatible with standard CMOS circuitry. Technology development and manufacturing is done at a US-based CMOS foundry, for high-yield and low-cost. Quantum Semiconductor is developing a Monte-Carlo semiconductor device simulator, which will enable comprehensive physical models to simulate the physics of the noiseless gain mechanism, and the generation of compact models for use in electronic and photonic simulators. Quantum Semiconductor is also developing a Technology Computer Aided Design (TCAD) model of the complete fabrication flow of the CMOS+SiGeC image sensor technology, which will enable the correlation between variation in fabrication parameters and variation in measured characteristics.

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: N68335-19-C-0168 **Ending on:** December 31, 2020

Milestone	Risk Level	Measure of Success	Ending TRL	Date
Monte-Carlo code development for modeling noiseless gain	Low	Reproduce experimental results	4	3rd QTR FY19
Develop test protocol and optical test hardware for sensor testing	Low	Successfully measure sensitive devices	4	4th QTR FY19
TCAD process and device modeling	Low	Optimize the manufacturing process	4	1st QTR FY20
Integration of Monte-Carlo and TCAD for SPICE modeling of sensor	High	Optimization of sensor design	5	1st QTR FY20
Design, manufacture and test of prototype	High	Successful yield of noiseless high gain photodiode arrays	6	3rd QTR FY19
Development of compact model for circuit design	High	Modeling of new circuits incorporating noiseless high gain photodiodes	6	4th QTR FY20

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 the 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. The technology platform development roadmap encompasses imaging in the Visible and Near-Infra-Red, and longer term, also 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 and performance, as well as form, fit and function at lower cost than existing solutions.

Potential Commercial Applications: Quantum Semiconductor technology significantly improves low light level detection for conventional passive image sensing and Light Detection and Ranging (LiDAR). 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 Short-Wavelength Infra-Red (SWIR), up to 2.5µm. The Silicon-based materials that efficiently absorb light in infra-red wavelengths can also be made to efficiently emit light at those wavelengths, making the materials suitable for silicon photonics. Commercial 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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