Department of the Navy SBIR/STTR Transition Program

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11/15/2023

Topic # N201-082
Visible to Near-Infrared Integrated Photonics Development for Quantum Inertial Sensing
Physical Sciences Inc.

WHO

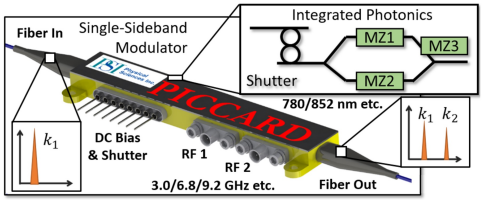
SYSCOM: SSP

Sponsoring Program: Navy SSP

Transition Target: Navy SSP

TPOC: SSP.SBIR@ssp.navy.mil

Other Transition Opportunities: This technology can also be used for Hypersonics, MDA, Air Force, and Space Force applications.



An integrated photonic platform generates phase-coherent photons to drive sequences of 2-photon Raman transitions for quantum inertial sensors.

Notes: Atom-based quantum sensors require many different laser frequencies locked to one another, and thus, these lasers typically dominate the size, weight, and power (SWaP) of the system, which impedes the deployment of quantum sensors.

From a single input laser, PSI's PICCARD device produces two phase-coherent and locked laser sources for quantum sensors to reduce the number of lasers required to drive a quantum sensor. Initial PICCARD modules will consist of a single laser input and produce a secondary laser based on a user-defined RF tone (single sideband, SSB). Future modules will be able to generate all of the necessary optical frequencies within a given band using a single optical input, to realize an optical bench on-a-chip for quantum sensors. Furthermore, as these chips are defined using lithographic methods, they can be scalably manufactured to reduce costs.

WHAT

Operational Need and Improvement: Quantum inertial measurements of accelerations and rotations can provide the sensitivity and accuracy required for even the highest performance inertial navigation applications; however, the complexity of the associated optical systems dominates the size, weight, and power (SWaP) of instruments that exceed a practical limit for use in portable applications such as an inertial navigation system (INS). To overcome this challenge, Physical Sciences, Inc. (PSI) is developing an integrated photonic platform to provide orders of magnitude reduction in the SWaP of the optical systems while meeting the strict optical frequency, phase, and power required for the quantum measurements. To produce the highest efficiency system, PSI's Photonic Integrated Circuits for Compact Atomic-Raman Devices (PICCARD) platform will leverage an electro-optically active photonic-integrated circuit material platform to provide electronic control of light produced provided by an external gain media while operating in the native visible and near infrared wavelengths of the relevant atomic transitions.

Specifications Required:
- Wavelength: 780 nm
- Output Power: >100 mW
- Modulator Bandwidth: >10 GHz
- Modulator RF Power: 100 mW
- Shutter Extinction Ratio: >60 dB

Technology Developed: A low-SWaP, single-sideband modulator that
- Operates at native atomic wavelengths and at relevant power levels for atom-based sensors
- Robustly generates phase-coherent frequencies using an RF input
- Is manufactured using a scalable fabrication approach to reduce costs

Warfighter Value: This technology will significantly reduce the SWaP of advanced quantum sensors paving the way for position, navigation, and timing applications.

WHEN

Contract Number: N68335-22-C-0848 **Ending on:** Jun 06, 2023

Milestone	Risk Level	Measure of Success	Ending TRL	Date
Gen1 Chip Fabrication	Low	Successful chip fabrication	3	1st QTR FY21
SSB Demo	Low	SSB generation at 6.8 GHz with 17 dB suppression	3	1st QTR FY21
Power Handling Evaluation	Low	Damage-free >10 mW	3	1st QTR FY21
Passive Optical Shutter Demo	Low	Demonstrated 27 dB rejection ratio	3	4th QTR FY22
Gen2 Chip Fabrication	Low	Successful chip fabrication with advanced designs for higher performance	4	3rd QTR FY23
Active Optical Shutter Demo	Medium	Electrical actuation of an optical shutter	4	4th QTR FY23
Full-Functionality Validation	Medium	Demonstration of SSB with optical shuttering on the same chip	4	1st QTR FY24
Packaged Prototype	High	Packaged chip with optical and electrical I/O	4	2nd QTR FY24

HOW

Projected Business Model: Physical Sciences Inc. (PSI) plans to create two product variants for commercialization. The first consists of fully packaged PICCARD modules that will produce pairs of optical frequencies to serve the near-term market that is developing the quantum sensor technology. Later variants will integrate multiple PICCARD units to realize an optical-bench on-a-chip to reduce the SWaP further.

Company Objectives: PSI develops advanced technologies and products for the military, aerospace, industrial process, energy, telecommunications, environmental, and medical markets. PSI is strongly committed to developing products based on innovative technologies developed under the SBIR program and has successfully transitioned numerous technologies to support the missions of the Department of Defense, NASA, EPA, and many commercial partners throughout the entire history of the SBIR program.

Potential Commercial Applications: This technology can be incorporated into sensors for applications including:
- Inertial navigation systems for the aerospace and automotive sectors
- Sensors for the oil and natural gas industry
- Support systems for quantum computers, networking, and sensors

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