Department of the Navy SBIR/STTR Transition Program

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NAVAIR 2019-903

Topic # N17A-T006
Super-Efficient Mid-Infrared Quantum Cascade Lasers with Continuous-Wave Wall-Plug Efficiencies in Excess of 40%
Intraband LLC

WHO

SYSCOM: NAVAIR

Sponsoring Program: PEO(T) PMA-272, NAVAIR Advanced Tactical Aircraft Protection Systems

Transition Target: Department of the Navy Large Aircraft Infrared Countermeasures (DoN LAIRCM)

TPOC:
(760)939-0239

Other transition opportunities: US Army and US Air Force Directed Infrared Countermeasures (DIRCM) programs.
Future opportunities include Chem/Bio detection and free-space communication links

Photo Courtesy of USMC (2016)

Notes: DoN LAIRCM protects fixed and rotary wing aircraft.

WHAT

Operational Need and Improvement: Due to the increasing threat posed by current and future generation heat-seeking missiles to military aircraft, compact, reliable and high-power mid-wavelength infrared (MWIR) lasers producing high output power in the continuous wave (CW) regime are increasingly critical for the Navy's current and future needs in DIRCM for installation in relevant manned or unmanned military aircraft environments. The lasers require significant space, electrical power, and liquid cooling, mostly driven by the low QCL wall-plug efficiency. Quantum Cascade Lasers (QCLs) presently have efficiencies at least four times worse than near-IR lasers. High-efficiency lasers can be packaged in arrays to increase power per package to reduce size, weight, and power (SWaP), increase output power or eliminate liquid cooling.

Specifications Required: MWIR laser that can produce room-temperature wall-plug efficiency no less than 40%, CW output power over 10 Watts, and output beam quality M2 < 1.5
Should enable 4x reduction in overall laser package and cooling system requirements
Potential to eliminate liquid cooling requirement

Technology Developed: We have developed MWIR lasers with the best-published CW output power for a metal-organic chemical vapor deposition (MOCVD) grown device. Through optimized laser designs and fabrication conditions, we expect to increase wall-plug efficiency from 12% to 30% and simulations show we should eventually reach at least 40% efficiency for a fully optimized design and process. These designs employ bandgap engineering with materials readily fabricated with existing equipment and processes for MOCVD material growth and fabrication. The increased efficiency should enable an increase in output power to 10W.

Warfighter Value: High-efficiency QCLs can provide up to 4x reduction in the SWaP requirements of existing and future DIRCM systems. The reduced requirements free up resources for other critical warfighter systems and enable deployment on smaller platforms. Lasers producing more power per chip reduce system complexity, enhancing reliability, by reducing cooling requirements and the number of laser modules required. The lasers could also be used in future DIRCM systems with higher optical output power enabling enhanced capabilities. Eventually, the high efficiency could enable entirely new capabilities such as a hand-held remote sensor for detecting chemical and biological hazards.

WHEN

Contract Number: N68335-19-C-0196 **Ending on:** December 17, 2021

Milestone	Risk Level	Measure of Success	Ending TRL	Date
Fabrication and demonstration of low-voltage QCLs	Med	Peak-pulsed WPE > 20%	3	October 2019
Obtain required waveguide loss and internal efficiency	Med	2x loss reduction, >85% internal efficiency	3	October 2020
Demonstrate QCL with > 40% wallplug efficiency	High	CW WPE > 40%	4	April 2021
Establish laser and packaging design for 10W single-mode CW output power	Med	Thermal and spatial-mode-selection models	4	April 2021
If Option funded, demonstrate 10 W CW single-spatial-mode operation and 40% CW wall-plug efficiency	High	Device provides 10W CW single-mode output at 40% WPE	5	April 2022

HOW

Projected Business Model: Intraband will provide QCLs and modules with industry-leading efficiency, power, reliability, and value. Intraband accepted its first commercial purchase order for QCLs in 2018. The company plans to be fabless initially and has formalized a services agreement with its mil-spec-quality manufacturing partner located in the US. The first product, to be released in 2019, will be a high-power QCL chip mounted on a submount and heat-sink suitable for OEM applications. Intraband has exclusive rights to patents controlling the QCL designs, which enable higher optical power and reliability with lower power consumption. The approach should also have higher manufacturing yields enabling lower costs. The company plans to continue high-power QCL innovations in the areas of arrays, surface emitters, and linewidth control. Intraband also plans to innovate at the module level to further improve performance and make the unit easier for an OEM to integrate.

Company Objectives: We have achieved 2.6W CW MWIR output power with 12 % wall-plug efficiency. This is the highest-published CW output power for an MOCVD-grown QCL. While we continue to improve power and efficiency, we would like to work with our manufacturing partner to offer our QCLs for sale to defense-system contractors providing IR-countermeasures systems as well as other MWIR and LWIR applications. We are interested in finding additional partners and investors to aid in scaling up production, developing module manufacturing capabilities, and understanding new application opportunities.

Potential Commercial Applications: Very high power QCLs can be used for materials processing where existing lasers have poor absorption. QCLs with proper spectral control can be used for environmental sensing, and industrial pollution monitoring, and process control.

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