Department of the Navy SBIR/STTR Transition Program

Topic # N20B-T029
Accelerated Burn-In Process for High Power Quantum Cascade Lasers to Reduce Total Cost of Ownership
adtech photonics, Inc.

WHO

SYSCOM: NAVAIR

Sponsoring Program: PEO (T)

Transition Target: QCLs are already deployed in the field in small quantities, for applications ranging from gas monitoring and remote sensing, industrial process control and analytical tools, to medical diagnostics. A common barrier to acquisition of this technology is its present high cost. This program's objective is to lower the cost of high power QCLs to enable the incorporation of this technology into to a wider range of applications where they are not presently considered due to the high costs.

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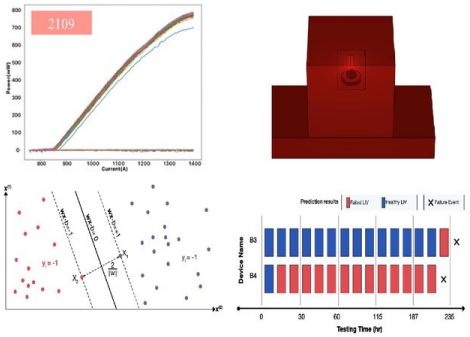

Photo provided by Adtech Photonics, Inc.

Other Transition Opportunities: A number of commercial applications will benefit from the availability of low-cost high power QCLs. Adtech plans to leverage the volume manufacturing of these devices to drive down costs to enable commercial or dual-use applications: Lidar / remote sensing, Photoacoustic spectroscopy, Laser material processing, Assisted surgery, Optical wireless secure communications.

Notes: A very different use case exists in the high-power systems used for Infra-Red Counter Measures (IRCM) applications. In these systems, a multi-emitter combination is required to achieve the desired power range. This requires the procurement of multiple devices which dramatically increases the total system cost. By lowering the individual chip cost, we can enable the acquisition of multi-watt laser systems in this space at a fraction of today's price.

WHAT

Operational Need and Improvement: Quantum Cascade Lasers are capable of delivering several watts of CW power in a high-quality beam in the 4.0- 5.0 micron spectral band. However, post-production laser failure is a substantial contributor to the high price of QCL-based products. To avoid costly integration of defective high power QCLs into infrared system platforms, devices with short life expectancies must be screened out at an early fabrication/packaging stage. Therefore, to minimize QCL fabrication cost, a large decrease in infant mortality of the QCLs reaching post-production must be achieved at the earlier chip, or chip-on-carrier, production stages.

Specifications Required: The main goal for this program is to develop, and experimentally validate, an accelerated QCL burn-in process that is effective in screening out defective devices, and that accurately predicts lifetime for high power QCLs suitable for DOD applications. This process will minimize the total required burn-in time, a requirement that is critical for QCL total cost minimization (ideally as much as by a factor of 5 in large volume applications).

Technology Developed: The planned steps in the program include:
1) Built a large dataset of burn-in test data from numerous QCL devices
2) Perform dedicated stress tests and failure analysis for selected QCL devices
3) Based on the collected data, Refine thermal models and Machine Learning (ML) algorithms for data analysis
4) Deliver a fully consistent package, including the ML algorithms, the analytical model insights, and the experimental data
5) Integrate the above deliverables into Adtech's manufacturing pipeline

Warfighter Value: The immediate goal of this program is to reduce the costs of QCLs. Once that is achieved, the primary military applications for QCLs would be in IRCM, in sensors (e.g. for nerve agents or explosives), and for optical free space communication. Secondary military uses might include industrial processes, various other sensors (including flying platform or space-based sensors), and medical applications.

WHEN

Contract Number: N68936-22-C-0035 **Ending on:** Sep 27, 2024

Milestone	Risk Level	Measure of Success	Ending TRL	Date
Investigate failure mechanisms of high power QCLs:	Low	Build 3D thermal models for device degradation	6	TBD
Define stressors that map failure modes specific to QCLs:	Low	Define "accelerated" burn-in procedures	6	TBD
Collect burn-in data on statistically meaningful sample	Low	Demonstrate modeling tool capabilities. Define "quick rejection" tests	7	TBD
Correlate burn-in data with model predictions	Low	Build ML algorithms for data analysis Identify key screening parameters leading to early signs of degradation	6	TBD

HOW

Projected Business Model: The high cost of QCLs does not allow for the development and commercialization of small, inexpensive systems based on the technology. With the cost reduction program being worked on, Adtech anticipates the cost of individual QCL devices can be reduced substantially, which can then enable a multitude of applications only accessible at lower system costs. These applications will broaden the market addressable by QCL technology and initiate a virtuous cycle that will allow for larger volumes and ongoing learning curve improvements, resulting in on-going reductions to the device price point.

Company Objectives: The manufacturing and broad commercialization of QCL lasers is the main objective of the research and development activities of Adtech.

Potential Commercial Applications: Transition to procurement may proceed either through direct Phase III contract, or via a Prime Contractor. We already have significant interest from several Defense Contractors such as Lockheed Martin, DRS, DHPC, and Forward Photonics.
In addition, a number of commercial applications will benefit from the availability of lower-cost high power QCLs, enabling Adtech to leverage larger manufacturing volume to increase productivity and thereby reduce costs. Examples of appropriate commercial or dual-use applications include Lidar / remote sensing, Photoacoustic spectroscopy, Laser material processing, Assisted surgery, and Optical free-space secure communications. These kind of applications have always matched Adtech's primary business strategy, and will be fully supported by Adtech's management and investors.

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