Topic: N182-108

Freedom Photonics LLC

Photonic Integrated Circuit Reliability

Freedom Photonics, a growing small business which focuses on the development of unique photonic components for high-performance systems, has teamed with The Aerospace Corporation to develop test methods for photonic integrated circuit (PIC) reliability analysis and corresponding reliability prediction models, to be applied to components integrated into aerospace applications and other military and commercial areas. There are no current PIC reliability prediction tools in the market. This effort was de-risked in Phase I through a trade study of reliability prediction strategies based on standard practices for microelectronic integrated circuits (ICs), individual photonic components, and new approaches developed in this program. Ultimately, these test methods and models will be marketed to PIC device manufacturers, prime contractors, and system users, including the US Department of Defense.

Technology Category Alignment:

Modeling and Simulation Technology
Air Platforms
Advanced Electronics

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SYSCOM: NAVAIR
Contract: N68335-20-C-0059

Corporate Brochure: https://navystp.com/vtm/open_file?type=brochure&id=N68335-20-C-0059

Department of the Navy SBIR/STTR Transition Program

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Topic # N182-108
Photonic Integrated Circuit Reliability
Freedom Photonics LLC

WHO

SYSCOM: NAVAIR

Sponsoring Program: NAE Chief Technology Office

Transition Target: TBD

TPOC:
(301)342-4122

Other transition opportunities: Ultimately, these test methods and models will be marketed to PIC device manufacturers, prime contractors, and system users, including the US Department of Defense.

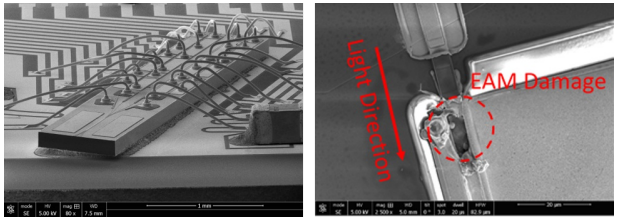

Image Courtesy of Freedom Photonics, LLC

Notes: (Image Left) Photonic integrated circuits (PICs) offer the potential increase system capability and reduce SWaP-C by replacing multiple discrete and bulky photonic modules with a single component. (Image Right) Scanning electron microscope image of a failed photonic integrated circuit. This Phase II effort seeks to improve understanding of how and why photonic integrated circuit components fail and to develop tools for predicting reliability in various deployed environments.

WHAT

Operational Need and Improvement: Photonic Integrated Circuit (PIC) and Planar Lightguide Circuit (PLC) based devices are rapidly gaining importance as core components in communications, sensing, computing and medical diagnostic systems for military and commercial applications. Thus, it has become very important to develop methodologies for PIC/PLC reliability prediction, verification, and validation. Freedom Photonics and The Aerospace Corporation have formed a strong team to bridge this information gap, primarily as it relates to PICs/PLCs for aerospace applications.

Specifications Required: Representative PICs should be selected and the main degradation modes should be experimentally and theoretically evaluated. Acceleration factors temperature, electrical bias, optical power, radiation, and mechanical stress should be considered according to MIL-HDBK 217 and MIL-STD-810. Particular emphasis should be placed on understanding the influence of individual PIC/PLC devices on the reliability of their neighboring devices on the same chip.

Technology Developed: The goal is to develop and demonstrate suitable test methods for PIC/PLC reliability analysis and corresponding reliability prediction software tools that can be used for aerospace applications and potentially in other military and commercial areas such as fiber optic networks, data centers and infrared sensors. The test methods and software tools will be verified and validated through the Phase II period of performance by selecting appropriate PIC/PLC devices for experimental reliability testing. These PIC devices will be subject to environmental, mechanical, and accelerated aging stress tests followed by root cause analysis of device failure.

Warfighter Value: Advanced systems based on optical technology have become ubiquitous to the modern warfighter. Photonic integrated circuit (PIC) and devices are rapidly gaining importance as core components in these systems due to their performance and compactness. In many cases, multiple discrete and bulky photonic modules can be replaced with a single PIC component. The incorporation of these devices into Department of Defense platforms is being hindered by the lack of information on their reliability. This Phase II effort seeks to improve understanding of how and why photonic integrated circuit components fail and to develop tools for predicting reliability in various deployed environments. This will ultimately enable more widespread adoption, resulting in smaller, lighter, cheaper, and more capable optical systems for the warfighter.

WHEN

Contract Number: N68335-20-C-0059 **Ending on:** December 5, 2021

Milestone	Risk Level	Measure of Success	Ending TRL	Date
1550 nm DFB/SOA PIC Lifetest Completed and Modelled	Low	Completed qualification of 1550 nm DFB/SOA PIC devices ready for commercial deployment with predictable reliability model	5	August 2021
Initial PIC Predictive Reliability Simulation Software Completed	Med	Software tool which provides modelling of PIC device reliability subject to use conditions and design type demonstrated	4	July 2022
Update PIC Predictive Reliability Software to Include Silicon Photonic Devices	Med	Completed testing of silicon photonic PIC devices with predictable reliability model	3	December 2022

HOW

Projected Business Model: The business model for the reliability prediction software technology is to market these test methods and models to PIC device manufacturers, prime contractors, and system users, including the US Department of Defense.

Company Objectives: We anticipate that the Navy SBIR/STTR Transition Program (STP) Forum will facilitate the development of a Technology Transition plan to define a clear path to the transition this technology into prime contractors, and system users, including the US Department of Defense.

Potential Commercial Applications: We anticipate these reliability prediction tools to be applied not only to PICs within the US Department of Defense, but to PICs which are commercially used for civilian applications, such as fiber optic networks, data centers, and telecommunications.

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