Department of the Navy SBIR/STTR Transition Program

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Topic # N131-068

Millimeter Thick, Periodically Oscillating Polarity GaN Grown via HVPE

Kyma Technologies, Inc.

WHO

SYSCOM: ONR

Sponsoring Program: Code 31 - Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR)

Transition Target:

TPOC:
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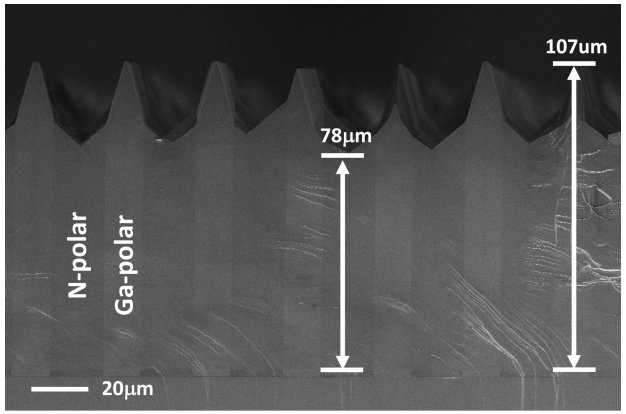
Other transition opportunities:

Notes: Cross sectional image of PO-GaN growy by HVPE at Kyma, Published by NRL & Kyma (see J. Hite, et al., "Development of periodically oriented gallium nitride for non-linear optics [Invited]", September 2012 / Vol. 2, No. 9 / OPTICAL MATERIALS EXPRESS 120



WHAT

Operational Need and Improvement: The Navy is looking for a nonlinear optical (NLO) material with a broad transparency range and a high laser damage threshold to handle increasingly high powered lasers that can adjust frequencies between the ultraviolet (UV) all the way through the mid-range infrared (IR) spectrum. Kyma is developing a periodically oriented Gallium Nitride (PO-GaN) material that offers a broader transparency range, from 0.39 to 6 µm and better thermo-optic (laser damage threshold, thermal conductivity) properties than any other NLO material.

Specifications Required: Goals for the PO-GaN growth would be for: low optical absorption and scattering (< 0.1 cm^-1), high-fidelity reproduction of pattern domains, and rapid growth of 1 millimeter thickness on centimeter scale wafers. Hydride vapor phase epitaxy (HVPE) has been demonstrated as a leading growth technique to deliver high growth rate epitaxial films needed to achieve millimeter thick films with acceptable optical quality. Specific phase II goals are 1) develop processes for extended millimeter growth of dual-polarity gallium nitride with low free carrier densities, 2) fabricate PO-GaN wafers with periodic polarity reversal for quasi-phase matched nonlinear frequency conversion, 3) conduct an evaluation of wafer optical quality and test nonlinear conversion of near-infrared laser system, 4) develop prototype PO-GaN devices for nonlinear conversion and quantify device efficiency and
bandwidths.

Technology Developed: We have advanced our ability to make thicker (~1 mm) periodically oscillating GaN materials with similar growth rates of the N-face and Ga-face regions, with reduced impurity levels, by careful adjustment of HVPE growth conditions and use of proprietary impurity reduction techniques. NLO crystals developed in this effort have been tested by NRL scientists who have observed exciting NLO effects at the laboratory test scale.

Warfighter Value: A number of future defense systems that utilize high power laser systems will benefit from smaller and higher performance NLO elements that operate in a broader spectral window and which can operate at higher laser power levels with high reliability.

WHEN

Contract Number: N00014-15-C-0017 **Ending on:** September 12, 2016

Milestone	Risk Level	Measure of Success	Ending TRL	Date
HVPE Growth Rates	Med	High level of success in establishing equal and fast N-face & Ga-face growth rates	4	April 2015
HVPE GaN Purity Control	High	4x reduction of background silicon impurity levels in N-face GaN growth	4	September 2015
Demonstrate MOCVD-Free Patterning Process	High	Successful demonstration of use of plasma vapor deposition to create the pattern	4	March 2016
NLO Crystal Edge Polishing	Low	Successful coarse level polishing	4	January 2016

HOW

Projected Business Model: Kyma plans to offer the PO-GaN materials and to partner with one or more leading NLO crystal suppliers to broaden their product offering while supplying them with our materials. We are open to licensing and technology transfer to the NLO supplier(s) if they would rather bring the PO-GaN materials fabrication capabilities in-house. We also have strong contacts with several DoD prime contractors and will solicit their input into what business models would best suit their needs.

Company Objectives: Kyma supplies materials and materials fabrication tools and processes. We are looking to talk with DoD prime contractors that are working in the high energy laser and infrared countermeasure (IRCM) space and to discover other programs of record that would benefit from a wideband optical material capable of handling large increases in power.

Potential Commercial Applications: Broadband nonlinear optical devices enabling frequency conversion over the targeted range (0.39 - 6 µm) offer the potential for broad impact across several commercial applications. High interest applications include replacing the LiNbO3 devices in imaging devices, medical illumination, gas sensors and biochemical detectors.

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