Electronic Materials and Photonics Division
Room B116 - Session EM2-FrM

Emergent Photonic Materials and Devices for Mid-IR Applications

Moderators: Parag Banerjee, University of Central Florida, **Erin Cleveland**, U.S. Naval Research Laboratory

10:40am **EM2-FrM-8 Enabling Novel Infrared (IR) Materials for Next-Generation Applications***, **Kathleen A. Richardson**,* University of Central Florida, College of Optics and Photonics **INVITED**

Technological advances in areas important to industry, defense and society are moving rapidly with requirements to ***see and sense*** in ways not thought possible before.To realize such advances, new materials with unique function can lead to new components for systems that are smaller, lighter in weight, requisite of less power and lower cost.Security and sensing systems must be versatile to work in a wide range of extreme environmental conditions such as in smoke, fog or in space.Other applications require more robust thermo-mechanical performance metrics, which much be evaluated in trade space to yield a viable solution for more rugged system needs.Materials that transmit light in the infrared portion of the electro-magnetic spectrum allows one to ‘see’ in these regions, often when visible imaging is not possible, but also to serve as windows if they are robust ‘enough’. How one transitions viable candidates from lab-scale demonstrators to commercial products takes an understanding of both science and engineering, manufacturability, and prioritization of attributes.This alignment with the end-customer needs must start early in the material design and development process, often well before the actual material solution is fully developed.

This talk reviews general aspects of how infrared glasses for bulk and planar film devices, glass ceramics as gradient refractive index (GRIN) media and alloys for optical phase change (O-PCM) have been designed, developed at prototype scale, and successfully transitioned from the university lab benchtop to the marketplace. These key outcomes suggest a methodology for how this could be done across other candidate optical material systems.

11:20am **EM2-FrM-10 Inverse Piezoelectric Effect in Reverse Biased High-Voltage GaN PN Diodes Observed by In-Situ Biased X-Ray Topography Imaging***, **Andrew Koehler**, N. Mahadik,* U.S. Naval Research Laboratory*; M. Liao,* National Research Council Postdoctoral Fellow Residing at U.S. Naval Research Laboratory*; A. Jacobs,* U.S. Naval Research Laboratory*; G. Foster,* Jacobs Inc. Residing at U.S. Naval Research Laboratory*; S. Atwimah, P. Pandey, T. Nelson, D. Georgiev, R. Khanna,* EECS Department University of Toledo*; K. Hobart, T. Anderson,* U.S. Naval Research Laboratory

Next-generation power systems demand increasingly compact and efficient power conversion circuits, which can be delivered by wide bandgap gallium nitride (GaN) technology. Vertical GaN PN junction diodes are fabricated by growing GaN PN epitaxial layers by metal organic chemical vapor deposition (MOCVD) on native GaN substrates. Greater than 800 V reverse blocking voltage is achieved by implementation of nitrogen ion implanted edge termination for electric field management. The termination scheme consists of a hybrid of a shallow implanted junction termination extension (JTE), multiple deeper implanted guard rings (GRs), and implanted isolation that penetrates the PN junction. The implanted nitrogen selectively compensates the P-type doping of the anode layer. 1 mm^2 discrete diodes were singulated from a wafer and mounted in an open lid custom package with a silver glass die attach, to allow for in-situ biased high resolution X-ray topography (XRT) using g = [11-20] diffraction conditions. Without applied bias, a compressive uniaxial strain of 0.015% is observed, resulting from the die attach process. As illustrated by technology computer aided design (TCAD), the electric field in the diode, under reverse bias, is spread by the edge termination, from the edge of the anode into the termination region, where lattice strain is introduced via the inverse piezoelectric effect. The edge termination effectively operates by reducing the peak electric field at the anode edge; however, the guard rings induce localized nonuniformities in the electric field profile across the termination region, particularly near the surface. The reverse in-situ biased XRT measurements show a nonuniform strain profile in the termination region corresponding to the nonuniform electric field of the GaN diode under reverse bias, with a peak strain near the isolation edge. At a reverse bias of 500 V, the observed piezoelectric induced strain peaked near the isolation implanted edge with a significant (0.32%) amount of strain, which could potentially induce material degradation, causing long-term reliability concerns. In-situ biased XRT imaging can be used as an experimental method to map piezoelectric strain from electric field in GaN, or other piezoelectric material systems to facilitate devices with increased performance and robust operation.

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