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Optical signatures of defects in nitride semiconductors

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Despite successful commercialization of GaN-based light emitting diodes (LEDs) and high frequency transistors, crystal defects continue to have a strong and often undesired impact on the opto-electronic properties of the III-Nitride family of materials. Fully realizing the potential of this fascinating materials system requires a better understanding of the physical origin of defects, their dependence on both substrate quality and epitaxial growth conditions, and their influence on electrical and optical properties. This talk will discuss the use of deep level optical spectroscopy (DLOS) to quantitatively study defect states in GaN-based materials. As a photocapacitance technique, DLOS is able to probe defect levels that are otherwise inaccessible to thermally-stimulated defect spectroscopies in wide band gap materials, such as the III-Nitrides. DLOS quantifies both the energy level and density of defects and probes defect states with nanoscale depth resolution. Beyond the canonical application of DLOS to thin films, this talk will describe new developments of DLOS to quantitatively study defect states in a wide variety of structures with nanoscale dimensionality, including InGaN/GaN multi-quantum wells and AlGaN/GaN core-shell nanowires. The microscopic origin of observed defect states and their influence on the electrical and optical properties of GaN-based LEDs and nanowire devices will be discussed. The reported studies establish DLOS as a critical technique for nanoscale dimensional defect metrology that is able to advance the development of conventional and emerging opto-electronic devices.