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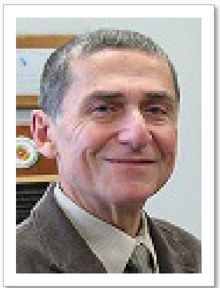

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Wide bandgap semiconductor materials: Surfaces, interfaces and applications

Advanced semiconductors i.e. 2D, wide bandgap systems are a key for numerous applications that extend from communications to automotive, avionic and security. Manufacturing of components is strongly dependent on in depth reliability studies that include physics-based approaches to complement the currently used industry techniques that are not adequate for improving the current status of technology. Point-like nano/microscopic defects can often be the cause of a macroscopic device to fail. The reported approach is based on physics, chemistry, mathematics and engineering. of interfaces and surfaces in order to control the generation and kinetics of defects in wide band gap semiconductors.

As the example of the stated approach, this paper is based on novel material and defect characterization results which are necessary to locate the prevalent defects as well as their concentration and dynamics over time. We have investigated the nanosecond thermal dynamics of AlGaN/GaN and GaAs devices using time resolved micro-Raman thermography. This technique allows one to use time resolved Raman thermography to measure transient temperatures. Knowledge of the device's temperature profile is critical in understanding degradation mechanisms. Through photo capacitance techniques, optical CV and DLOS measurements we have quantified the properties of deep levels. Finally high resolution TEM techniques have allowed us to image interface defects as well as bulk defects. As part of this research, in-situ and ex-situ characterization of the HFET structures techniques have been developed. These capabilities require the development of a novel thermal imaging technique using a TEM to generate thermal images of operating devices with approximately 50 nm resolution. The failure mechanisms during the HFET operation have been carried out. This is important, as failed devices often show a number of differences from the as-fabricated devices. These defects include donor migration, interfacial diffusion, in addition to point and line defects. Often, it is difficult to determine which of the defects are the cause of failure and which are effects of the failure. By observing device failure in real-time, it has been possible to reconstruct the failure and better-inform the device fabrication for more robust devices.

The major outcome of a reliable GaN technology and future advanced Wideband Gap Semiconductor device technologies can be foreseen at the systems level: by enabling reduced system size and cost, maximizing speed, high voltage handling capabilities, maximizing power output. The total life cycle system costs will be greatly reduced. Smart Grid Modules based on active electronically scanned voltage switching will dominate all application areas in the energy sector. The performance enhancement possible with the insertion of the emerging wide band-gap semiconductor power devices can only be possible if all degradation mechanisms are understood and reliability can be achieved.

Biography

Christou was previously a Professor of Electronic Materials at Rutgers University and Head of the Surface Physics Branch of the Naval Research Laboratory, Washington DC. Fellow, a recipient of the DoD-Berman Publication Awards,and an IEEE Guest Lecturer. Professor Christou was the 2004 recipient of the INEER Achievement Award. International Burgess Memorial Award "For his seminal scientific contributions in the field of electronic materials, packaging and devices". Professor Christou is a member of APS, ASM,TMS and MRS and was the past President of the Federation of Materials Societies from 2004-06 and is presently a member of the FMS Board of Trustees.

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