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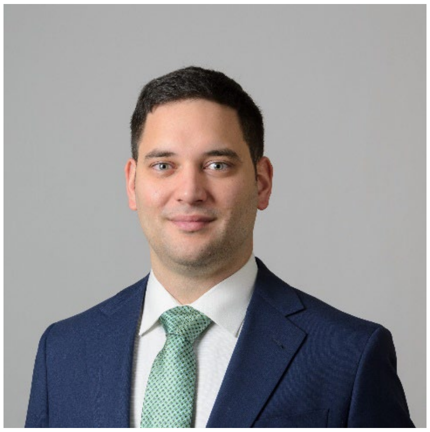

Hyperspectral Thermal Imaging of Wide Bandgap Semiconductor Devices

Prof. Georges Pavlidis

With the commercialization of wide bandgap (WBG) semiconductors for high frequency/power electronics, significant efforts have been invested in discovering the potential of ultra-wide bandgap (UWBG) semiconductors for the next generation of electronics. By reaching higher bandgaps (> 3.4 eV), UWBG devices will be able to operate at higher temperatures as well achieve lower on-resistance with faster switching. Through design and failure analysis, the main limiting factor related to the device power density, has been attributed to excessive localized Joule heating that arises from the poor thermal conductivity of UWBG such as AlGaN (10-20 W/mK). The channel temperatures have been demonstrated to reach 200 °C under biasing conditions equating to 5 W/mm. To mitigate self-heating and overcome this thermal challenge, research efforts must be focused on understanding the thermal transport in these heterostructures as well as other UWBG semiconductors. This talk will focus on implementing alternative approaches to established thermal metrology techniques that can assist in quantifying the thermal dynamics of AlGaN, GaN and Gallium Oxide based transistors.

High throughput techniques, such as Transient Thermoreflectance Imaging (TTI), use light emitting diodes (LEDs) to provide thermal images of transistors with high spatial (≈ 200 nm) and temporal resolution (≈ 50 ns). The full device image, however, can only be obtained by using illumination wavelengths near the bandgap of the semiconductor that will accurately probe the channel surface temperature. When moving to wider bandgap materials, the LED wavelength requirements start to pose a challenge to classical TTI setups. This talk will explore the development of customized DUV enhanced microscopes for thermal imaging of UWBG devices that can specifically accommodate deep UV wavelength optics, CCDs as well as LEDs. Additionally, recent reports have demonstrated the feasibility of sub-band gap thermoreflectance imaging for GaN transistors. A hyperspectral approach will be implemented to extract accurate channel temperatures in GaN HEMTs. As verification, the electrical Gate Resistance Thermometry (GRT) method will be used to cross check the gate metal temperature via a four-point Kelvin measurement. Furthermore, the uncertainties associated with GRT will be discussed and solutions to minimize the error due to high leakage currents and non-zero gate biases will be presented.

Bio:

Dr. Pavlidis is an Assistant Professor in the School of Mechanical, Aerospace and Manufacturing Engineering at the University of Connecticut. He leads the Nanoscale Imaging and Transport Lab which focuses on developing new approaches to understand the multi-physics transport in microelectronics. He earned his M.Eng in Mechanical Engineering from Imperial College London in 2013 and his M.S., Ph.D. degree in Mechanical Engineering from the Georgia Institute of Technology in 2018. His doctoral research was focused on assessing the reliability of new generation wide bandgap transistors using optical and electrical techniques with high spatial and temporal resolution

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