Mechanical Engineering Department Seminar

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Thermal Engineering of GaN Semiconductor Devices

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The development of gallium nitride (GaN) on a variety of substrates from SiC to diamond is under development to create high power RF technologies for advanced communications and power electronic devices. In general, GaN devices can accommodate high operational frequencies, high junction temperatures, and high voltages, allowing them to operate at higher power with increased efficiency in smaller form factors. It is expected that GaN will play a major role in rf communications and create highly efficient power converters for electronic systems operating below 600 V. However, GaN is typically grown on non-lattice matched substrates which results in interfacial thermal resistances, dislocations, and stresses that can impede the operation and reliability of the devices.
In this talk we use a variety of experimental techniques to measure the thermal conductivity, thermal boundary resistance (TBR) and thermal performance for AlGaN/GaN layers on SiC and diamond substrates. Metrology methods to measure these properties will be presented including Raman thermometry, thermoreflectance, and gate resistance thermometry. An update on the status of CVD diamond layers for cooling GaN devices from the current Diamond Round Robin funded by DARPA will be discussed. Finally, the electro-thermomechanical behavior of GaN HEMTs under DC and pulsed operation will be presented where the temperature of the devices was measured using Raman Spectroscopy while the mechanical deformation was measured by Scanning Joule Expansion Microscopy. Data will show that rapid heating and high tensile stresses near the drain side edge of the gate during pulsed operation is dependent on the bias conditions, the TBR, substrate material, and the mechanical properties of the device. The implications of these findings on device performance and reliability will be discussed.

Bio: Samuel Graham is the Neely Professor and Associate Chair for Research in the Woodruff School of Mechanical Engineering at the Georgia Institute of Technology. He leads the Electronics Manufacturing and Reliability Laboratory which is focused on the packaging and reliability of wide bandgap semiconductors, solar cells, and flexible electronics. He also holds a courtesy appointment in the School of Materials Science and Engineering at the Georgia Institute of Technology. He is a Fellow of ASME, a member of the Defense Science Study Group, Air Force Scientific Advisory Board, and the Engineering Sciences Research Foundation Advisory Board of Sandia National Laboratories.