

# Mechanical Engineering Department Seminar

3:35pm February 3, 2016  
1130 Mechanical Engineering  
111 Church Street SE, Minneapolis, MN 55455

## The Development of GaN Electronics from a Thermal and Mechanical Perspective

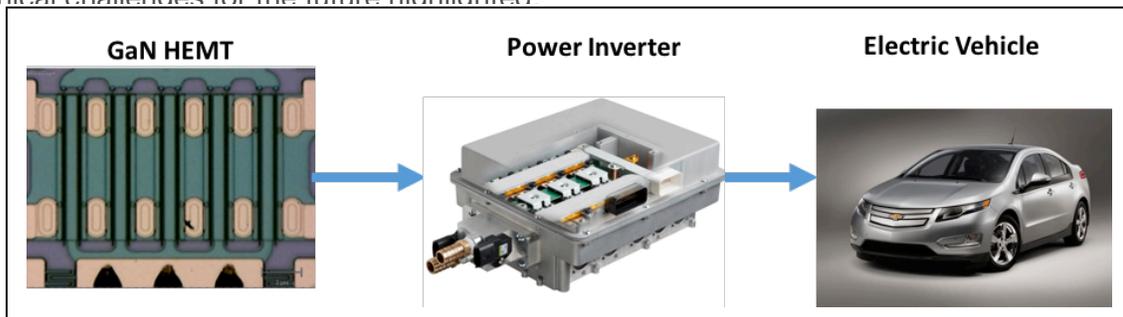
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The development of gallium nitride (GaN) on a variety of substrates from Si to GaN is under development to create devices for advanced rf communications and efficient power electronics technologies. Especially in the air or power electronics, there is a push to develop new efficient power switches in order to reduce electrical power losses in applications such as electric vehicles, renewable energy conversion devices, industrial motors, and computer servers. GaN is well suited for both of these technological applications due to its large bandgap, large breakdown field, and high carrier mobility. This allows GaN electronics to accommodate faster switching speeds, and higher breakdown voltages, with lower power losses than Si-based devices. In spite of the promise shown by GaN and the large international investments in this technology, a number of major challenges exist that must be addressed. Among them include challenges in thermal management, induced stresses, and reliability which must be solved in order to advance this state-of-the-art technology further into the real world applications.

In this work we use a variety of experimental techniques to measure the thermal properties and thermal performance for GaN grown on Si, SiC, GaN, and diamond substrates. Both thermal conductivity and thermal boundary resistance (TBR) are explored and the impact of these factors on device performance are discussed. Methods to tailor the TBR at the interface of GaN on Si as well as current efforts in GaN on Diamond for high power density systems will be presented. Combining our understanding of thermal properties along with models of the electric fields in the devices, we then evaluate the self-heating and stresses that develop in GaN electronics under DC and pulsed operational conditions. These results show critical regions in the devices where failure can initiate and lead to device degradation. For medium voltage lateral GaN HEMTs, we present a unique substrate removal method that allows for operation up to 3000V and the prospects of the new technology are discussed. Finally, recent developments and challenges of vertical GaN power electronics which show prospects of competing with SiC in the 1200 – 3000V application range will be discussed and the numerous thermal and mechanical challenges for the future highlighted.



**Bio:** Dr. Graham is currently the Rae S. and Frank Neely Professor in the Woodruff School of Mechanical Engineering at the Georgia Institute of Technology and the co-founder of the HeatLab. He also holds joint appointment with Oak Ridge National Laboratory in the Energy and Transportation Sciences division. Prior to joining Georgia Tech, he served as a Senior Member of the Technical Staff at Sandia National Laboratories. He is a member of the Defense Science Study Group, MRS, AVS, and a Fellow of the American Society of Mechanical Engineers where he led the technical committee on Heat Transfer in Electronic Devices. His work focuses on the packaging, thermal management, and reliability of semiconductor devices including GaN and flexible electronics.