School of Computer Science and Engineering
Presentation

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Wide-bandgap Integrated Electronics for Operation within Extreme Environments

Abstract:

Extreme environments and emerging electrification applications demand the right choices of materials, novel devices and circuits, and new electronic platforms. Such electronics have applications in down-hole drilling, automobile, air, and space industries. In the recent decades, wide bandgap semiconductor technologies such as Gallium Nitride (GaN) and Silicon Carbide (SiC) have been suggested as viable candidates for building these platforms, owing to the superior properties of the materials. Using these materials enable the implementation of efficient power converters, as well as radiation-hard and high-temperature electronics.

In this talk, I'll discuss the challenges of developing SiC-based and GaN-based platforms, to realize reliable integrated electronics for operation within extreme environments. In particular, device modeling, circuit design, layout design, and measurements will be elaborated for a range of circuits including operational amplifiers, linear voltage regulators, drivers for power switches, and power converters with integrated control circuitry. The demonstrated circuits were tested from 25 °C to 500 °C. From the circuit design viewpoint, I'll describe techniques such as negative-feedback, temperature-insensitive biasing, buffering and Darlington stages, which are shown to be useful for high-temperature SiC-based IC design. As one example, I'll show that the performance of a SiC linear voltage regulator can be significantly improved by using a tailored high-current lateral Darlington power device in the same fabrication process. Finally, I'll present my latest research on the monolithic GaN-based electronics and a novel heterogenous wide-bandgap device, which enables new frontiers in space exploration, deep-well drilling, and electrified aircraft/automobiles applications. During the talk, I'll introduce a new paradigm in the design of electronics in immature technologies, and its implications on the need for new approaches in engineering research and education.