PhD Seminar by Neil Moser

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ENGR 3202

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β-Ga_2O_3 MOSFET Development for Power Switch and RF Applications

Gallium oxide, Ga_2O_3, is a transparent semiconducting oxide with an ultra-wide bandgap that has recently received renewed attention as a potential material for solar-blind photodetectors, high temperature gas sensors, and power semiconductor switches. For power field effect transistors (FETs) and Schottky barrier diodes (SBDs) used in power switching applications, the β polymorph, β-Ga_2O_3, receives the most attention due to its combination of a wide bandgap, ~4.8 eV, and thermal stability allowing it to be the only wide bandgap semiconductor with substrates grown from the melt. Recently, rapid development of substrate growth using several melt growth techniques, epitaxial layer growth using many methods including molecular beam epitaxy and metal organic vapor phase epitaxy, and n-type dopant control with tin (Sn), silicon (Si), and germanium (Ge) has led to metal oxide semiconductor FET (MOSFET) devices and SBDs with high breakdown voltage and very good electrical performance even at high temperatures.

In this graduate seminar, the development of β-Ga_2O_3 FETs for power semiconductor switch applications and potential integrated RF will be showcased. Material parameters of Ga_2O_3 that lead to figures of merit for switch losses lower than GaN and SiC and for RF performance comparable to GaN will be described. Realization of those material parameters in MOSFETs and SBDs will be evaluated from the literature. State of the art results including a breakdown field greater than GaN or SiC realized in a MOSFET, enhancement-mode operation through wrap-gate transistor technology, near theoretical high pulsed MOSFET current densities, and initial RF operation in the GHz range from our research group will be highlighted. Impending developments for gate length scaling using thin-film PLD channels, for gate oxide characterization using capacitance measurement techniques, for self-aligned gates using implant doping, for thermal management using top-side heat sinks, and for increasing lateral breakdown using field-plate technology will be discussed. Finally, progress toward long term goals including vertical transistors for high-breakdown, high density power switch applications and heterojunction FETs for extremely low on resistance and higher RF performance will be assessed.