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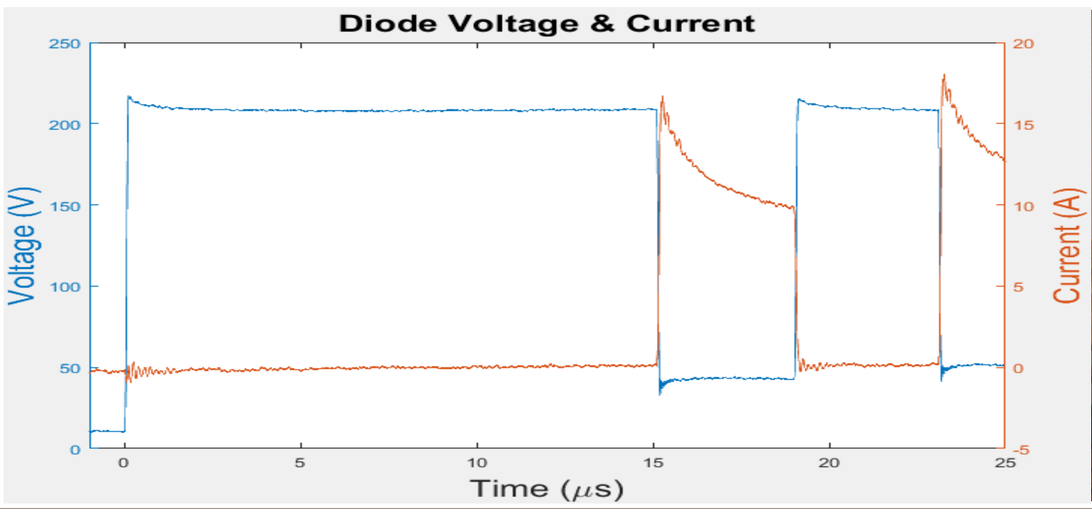
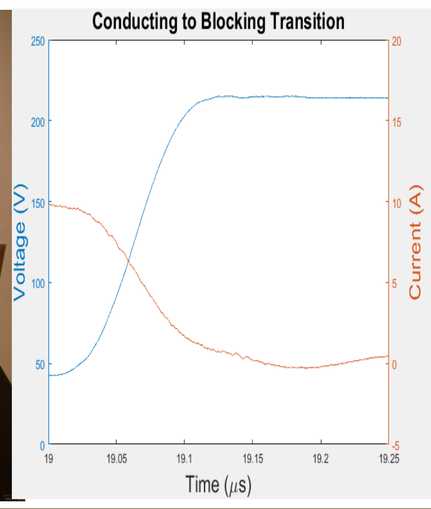
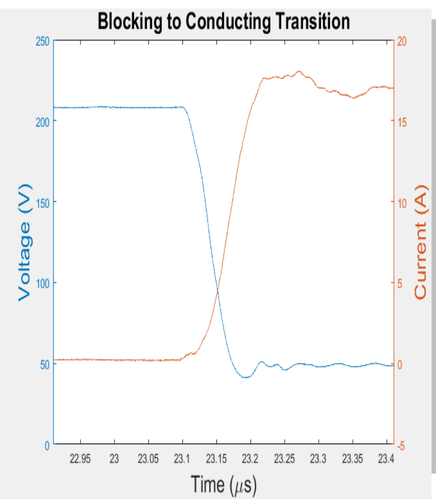






Switching Characterization of Wide-Bandgap Power Semiconductor Devices

1. Motivation

Wide-bandgap semiconductors such as Silicon Carbide (SiC) and GaN have material properties that make them **theoretically superior** to Silicon for power electronics for energy storage systems

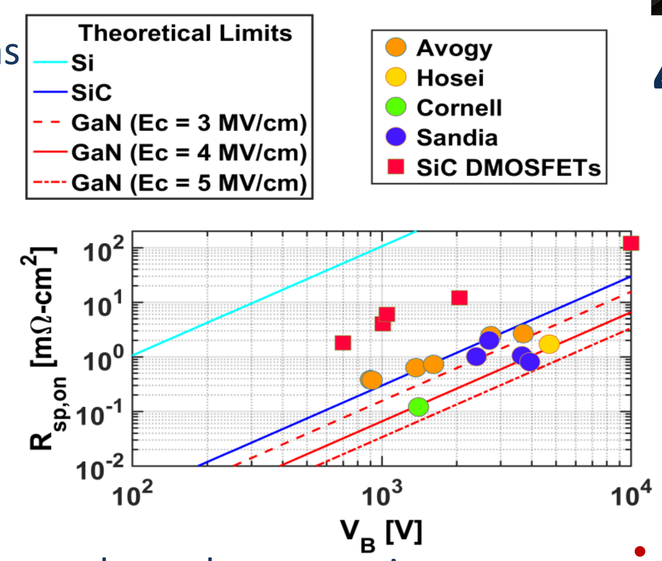
- *SiC and GaN promise to **reduce the size, complexity, and cost** of power conversion systems*

13.5 kV, 100 A Si IGBT module

10 kV, 120 A SiC MOSFET module
10% weight and 12% volume of Si module

2. The "Next" Next-Generation Device

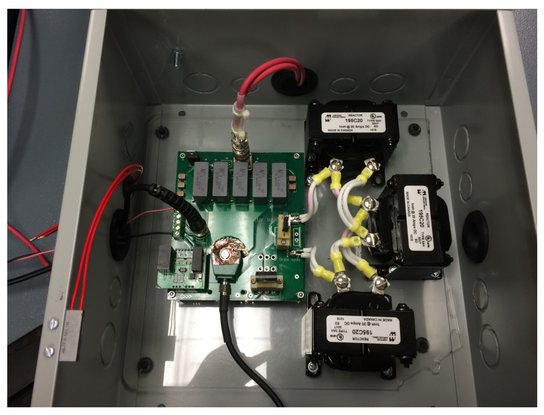
- Vertical-GaN (v-GaN) is **emerging** as the next material system enabling higher performance power electronics
- Unipolar Figure of Merit (FOM) **surpasses** that of SiC

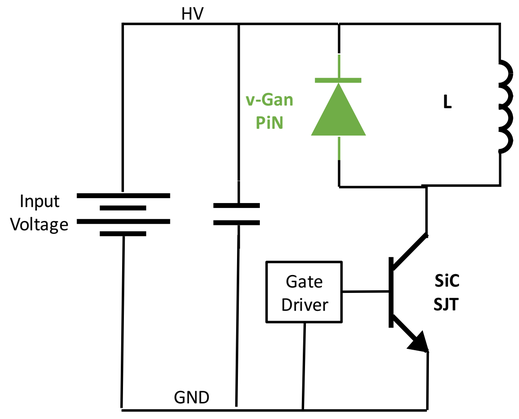


- V-GaN diodes exhibit high breakdown voltage, low on-resistance, small reverse-recovery energy, and avalanche ruggedness, but **little characterization** has been reported to date
- **We have evaluated the static and switching characteristics of Avogy v-GaN PiN diodes**
  - **Future work will analyze long-term operational** reliability

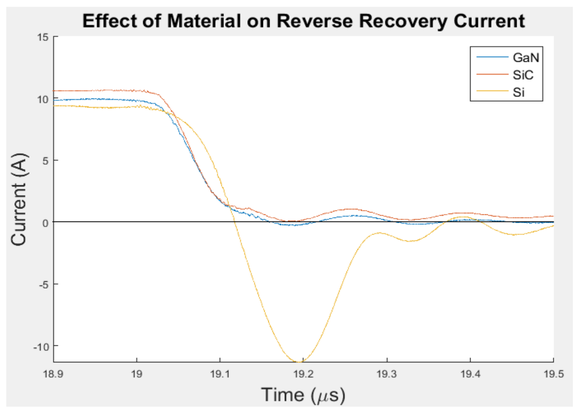
3. Experimental facilities

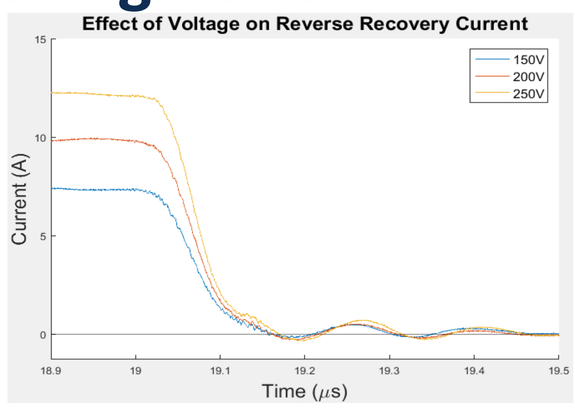
- *Leverages Sandia's role as the lead DOE lab for electronics, including significant investments in silicon (e.g. ASICs) and compound semiconductors (e.g. solid-state lighting EFRC)*
- Hot chuck capable of 600˚C operation
- High-power system for evaluation of power semiconductor devices
  - 3 kV, 50 A
  - Packaged parts to 400˚, Wafers and die to 300˚C
- Double pulse test circuit (DPTC) for switching evaluation of power semiconductor switches diodes under inductive load
  - System rated to 1000V, 100 A
  - Characterization of **both switches and diodes**





4. v-GaN Diode Switching Performance





- *v-GaN diode reverse recovery is **similar** to that of a SiC Shottky Barrier Diode with **nearly zero** reverse recovery*
  - ***Much lower** than conventional Si PiN diode*
- *Switching characteristics **do not** change under different voltages*
  - *Stored minority-carrier charge is negligible*
  - *Switching time lower than resolution of setup (100ns)*

→ ***Extremely short** carrier lifetime*

U.S. DEPARTMENT OF ENERGY

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