A Discussion of the State and Direction of Power Electronic Conversion

Sandia National Laboratories

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What is the grand challenge that can be addressed with new circuit topologies and/or wide band-gap semiconductors?

- ***Size, weight and cost improvements on power conversion systems to enable 1) PV cost parity with Natural Gas, 2) Manufactured cost and CO2 footprint of Hybrid vehicles on par with that of conventional gas-powered vehicles, and 3) realization of a truly Hybrid AC/DC power grid at Transmission and distribution levels***

Are packaging and module technologies sufficient to extract the maximum bene

- ***Currently, yes. Although as power levels and switching frequencies increase, circuit limiters will be due to limitations of packaging and/or passive components and not to semiconductors. The application of RF packaging expertise to power electronics may be needed to increase power conversion switching frequencies. Additionally, new materials systems for passives (e.g. inductor magnetic materials) are needed to push switching frequencies.***

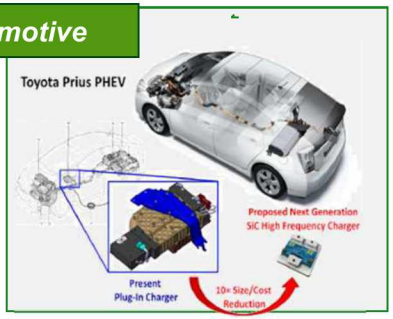
What are the state of the art metrics for your application area?

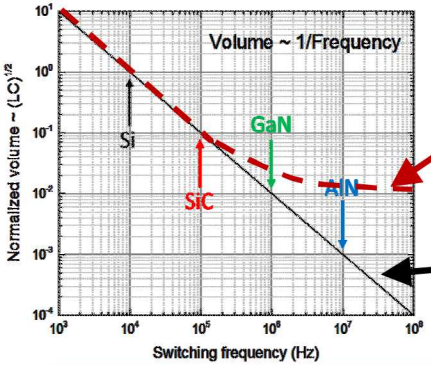
- ***Efficiency, Power Density, Specific Power, Cost are main drivers.***

What target metrics need to be met to accomplish the grand challenge?

- ***A defined metric a la the Little Box Challenge would enable technological improvements. For example, A power conversion system that switches 1 MW at 1 MHz would be a fascinating, moonshot-style grand challenge goal. Sample development-level targets include***
  - ***Active Transistors capable of V_{DS} > 15 kV, > 1MHz switching***
  - ***Magnetic materials capable of $|B_{max}|$ > 1 Tesla at 1MHz***
  - ***Circuit topologies capable of >100 kW of power conversion without magnetics***

Automotive



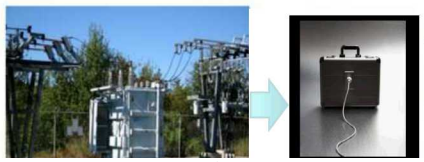


System Improvement without passive/package innovations?

Ideal System Improvement

Example Technology	Efficiency	Power Density	Cost
Existing Microinverters	94-97%	5 W/in^3	$0.25-$0.55 / Watt
Target Microinverters	>98%	100 W/in^3	< $0.06 / Watt

Power Grid



Silicon Carbide IGBT; 15 kV, 100 A; 50 kHz from Cree Inc.

Potentially 100 lbs Transformer

8000 lbs, 60 Hz Distribution Transformer

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