PowerAmerica | Next Generation Power Electronics Manufacturing Innovation Institute

Annual Meeting
February 23-25, 2021
All Times EST

Meeting opens at 10:50 a.m. each day. Chrome is the preferred browser.

Tuesday, February 23	
11 AM	**Welcome and Introduction to Tutorials** *Victor Veliadis, PowerAmerica Executive Director and CTO*
11 AM-12:30 PM	GaN Power Transistors: Devices, Technology and Reliability *Professor Matteo Meneghini, University of Padova*
12:30-12:45 PM	**Networking Break**
12:45-2:15 PM	Wide Bandgap Devices – Design for Reliability *Professor Frede Blaabjerg, Aalborg University*
2:15-2:30 PM	**Networking Break**
2:30-4 PM	SiC/GaN Converter Systems - There is No Boogeyman Under the Bed *Professor Johann W. Kolar, ETH (Swiss Federal Institute of Technology)*
4 PM – 4:30 PM	**Networking Break**
4:30-5:30 PM	**Member Advisory Committee Meeting (PowerAmerica Members Only)** See separate agenda.

Wednesday, February 24	
11-11:10 AM	**Welcome and Introduction of Keynote Speaker** *Victor Veliadis, PowerAmerica Executive Director and CTO*
11:10- 11:50 AM	**Keynote Remarks** **The Impact of Intelligent Gate Drivers on Safety, Range, and Reliability for Electric Vehicles (xEV).** *Jerry Rudiak, Senior Principal Architect, Drivers and Energy Systems Division, NXP Semiconductors*
11:50 AM- 12:20 PM	**Member-Initiated Project Final Report** **Prototyping and Evaluation of High-Speed 10kV SiC MOSFET Power Modules with High Scalability and Partial Discharge Inception Voltage** *Christina DiMarino, Virginia Tech*

12:20-12:50 PM	**Member-Initiated Project Final Report** **Surge Energy Robustness of GaN Power Devices and Modules: Application-Drive Evaluation and Physics-of-Failure Modeling** *Yuhao Zhang, Virginia Tech*
12:50-1:20 PM	**Networking Break**
1:20-1:50 PM	**Member-Initiated Project Final Report** **Packaging a Top-Cooled 650V/>150A GaN Power Module with Insulated Thermal Pads and Gate-Drive Circuit** *Kevin Bai, University of Tennessee-Knoxville*
1:50 – 2:50 PM	**Panel on Vehicle Electrification: What's Needed Next from SiC and GaN?** *Zilai Zhao, Director, eMobility Engineering, Navistar International* *John Tilly, Design Director, Analog Devices* *Chingchi Chen, Technical Leader, Ford Motor Company*
2:50-3:20 PM	**Networking Break**
3:20–3:50 PM	**Summary of Department of Energy-Funded Projects** *Victor Veliadis, PowerAmerica Executive Director and CTO*
3:50-4:30 PM	**New Member Presentations** *Stephanie Butler, Texas Instruments* *Albert Gu, Analog Power Conversion* *Tamara Baksht, VisIC Technologies* *Qing-Chang Zhong, Syndem*
4:30-5 PM	**Plans for Thursday's Technology Roadmapping Discussion**
5-5:30 PM	**Post-Session Networking**

Thursday, February 25

11-11:05 AM	**Welcome and Introduction of Keynote Speaker** *Victor Veliadis, PowerAmerica Executive Director and CTO*
11:05-11:45 AM	**Keynote Remarks** **Next-Generation Power Module Patent Landscape: WBG Technologies and EV/HEV Applications** *Remi Comyn, Patent and Technology Analyst, KnowMade*
11:45 AM-12:30 PM	**Market Trends and Forecasts: SiC and GaN for Electric Vehicles** *Ezgi Dogmus, Yole Developpment* *Simon Price, Exawatt*
12:30-1 PM	**New Member Presentations** *Stephen Kelley, Southern Company* *Raghav Khanna, University of Toledo* *Adel Nasiri, University of Wisconsin-Milwaukee*

1-1:30 PM	**Networking Break**
1:30-3:30 PM	**Technology Roadmapping Breakout Sessions Including Topics for Member-Initiated Projects. See the attachment to this agenda.** **Note -- This portion and the remainder of the meeting will be conducted on Zoom at:** **https://us02web.zoom.us/j/86095172151?pwd=ZTRaazVvZUg3cGc1VEVIR1AwM1BTUT09** **Meeting ID: 860 9517 2151** **Passcode: 773632** **Dial in: (301) 715-8592** **Please make sure you have the 5.3 or later version of Zoom to ensure good functionality.**
3:30 PM	**Closing Remarks** *Victor Veliadis, PowerAmerica Executive Director and CTO*
3:45 PM	**Post-Meeting Networking on Remo**

Roadmapping Discussion Topics
PowerAmerica 2021 Annual Meeting

The PowerAmerica Annual Meetings are occasions in which members update the PowerAmerica Technology Roadmap and shape topics for future member-funded projects. The data and results of these projects are intended to benefit PowerAmerica's members.

Time is provided on the 2021 Annual Meeting agenda to divide attendees into online breakout groups to discuss ideas that could form the basis for future projects. The five general topics and many sub-topics listed below are intended to be discussion starters and are based on the Technology Roadmap and on comments received from members at previous PowerAmerica meetings. Ideas for future PowerAmerica projects should be of broad interest to PowerAmerica members. The breakout discussion results will be used to develop technology projects that benefit the wide bandgap semiconductor industry.

Members are invited to participate in one or more of the virtual discussion groups and edit the sub-topics listed, add and subtract sub-topics, set priorities among sub-topics, and refine sub-topics in a way that can form the basis of future PowerAmerica projects. Discussion leaders will report the items of greatest interest to each discussion group. For your reference, a list of on-going and completed projects that address priorities identified by PowerAmerica members at previous meetings appears at the end of this document.

Breakout Topic 1: SiC and GaN Device Package/Module Reliability and Ruggedness

1. Develop unified standards for gate oxide reliability of different SiC MOSFET products
2. Die interconnect, attach and termination schemes to reduce parasitic inductance, hence EMI, (new wire bonding, double side mounting, lead attachment alternatives, etc.)
3. Alternatives to traditional bond wires, such as foil and welding in place of wire bonding
4. New concepts for device cooling, heat spreading, and low thermal resistance
5. Packaging techniques for reliable operation at extreme temperatures/pressures (e.g. -55C to 250C) with heat flux focused into baseplate not adjacent componentry
6. Chip scale packaging with double-sided mounting options for PCB pick and place manufacturing
7. Standard package that can be compatible with Si IGBT power modules, but improved to allow faster switching and minimal parasitics
8. Reliability improvement to meet standards of automotive/aerospace systems
9. Degradation and failure mode analysis of devices specific to certain applications, such as traction inverter, or harsh operating environments (very low/high temperature, pressure; vibration and impact)
10. Impact of low temperature and pressure on partial discharge
11. Predictive reliability and prognostics investigation of devices
12. Reliability and performance aspects of integrating passives (e.g. decoupling capacitors) with a view of determining the thermal, material, and manufacturing issues to be solved
13. Improved capacitors to withstand higher temperatures or demonstrate thermal isolation from SiC devices
14. Impact on performance related to device paralleling

Breakout Topic 2: SiC and GaN Device Design and Gate-drivers

1. Compact monolithic/integrated smart gate drivers with device health monitoring capability
2. New device modeling techniques, for example, high current surge in SiC diodes and short circuit conditions in MOSFETs
3. A realizable roadmap for on-resistance, device capacitance and current rating for MV SiC MOSFETS.
4. Improved Rds-on of low voltage devices; gate oxide interface for higher mobility
5. GaN gate drivers for multiple paralleled devices with fast short-circuit response times/shut off control (< 2 or 3 microseconds)
6. High current for 3.3 kV devices
7. Gate driver solutions for GaN device paralleling
8. SiC devices with on-chip protection circuits and gate charge scaling

Breakout Topic 3: System Demonstrations and Integration Innovations for SiC and /or GaN Technology

1. Fast chargers for phone/laptop adapters and power supply designs with ease of control - GaN
2. SiC-based designs for energy storage, power conversion and management for medical equipment (MRI, X-ray)
3. Demonstration of SiC and GaN in power storage and conversion in renewable energy systems that provide game-changing efficiencies
4. Motor control for hybrid electric aircraft
5. System demonstration in electric motors; new ways to drive motors for that fully harness the advantages of SiC and GaN technology, for example power electronics built into generator/motor chassis
6. High Power AC/DC with PFC implementations above 10kW
7. Demonstrate devices in datacenter power supplies 99%+ PFC stage and 98-99% dc-dc stage
8. Develop a power converter that looks and behaves like a UHF turner, signal in – signal out, nothing else.
9. Document the cost of a power device/module, with thorough understanding it would be possible to apply technology to cost reduce the device/module; right now, cost reductions are scale bigger, is that the only solution?
10. Demonstration of SiC switching (e.g. 50kHz) vs. silicon IGBT (e.g. 4kHz) on a typical/standard inverter rated motor with the aim of showing careful measurement of motor loss at the two different frequencies. A filter could be placed on the front end of the motor and show how big it would be in the two cases.
11. Demonstration of SiC technology in the context of smart grid technology
12. Shipboard demonstrations at 3.3kV at 400-500A Open demonstration of new GaN performance capabilities and novel applications
13. Mission profile standardization (GaN): develop a template and/or standardized set of mission profiles for key applications such as adapters, data centers, AC:DC

Breakout Topic 4: Out-of-the-Box Ideas

1. Exploit RF community lessons for power electronics
2. Can PowerAmerica develop realistic business cases for SiC and GaN in different applications?

3. Customer and workforce education: Can PowerAmerica facilitate best design practices, tutorials/short-courses on WBG EMI, inductance/parasitics, gate drive and circuit design?
4. High frequency components transformers/circuit breakers/fuses: Investigate need for development and supply chain issues
5. Development of high RPM motors that can leverage the improved performance of SiC MOSFETs; engage industrial partners to bring more of them to market

Breakout Topic 5: Manufacturing Equipment, Processes, and Testing for SiC and GaN Technology

1. Processes for die interconnect, attach and termination schemes to reduce parasitic inductance, hence EMI, (new wire bonding, double side mounting, lead attachment alternatives, etc.)
2. Processes for alternatives to traditional bond wires, such as foil and welding in place of wire bonding
3. Test and measurement equipment capabilities to address unmet test and reliability/ruggedness measurement needs for SiC and GaN
4. Use of PowerAmerica SiC and GaN failure mode studies and other results to evaluate manufacturing process steps to find opportunities for process step improvements that increase device and module manufacturing yields
5. Development of new materials for use in the SiC or GaN manufacturing processes

PowerAmerica Member-Initiated Projects completed, on-going, and starting soon:

- Quantifying Power Device Reliability Due to Terrestrial and Other Radiation Sources –Akin Akturk, CoolCAD Electronics
- Reliability Analysis of Wide-Bandgap Semiconductor Devices (Testing Facility) – Stephen Bayne, Texas Tech/Joshua MacFie, Group NIRE
- Short-circuit Behavior and Protection of Next Generation SiC Modules – Jin Wang, Ohio State
- WBG Integrated High Voltage APM/OBCM Converter for Future Use in Autonomous Vehicles – Qiang Li, Virginia Tech
- Prototyping and Evaluation of High-Speed 10 kV SiC MOSFET Power Modules with High Scalability and Partial Discharge Inception Voltage, Christina DiMarino, Virginia Tech (teamed with NREL and Wolfspeed);
- Packaging a Top-cooled 650V/>150A GaN Power Module with Insulated Thermal Pads and Gate-Drive Circuit, Kevin Bai, University of Tennessee-Knoxville (teamed with GM, GaN Systems and Hella);
- Surge Energy Robustness of GaN Power Devices and Modules: Application-driven Evaluation and Physics-of-Failure Modeling, Yuhao Zhang, Virginia Tech (teamed with Lockheed Martin)
- Silicon Carbide Power Modules for Medium Voltage Applications Member Initiated Project Proposal, Alan Mantooth, University of Arkansas-Fayetteville (teamed with Microchip and NREL)
- Embedded GaN Power Module for High Frequency 400V/>20A Operation with Double-Sided Cooling and Integrated Gate-Drive Circuit, Helen Cui, University of Tennessee-Knoxville (teamed with GaN Systems and NREL)
- SiC-based Module Building Block with Integrated Inductor and Gate Driver

Member Initiated Project Proposal, Christina DiMarino, Virginia Tech (teamed with Infineon and Lockheed-Martin)

- Demonstration of Advanced Power Packaging Technology for Near Term Commercialization, Doug Hopkins, North Carolina State University (teamed with Transphorm and UnitedSiC)

Note: The last four "starting soon" projects will begin shortly and have the following "High Power Module" and "Low Power Module" requirements:

High Power Module

Power: (> 1000 kW) with a goal of 1000 A. Proposals will be scored in part according to how close to the goal the proposal aims to achieve using realistic methods. In meeting this goal, proposals can be:

Single phase with a goal of 1000A (rms); DC current goal 1600A
Double phase with a goal of 500A (rms)/phase; DC current goal 900A
Three-phase with a goal of 350A (rms)/phase; DC current goal 560A

Components: Must use commercially available SiC and/or GaN devices and peripheral components, no new devices designs are being sought. It is assumed, for purposes of this project, that commercially available SiC devices do not exceed 1700V or 50A at case temperature >= 90C.

Module Size: Not to exceed 100 cm^3

Inductance < 1 nH

Ambient temperature: Operational within a range of -60C to >=90C case temperature with a goal of at least 600,000 lifetime temperature cycles before failure. The project need not perform lifetime tests to demonstrate the goal but should explain how this goal is considered in the design.

Low Power Module

Power: < 10 kW with a minimum of 20A

Components: Must use commercially available SiC and/or GaN devices, 600V minimum and peripheral components; no new device designs are being sought.

Module Size: Not to exceed a footprint of 2 x 3 cm^2

Ambient temperature: Operational within a range of -60C to >=90C case temperature

Frequency: 600 kHz minimum with a goal of 1000 kHz. Proposals will be scored in part according to how close to the goal the proposal aims to achieve using realistic methods.