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Xiu Yao, University at Buffalo, SUNY
Andrew Binder, University of Central Florida
Yushi Liu, University of Colorado Boulder
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Brett Hull, Sei-Hyung Ryu, Wolfspeed
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Dear Colleagues,

It is my pleasure to welcome you to Atlanta, Georgia, USA, for the 6th Annual IEEE Workshop on Wide Band Gap Devices and Applications (WiPDA 2018), sponsored by the IEEE Power Electronic Society (PELS) and IEEE Power Sources Manufacturers Association (PSMA). WiPDA is a relatively new workshop with a focus on the full span of topics related to wide-band-gap power electronics, from semiconductor devices, to their applications in circuits and systems. WiPDA provides a unique opportunity for engineers, researchers, students, and other professionals in the power electronics community to exchange technical knowledge, network, and get exposed to the latest technology trends.

The heart of this year’s workshop is the technical program, which, as in past years, focuses on wide-bandgap power devices and their applications. One of the primary objectives of this workshop is to foster interactions and collaborations between device scientists and circuit and application engineers, which is vital to the success of this vibrant and growing field. Both SiC- and GaN-based technologies are covered in the program, with a few hints of even newer semiconductor materials on the horizon. The number of submissions this year dictated that the technical program be divided into three parallel sessions, which have been arranged with great care and thought to maximize the experience for every attendee. A poster session held in conjunction with our banquet will provide another opportunity for attendees to view high-quality work in the area of wide-bandgap power electronics. Finally, eight keynote talks given by recognized experts in the field complement the technical program, covering both devices and applications.

WiPDA 2018’s professional program begins Wednesday Oct. 31st, with 7 tutorial sessions that offer an in-depth discussion of important and complex technical topics covering both devices and applications including SiC and GaN technologies. The tutorials sessions are intentionally not overlapping so that attendees may attend all of them. Additionally, this year’s workshop will feature two discussion panels, one devoted to SiC and the other to GaN. The panels feature recognized experts in the industry and are designed to stimulate discussion between the panelists and the workshop attendees in this exciting field.
Our partners and exhibitors will showcase their state-of-the-art technologies, products, and solutions in the Exposition Hall, which we hope will become a highly interactive networking environment.

I would like to express my utmost gratitude to the members of the WiPDA 2018 Organizing Committee, the WiPDA Steering Committee, and student volunteers, who with hard work and selfless dedication have made this event possible. I would like to thank PELS and PSMA for their sponsorship and stewardship, and the generous support of all our corporate partners, whose support is an integral element of the workshop’s success. I would also like to thank each and every one of you, whether you are present as a presenter, attendee, exhibitor, volunteer, or any combination of the above, for your contribution and participation.

Once again, I welcome you to WiPDA 2018 and I wish you a productive workshop.

Prof. Maryam Saeedifard
General Chair IEEE WiPDA 2018
### SCHEDULE AT A GLANCE: Wednesday
October 31, 2018

<table>
<thead>
<tr>
<th>Start</th>
<th>End</th>
<th>Agenda Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:00 AM</td>
<td>5:00 PM</td>
<td>ITRW Meeting (Salon I,II,V, VI)</td>
</tr>
<tr>
<td>7:30 PM</td>
<td>9:30 PM</td>
<td>JEDEC Meeting (Salon III &amp; IV)</td>
</tr>
</tbody>
</table>

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**MISSION**

The International Technology Roadmap for Wide band-gap power semiconductors (ITRW) will provide reference, guidance and services to identify the future research and technology developments of wide band-gap power semiconductors and their application, and thereby provide a reliable and comprehensive view on the Strategic Research Agenda and Technology Roadmap.
Continental-style breakfasts will be served at the Break Area closest to the Ballroom. The food is available from 7 am to 4 pm and cold beverages from 7 am to 5 pm daily.

Tutorial Sessions Location: **Salon III – IV**

<table>
<thead>
<tr>
<th>Start</th>
<th>End</th>
<th>Agenda Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:00 AM</td>
<td>10:00 AM</td>
<td><strong>Tutorial: “SiC Power Device Reliability”</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Donald A. Gajewski, <em>Wolfspeed</em></td>
</tr>
<tr>
<td>10:00 AM</td>
<td>11:00 AM</td>
<td><strong>Tutorial: “How to Design High Efficiency and High Density GaN Switching Power Supply”</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Qingyun Huang, <em>University of Texas at Austin</em></td>
</tr>
<tr>
<td>11:00 AM</td>
<td>12:00 PM</td>
<td><strong>Tutorial: “Developing High Power, Medium Voltage Silicon Carbide based Power Electronics”</strong></td>
</tr>
<tr>
<td>12:00 PM</td>
<td>1:30 PM</td>
<td>Lunch (Tutorials attendees only, GT Hotel Dining)</td>
</tr>
<tr>
<td>1:30 PM</td>
<td>2:30 PM</td>
<td><strong>Tutorial: “Silicon Carbide Power Devices: Making the Transition From Silicon”</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Victor Veliadis, <em>PowerAmerica/North Carolina State University</em></td>
</tr>
<tr>
<td>2:30 PM</td>
<td>3:30 PM</td>
<td><strong>Tutorial: “Measurement and Analysis Method of Parasitic Capacitance and Inductance in Power Device and Power Electronic Circuit”</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ryo Takeda, <em>Keysight Technologies</em></td>
</tr>
<tr>
<td>3:30 PM</td>
<td>4:30 PM</td>
<td><strong>Tutorial: “Advanced Power Module Packaging: from Design to Validation”</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fang Luo, David Huitink, and Yarui Peng, <em>University of Arkansas</em></td>
</tr>
<tr>
<td>4:30 PM</td>
<td>5:30 PM</td>
<td><strong>Tutorial: “Emerging Ultra-Wide Band Gap (UWBG) Power Electronic Devices”</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sriram Krishnamoorthy, <em>University of Utah</em></td>
</tr>
<tr>
<td>6:00 PM</td>
<td>8:00 PM</td>
<td>Vendor Exhibits and Social Reception</td>
</tr>
</tbody>
</table>
**Continental-style breakfasts** will be served at the Break Area closest to the Ballroom. The food is available from 7 am to 4 pm and cold beverages from 7 am to 5 pm daily.

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<thead>
<tr>
<th>Start</th>
<th>End</th>
<th>Agenda Item</th>
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<tbody>
<tr>
<td>8:00 AM</td>
<td>8:15 AM</td>
<td><strong>Welcome Address</strong>&lt;br&gt;Eric Persson, Infineon <em>(Salon III – IV)</em></td>
</tr>
<tr>
<td>8:15 AM</td>
<td>8:45 AM</td>
<td><strong>Keynote</strong>&lt;br&gt;“WBG Power Electronics: Major Challenges and Potential Pathways for Commercialization”&lt;br&gt;JOHN SHEN, Illinois Institute of Technology <em>(Salon III – IV)</em></td>
</tr>
<tr>
<td>8:45 AM</td>
<td>9:15 AM</td>
<td><strong>Keynote</strong>&lt;br&gt;“Challenges, Opportunities, and Applications for GaN-based Flying Capacitor Multi-Level Converters”&lt;br&gt;ROBERT PILAWA-PODGURSKI, University of California, Berkeley <em>(Salon III – IV)</em></td>
</tr>
<tr>
<td>9:15 AM</td>
<td>9:40 AM</td>
<td><strong>Break</strong>&lt;br&gt;Coffee, Tea, and Refreshments provided by JEDEC</td>
</tr>
<tr>
<td>9:45 AM</td>
<td>10:30 AM</td>
<td><strong>Panel Session</strong>&lt;br&gt;“Ask the Experts: GaN Reliability /Qualification Q and A”&lt;br&gt;SANDEEP BAHL, TI&lt;br&gt;KENICHIRO TANAKA, Panasonic&lt;br&gt;SAMEH KHALIL, Infineon Technologies&lt;br JAUME ROIG, ON Semiconductor&lt;br&gt;RON BARR, Transphorm <em>(Salon III – IV)</em></td>
</tr>
<tr>
<td>10:30 AM</td>
<td>11:15 AM</td>
<td><strong>Panel Session</strong>&lt;br&gt;“SiC MOSFET Reliability and Ruggedness: Present Status and Future Directions”&lt;br&gt;ANANT AGARWAL, The Ohio State University&lt;br&gt;AIVARS LELIS, Army Research Laboratory&lt;br&gt;DON GAJEWSKI, Wolfspeed&lt;br&gt;SUBHASHISH BHATTACHARYA, North Carolina State University&lt;br&gt;BRIAN PEASLEE, General Motors <em>(Salon III – IV)</em></td>
</tr>
<tr>
<td>11:15 AM</td>
<td>1:15 PM</td>
<td><strong>Lunch</strong>&lt;br&gt;(GT Hotel dining)&lt;br&gt;Buffet provided by Focused Test, Inc.</td>
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<td>Start</td>
<td>End</td>
<td>Agenda Item</td>
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<tr>
<td>1:15 PM</td>
<td>1:45 PM</td>
<td><strong>Keynote</strong> “DOE Advanced Manufacturing Office Programs on Wide-Bandgap Power Electronics” ALLEN HEFNER, NIST and DOE Advanced Manufacturing Office (Salon III – IV)</td>
</tr>
<tr>
<td>1:45 PM</td>
<td>2:15 PM</td>
<td><strong>Keynote</strong> “Reliability of GaN Power Transistors” KENICHIRO TANAKA, Panasonic Corporation (Salon III – IV)</td>
</tr>
<tr>
<td>2:15 PM</td>
<td>2:45 PM</td>
<td><strong>Keynote</strong> “GaN and SiC: How They Will Impact the Future of Power Electronics Industry” ANA VILLAMOR, Yole Développement (Salon III – IV)</td>
</tr>
<tr>
<td>2:45 PM</td>
<td>3:15 PM</td>
<td>Break/Session Setup Period Coffee, Tea, and Refreshments</td>
</tr>
</tbody>
</table>
| 3:15 PM  | 5:20 PM  | Technical Session 1  
GaN Enabled Application and Hybrid Switches (Conference A)  
GaN Reliability and Devices (Salon I-II)  
SiC Device Fabrication and Reliability (Salon V – VI) |
| 6:00 PM  | 9:00 PM  | Conference Banquet and Poster Session (Grand Ballroom Foyer)                |
**SCHEDULE AT A GLANCE: FRIDAY**  
November 2, 2018

Continental-style breakfasts will be served at the Break Area closest to the Ballroom. The food is available from 7 am to 4 pm and cold beverages from 7 am to 5 pm daily.

<table>
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<tr>
<th>Start</th>
<th>End</th>
<th>Agenda Item</th>
</tr>
</thead>
</table>
| 8:00 AM        | 8:30 AM  | **Keynote**  
                   “Switched Tank Converters – Leveraging the Benefits of GaN and SiC”  
                   DONG CAO, *North Dakota State University*  
                   (Salon III – IV) |
| 8:30 AM        | 9:00 AM  | **Keynote**  
                   “Gate Drive and Protection Considerations in Applying SiC MOSFETs”  
                   LEON TOLBERT, *Oak Ridge National Laboratory*  
                   (Salon III – IV) |
| 9:00 AM        | 9:30 AM  | **Keynote**  
                   “Achieving High Power Density Through GaN Power Devices”  
                   ALEX Q. HUANG, *University of Texas at Austin*  
                   (Salon III – IV) |
| 9:30 AM        | 10:00 AM | Break/Session Setup Period  
                   Coffee, Tea, and Refreshments |
| 10:00 AM       | 11:40 AM | **Technical Session 2**  
                   **GaN Device Characterization and Gate Drive**  
                   (Conference A)  
                   **High Efficiency SiC-based Power Converters**  
                   (Salon I-II)  
                   **SiC Device Characterization**  
                   (Salon V-VI) |
| 11:40 AM       | 1:00 PM  | Lunch (GT Hotel Dining)  
                   Lunch provided by Texas Instruments  
                   (12:30 PM – 1:00 PM: Session Setup Period) |
| 1:00 PM        | 2:40 PM  | **Technical Session 3**  
                   **GaN Soft switching and Multilevel Applications**  
                   (Conference A)  
                   **GaN Device Integration and Performance**  
                   (Salon I-II)  
                   **Practical Considerations in SiC-based Power Converters**  
                   (Salon V-VI) |
| 2:40 PM        | 3:00 PM  | Break/Session Setup Period  
                   Coffee, Tea, and Refreshments provided by *SemiProbe* |
<table>
<thead>
<tr>
<th>Time</th>
<th>Session Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>3:00 PM</td>
<td><strong>Technical Session 4</strong></td>
</tr>
<tr>
<td>4:00 PM</td>
<td><strong>GaN Power Module and Package</strong> (Conference A)</td>
</tr>
<tr>
<td>4:40 PM</td>
<td><strong>SiC Power Modules and Devices for High Performance Power Converters</strong> (Salon I-II)</td>
</tr>
<tr>
<td>4:40 PM</td>
<td><strong>Conference Wrap-up</strong></td>
</tr>
<tr>
<td>5:00 PM</td>
<td><strong>Maryam, Georgia Tech</strong></td>
</tr>
</tbody>
</table>
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SiC

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poweramericainstitute.org
Dr. Z. John Shen

Illinois Institute of Technology, Chicago

“WBG Power Electronics: Major Challenges and Potential Pathways for Commercialization”

Thursday, November 1, 2018, 8:15 AM

Speaker Biography

Z. John Shen received BS from Tsinghua University, China, in 1987, and M.S. and Ph.D. degrees from Rensselaer Polytechnic Institute, Troy, NY, in 1991 and 1994, respectively. He is currently Grainger Endowed Chair Professor in Electrical and Power Engineering at Illinois Institute of Technology. Between 1994 and 1999, he held a variety of positions with Motorola Inc. He was on faculty of the University of Michigan-Dearborn between 1999 and 2004, and the University of Central Florida between 2004 and 2012. During 2002-2012 he was also a board member and Chief Scientist at Great Wall Semiconductor (now a division of Intersil Renesas), responsible for developing MHz-frequency lateral power MOSFET technologies. His research interests include power electronics, power semiconductor devices and ICs, automotive electronics, and renewable and alternative energy systems. He has published over 200 journal and conference articles, and holds 18 issued and several pending U.S. patents in these areas. Dr. Shen is a recipient of the 2012 IEEE Region 3 Outstanding Engineer Award, the 2003 NSF CAREER Award, the 2006 IEEE Transaction Paper Award from IEEE Society of Power Electronics, the 2003 IEEE Best Automotive Electronics Paper Award from IEEE Society of Vehicular Technology, and the 1996 Motorola Science and Technology Award. He has been an active volunteer in the IEEE Power Electronics Society (PELS), and has served as VP of Products 2009-2012, Associate Editor and Guest Editor in Chief of the IEEE Transactions on Power Electronics, General Chair of several major IEEE conferences including ECCE2016 and ISPSD2018.
Abstract

WBG power electronics research has kicked into high gears in the past few years. Numerous power converter designs, in which the existing silicon power devices were simply replaced with new WBG devices, have been reported and demonstrated tangible performance benefits. However, considering the high cost and other constraints of today’s WBG devices, the power electronics industry may need to look at other innovative pathways for large scale commercialization beyond the simple “brute force” substitution approach. In this talk, we will first examine the unique advantages and major challenges of WBG vs. silicon devices, and propose a few potential pathways to overcome the barriers. WBG devices should be judiciously deployed in future power electronic systems to maximize their performance benefits while low cost silicon devices should be used wherever their performance suffices. Combined or mixed use of both WBG and silicon devices should be explored at the component, converter, and system levels. This hybrid approach essentially allows WBG and silicon devices to do what they do best, individually and collectively. Several examples and case studies will be discussed along this line of thinking. In particular, we will discuss a paradigm of partial power processing (P3) which combines low-frequency high-efficiency Si base power processing with high-frequency, fractional power WBG micro-STATCOM. This approach may help deliver better performing and more cost-effective power electronic designs, and expand the WBG market at the same time. To address the current reliability concerns with WBG devices, we will look into fault-tolerant operation and control strategies of multilevel and multithread converter topologies. Furthermore, we will discuss the potential of expanding power ratings through multilevel topologies and a differential power processing approach. The purpose of this talk is to stimulate discussions and debates among the research community on these nonconventional technical approaches in commercializing WBG power electronics.
Dr. Robert Pilawa-Podgurski
University of California, Berkeley

“Challenges, Opportunities, and Applications for GaN-based Flying Capacitor Multi-Level Converters”

Thursday, November 1, 2018, 8:45 AM

Speaker Biography

Robert Pilawa-Podgurski is currently an Associate Professor in the Electrical Engineering and Computer Science Department at the University of California, Berkeley. He received his BS, MEng, and PhD degrees from MIT. He performs research in the area of power electronics. His research interests include renewable energy applications, electric vehicles, energy harvesting, CMOS power management, high density and high efficiency power converters, and advanced control of power converters. Dr. Pilawa-Podgurski the 2014 Richard M. Bass Outstanding Young Power Electronics Engineer Award of the IEEE Power Electronics Society, given annually to one individual for outstanding contributions to the field of power electronics before the age of 35. In 2015, he received the Air Force Office of Scientific Research Young Investigator Award, the UIUC Dean’s Award for Excellence in Research in 2016, the UIUC Campus Distinguished Promotion Award in 2017, and the UIUC ECE Ronald W. Pratt Faculty Outstanding Teaching Award in 2017. In 2018 he received the IEEE Education Society Mac E. Van Valkenburg Award, for outstanding contributions to teaching unusually early in his professional career. Since 2014, he serves as Associate Editor for IEEE Transactions on Power Electronics, and for IEEE Journal of Emerging and Selected Topics in Power Electronics. He is co-author of nine IEEE prize papers.
Abstract

Recently, the flying capacitor multilevel converter (FCML) topology has received renewed interest owing to its potential in high density, high efficiency power conversion. While its theoretical benefits have been well known for quite some time, practical challenges associated with gate driving, capacitor voltage balancing, and commutation inductance have to-date prevented its widespread adoption. However, in the last few years advances in packaging, integration, and control have led to several FCML hardware prototypes being demonstrated with outstanding performance. In this talk, I will highlight some of the challenges associated with FCML design and operation, along with opportunities in emerging applications where the need for high power density makes the FCML an attractive option. Examples from electric aircraft powertrain and grid-interfaced power converters will be highlighted, along with unique challenges and opportunities associated with GaN-based FCML converters from a thermal management, EMI, and reliability perspective.
Dr. Allen Hefner
NIST and DOE Advanced Manufacturing Office

“DOE Advanced Manufacturing Office Programs on Wide-Bandgap Power Electronics”

Thursday, November 1, 2018, 1:15 PM

Speaker Biography

Dr. Allen Hefner (IEEE Fellow 2001) joined NIST in 1983 where he leads NIST’s Power Semiconductor Devices project and the NIST Smart Grid project on standards and test for distributed generation, storage and microgrids. Since 2016 he has also served as the Technology Manager for the DOE EERE Advanced Manufacturing Office programs on wide-bandgap power electronics including the PowerAmerica Institute, the Next Generation Electric Machine programs, and the Wide Bandgap Power Electronics Traineeship programs.

Dr. Hefner is known for developing the theoretical foundation for understanding the Insulated Gate Bipolar Transistor (IGBT) operation, and the performance trade-offs for designing IGBTs with fast switching speeds. The Hefner Model is used in circuit simulation tools for power electronics application integration of IGBTs and power MOSFETs. He is also known for his leadership role in U.S. Government programs for advancing wide-bandgap power semiconductor devices and applications. He is the author of 180 publications, two U.S. patents, and has received many best paper and prestigious technical achievement awards for his leadership.
Abstract
Wide Bandgap (WBG) power electronics is an emerging technology area with significant advantages in existing applications as well as the ability to enable new applications that are not possible with previous technology. The DOE Advanced Manufacturing Office has recently initiated several programs to accelerate manufacturing of WBG power semiconductor devices, to enable more rapid supply chain integration for WBG power electronic systems, and to develop technologies needed to take full advantage of the WBG power semiconductor capability. These programs include the PowerAmerica next generation WBG power electronics manufacturing institute, the Next Generation Electric Machines (NGEM) medium-voltage high-speed direct drive motors program, and the WBG Power Electronics Traineeship education and workforce development programs. The presentation will review the goals and status of these programs and will describe some of the transformative advancements that they have achieved.
Dr. Kenichiro Tanaka
Panasonic Corporation

“Reliability of GaN Power Transistors”

Thursday, November 1, 2018, 1:45 PM

Speaker Biography

Dr. Kenichiro Tanaka received the bachelor, the master and the doctor degree of Engineering from the University of Tokyo in 1997, 1999, and 2003, respectively. In his doctoral thesis, he had investigated the optical properties of lead-iodide-based inorganic-organic perovskite materials which have been gaining attention in recent years owing to their outstanding properties as a solar cell. After he had investigated as a Special Postdoctoral Researcher in RIKEN institute, Japan, he joined Semiconductor Device Research Center, Matsushita Electronics Corporation (currently Panasonic), Kyoto, Japan in 2007. Since then, he has been engaging in the development of GaN power transistors applicable for high-frequency switching applications. He started his career with the development of crystal growth of GaN on Si substrate, and he has involved the device design, manufacturing, reliability, and simulation study. He had involved in MHz high-frequency power converter design employing GaN power transistors in CPES, Virginia Tech, in the USA from 2015 to 2017. He is currently developing MHz-region power converter with Panasonic’s GaN power transistors. He authored and coauthored 26 technical papers. He is a member of Japanese Journal of Applied Physics and was a sub-committee member of International Reliability Physics Symposium (IRPS) in 2017 and 2018. He is also contributing in the standardization of GaN power transistors, JEDEC JC-70.
Abstract

Recently, as GaN power transistors come into widespread use as the promising switches for power converter applications, it is all the more important and inevitable to guarantee their reliability. Here we firstly review how we strengthen the robustness of GaN power transistors. We incorporated a bunch of technologies to strengthen the robustness of GaN power transistors. In particular, we introduce a Hybrid-Drain-embedded Gate Injection Transistor (HD-GIT), the structure of which is quite effective to ensure the GaN reliability to the commercially-applicable level.

Secondly, we discuss how we evaluate the robustness of GaN power transistors. The robustness of GaN power transistors should be examined under switching operations as well as under the conventional DC tests standardized for Si power transistors, because severe switching event induces the so-called current collapse, which may lead to the degradation. Since the magnitude of current collapse depends strongly on the trajectory of IDS-VDS during the switching event, the concept of Switching Safe Operating Area (SSOA) is proposed recently to define the IDS-VDS limit inside which the device can be switched safely. In this session, we exemplify the SSOA for the HD-GIT under the switching for a short period of time. In addition, we extract the SSOA for HD-GIT under the switching for a longer period of time based on the lifetime investigation under accelerated switching conditions. We hope that the methodology presented here is utilized to guarantee the robustness of GaN power transistors and it accelerates the more widespread use of GaN power transistors.
Dr. Ana Villamor

Yole Développement

“GaN and SiC: How They will Impact the Future of Power Electronics Industry”

Thursday, November 1, 2018, 2:15 PM

Speaker Biography

Dr. Ana Villamor serves as a Technology & Market Analyst, Power Electronics & Compound Semiconductors within the Power & Wireless division at Yole Développement. She is involved in many custom studies and reports focused on emerging power electronics technologies, including device technology and reliability analysis (MOSFET, IGBT, HEMT, etc). During her PhD, Ana was involved in a high-added value collaboration related to SJ Power MOSFETs, within the CNM research center and the leading power electronic company ON Semiconductor. During this partnership and after two years as Silicon Development Engineer, she acquired a relevant technical expertise and a deep knowledge of the power electronic industry. Ana is author and co-author of several papers as well as a patent. She holds an Electronics Engineering degree completed by a Master in micro and nano electronics, both from Universitat Autonoma de Barcelona (SP).
Abstract

Wide-band gap (WBG) technologies are now commonly accepted as a pertinent alternative to Silicon. Most power module and power inverter manufacturers have already included Silicon Carbide (SiC) and Gallium Nitride (GaN) in their roadmap as an option or as a firm project. However, time-to-market differs from application to application as a function of value proposals for cost, specifications, availability, etc.. According to Yole estimations, the market for SiC and GaN-on-silicon devices will reach about 10% of the power electronics market share in five years, impacting directly all the power electronics supply chain.

The first commercially available SiC diode has arrived to the market 18 years ago and since then progressively replaced silicon diodes in many applications. Afterwards, SiC MOSFETs has also become commercially available, making the actual period crucial for the whole SiC industry with the gain in confidence of numerous customers and the penetration into different applications. Actually, SiC MOSFET manufacturers have improved the device reliability, the performance and the availability of SiC transistor, which has enabled the realization of full-SiC power modules for different applications, providing the strongest benefits compared to silicon-based power modules.

On the other hand, GaN-on-Silicon power devices are less mature compared to SiC power devices. Nowadays, the GaN Power market is driven by low voltage high frequency applications such as Lidar or wireless charging, where GaN has its distinguished selling point. It is entering also in the consumer power supply market, with both power ICs and discrete devices, for solutions where the weight and size are extremely important or where efficiency is the main driver. Several GaN-on-Silicon power devices suppliers claim to have entered or to soon enter to the mass production phase which will also reshape the power electronics market and ecosystem.

Which will be the driving markets? How does the adoption of SiC and GaN will evolve? Which are the different business models? Market numbers and forecasts for both materials and for different applications will be shown during the presentation.
Dr. Dong Cao
North Dakota State University

“Switched Tank Converters – Leveraging the Benefits of GaN and SiC”

Friday, November 2, 2018, 8:00 AM

Speaker Biography
Dong Cao received the B.S. degree from Zhejiang University, Hangzhou China, in 2005, the M.S. and Ph.D. degrees in electrical engineering from Michigan State University, East Lansing USA, in 2010 and 2012, respectively. He worked at Ford Motor Company as a core power electronics engineer for hybrid electric vehicle electrified driveline hardware development from 2012 ~ 2014. He joined North Dakota State University as an assistant professor since Aug. 2014.

His research interests include emerging applications utilizing high power or high frequency wide bandgap devices e.g. SiC or GaN; high density power conversion using innovative topologies for data center and transportation electrification; health monitoring and lifetime prediction of power converters; smart grid integration with renewable energy sources; LED driving; power conversion topology innovations including Z-source, multilevel, switched-capacitor, and switched-tank converters, as well as intelligent gate drive for IGBT/SiC power modules.

He received two prize paper awards from the IEEE Industry Applications Society Industrial Power Converter Committee in 2010 and 2011, and one prize paper award from IEEE Journal of Emerging and Selected Topics in Power Electronics in 2018. He is the co-author of the outstanding presentation award at Applied Power Electronics Conference and Exposition (APEC) 2010 and 2016. He received the prize poster award at IEEE Energy Conversion Congress & Exposition (ECCE) 2011. He is the guest associated editor for the IEEE Transactions on Power Electronics. He has published more than 60 IEEE journal/conference papers with over 1700 citations.
Abstract

In this presentation, the efficient power delivery challenges of data-center, renewable energy sources grid integration, and the automotive application will be discussed. The advantages and application challenges of GaN and SiC power devices based power converters will be summarized. The limitation of magnetic materials for future high frequency and high power applications will also be reviewed. The power converter solution concept – switched tank converter that has the potential of fully leveraging the GaN and SiC power devices advantage with minimal or zero usage of magnetic materials will be presented.

The development history or origin of the switched tank converters will be reviewed. It will include the topology level development and evolution of switched capacitor converters, magnetic-less multilevel dc-dc converters, and recent resonant and soft-switching switched-capacitor or multilevel converters. The high power and mass-production challenges of these converters for commercial applications will be addressed, the newly proposed switched tank converter concept to address the above issues will be covered. The GaN-based switched tank converter example for the intermediate bus converter in the data center application including the design optimization will be presented. The practical mass production challenges and solutions for the proposed switched tank converter for data center application in mass production application will be addressed. Several new application areas utilizing the GaN switched tank converter concept with the partial power regulator for high-density automotive applications and solar farm application will also be discussed. Recent advances of utilizing the SiC-based switched-tank converter for high voltage, high power (~100 kW) automotive application will be finally presented.
Dr. Leon M. Tolbert  
*Oak Ridge National Laboratory*

“Gate Drive and Protection Considerations in Applying SiC MOSFETs”  
*Friday, November 2, 2018, 8:30 AM*

**Speaker Biography**

Leon M. Tolbert received the Bachelor’s, M.S., and Ph.D. degrees in electrical engineering from Georgia Tech. He worked at Oak Ridge National Laboratory (ORNL), Oak Ridge, TN, from 1991 until 1999 on electric distribution and power quality projects. He was appointed as an Assistant Professor with the Department of Electrical and Computer Engineering, The University of Tennessee, Knoxville, in 1999. He is currently the Min H. Kao Professor in Electrical Engineering and Computer Science, The University of Tennessee. He is a founding member for the National Science Foundation/Department of Energy Engineering Research Center, CURENT (Center for Ultra-wide-area Resilient Electric Energy Transmission Networks). He is also a part-time Senior Research Engineer with the Power Electronics and Electric Machinery Research Center, ORNL.

Dr. Tolbert is a Registered Professional Engineer in the state of Tennessee and a Fellow of the IEEE. He was the recipient of the 2001 IEEE Industry Applications Society Outstanding Young Member Award, and six prize paper awards from the IEEE Industry Applications Society and IEEE Power Electronics Society. He was an Associate Editor of the IEEE Transactions on Power Electronics from 2007 to 2013. He was the Paper Review Chair for the Industry Power Converter Committee of the IEEE Industry Applications Society from 2014 to 2017. He conducts research in the application of wide bandgap devices to data center power supplies, medium voltage utility applications, and electric vehicles.
Abstract

SiC MOSFETs are expected to bring improvements in efficiency, size, and weight to several applications such as transportation, data center power supplies, and electric utility converters. These fast switching devices enable higher bandwidth control and smaller filter size, but also can cause issues in converters because their high dv/dt and di/dt can induce overvoltages or cross-talk in an inverter phase leg.

This keynote address will provide several voltage source gate (VSG) drive techniques that enable high-speed switching of these devices without incurring cross-talk or overvoltage penalties. An intelligent gate assist circuitry is proposed to be embedded into a gate drive integrated circuit, offering a simple, compact, and reliable solution to maximize the benefits of SiC devices in actual power electronics applications. Also, a current source gate drive (CSG) dedicated for SiC discrete devices is proposed, which can provide constant current during the switching transient to enable faster switching of the device.

Because of their small size and thermal mass, the short circuit withstand capability of SiC devices tends to be lower than comparable Si ones. This keynote presents overcurrent protection methods to improve the reliability and overall cost of SiC MOSFET-based converters that can be implemented to ensure extremely fast fault identification and interruption of a SiC device.
Dr. Alex Q. Huang

Semiconductor Power Electronics Center, University of Texas at Austin

“Achieving High Power Density Through GaN Power Devices”

Friday, November 2, 2018, 9:00 PM

Speaker Biography

Dr. Alex Huang is the Dula D. Cockrell Centennial Chair in Engineering at University of Texas at Austin. Dr. Huang received the bachelor’s degree in electrical engineering from Zhejiang University, China in 1983 and his M.S. degree from University of Electronic Science and Technology of China in 1986. He received his Ph.D. in electrical engineering from University of Cambridge, UK in 1992. Prior to joining UT Austin, Dr. Huang has been a faculty member at Virginia Tech (1994-2004) and NC State University (2004-2017). At NC State, Dr. Huang has established a number of internationally renowned public-private partnerships such as the NSF FREEDM ERC in 2008, NCSU’s Advanced Transportation Energy Center (ATEC) in 2008 and the DOE PowerAmerica Institute in 2014. Dr. Huang is a world renowned expert of power semiconductor devices and power electronics. He has published more than 500 papers in journals and conferences, and is the inventor of more than 20 US patents. He has mentored and graduated more than 80 Ph.D. students and master students. Dr. Huang is an IEEE fellow.

Abstract:

In this talk, the static and dynamic characteristics of GaN power devices will be critically reviewed with respect to SiC and Si power devices. Taking advantage of the ultra-low dynamic losses in the GaN power device, both high power efficiency and high power density can be achieved at the same time, for converters with a wide range of power levels. Example GaN converters will be discussed to demonstrate the justifications for replacing Si in certain applications that demands efficiency and power density.
**Ask the Experts: GaN Reliability/Qualification Q&A**

Thursday, November 1, 2018, 9:45 AM  
**Salon III-IV**  
What is recent progress and any challenges remaining for GaN Reliability and Product Qualification? This open panel will take your questions.

**Moderator**  
- TIM McDONALD, Chair of JEDEC JC 70.1, PSMA Board of Directors, Chair of Power America Membership advisory committee and Consultant to Infineon

**Panelists**  
- SANDEEP BAHL, TI  
- KENICHIRO TANAKA, Panasonic  
- SAMEH KHALIL, Infineon Technologies  
- JAUME ROIG, ON Semiconductor  
- RON BARR, Transphorm

**SiC MOSFET Reliability and Ruggedness: Present Status and Future Directions**  
Thursday, November 1, 2018, 10:30 AM  
**Salon III-IV**  
SiC MOSFETs are available as product from multiple suppliers who are aggressively seeking to capture market share. In addition to better performance, reliability and ruggedness are prerequisites for SiC wide adoption. Improvements in material quality and processing contribute to device reliability. Ruggedness is one of the numerous device design trade-offs. The panel will discuss SiC MOSFET reliability and ruggedness, intelligent SiC gate drives for superior fault protection, and the stringent device requirements for breaking into the lucrative automotive market.

**Moderator**  
- VICTOR VELIADIS, Power America/North Carolina State University

**Panelists**  
- ANANT AGARWAL, The Ohio State University  
- AIVARS LELIS, Army Research Laboratory  
- DON GAJEWSKI, Wolfspeed  
- SUBHASHISH BHATTACHARYA, North Carolina State University  
- BRIAN PEASLEE, General Motors
Thursday, November 1, 2018

TECHNICAL SESSION 1

GaN Enabled Application and Hybrid Switches

Session Chairs: Sudip Mazumder, University of Chicago
John Shen, Illinois Institute of Technology

3:15 PM – 3:40 PM  Smart LED Lighting Using GaN-Based “Discrete” Power and Data Sequential Co-Transfer Network
Ankit Gupta, Sudip Mazumder

3:40 PM – 4:05 PM  Comparison of 60V GaN and Si Devices for Class D Audio Applications
Jordan Sangid, Gavin Long, Parker Mitchell, Benjamin Blalock, Daniel Costinett, Leon Tolbert

4:05 PM – 4:30 PM  A GaN/Si Hybrid T-Type Three-Level Configuration for Electric Vehicle Traction Inverter
Juncheng Lu, Ruoyu Hou, Peter Di Maso, Julian Styles

4:30 PM – 4:55 PM  A Bidirectional Buck-Boost Converter Using 1.3kV Series-Stacked GaN E-HEMT Modules for Electric Vehicle Charging Application
Mehdi Shojaie, Nour Elsayad, Solale Tabarestani, Osama Mohammed

GaN Reliability and Devices

Session Chairs: Sandeep Bahl, Texas Instruments
Darshan Gandhi, Navitas

3:15 PM – 3:40 PM  High Voltage GaN Switch Reliability
Ronald Barr, Jeff Haller, Ken Shono, Kurt Smith, Elena Georgieva, Jim McKay, Peter Smith, Rakesh Lal, Yifeng Wu

3:40 PM – 4:05 PM  Reliability & Performance Related to Internal Avalanche of GaN Cascode Devices
Yifeng Wu, Yan Lai

4:05 PM – 4:30 PM  Investigation of Performance Degradation in Enhancement-Mode GaN HEMTs Under Accelerated Aging
Chi Xu, Enes Ugur, Fei Yang, Shi Pu, Bilal Akin

4:30 PM – 4:55 PM  C-V Measurement Under Different Frequencies and Pulse-Mode Voltage Stress to Reveal Shallow and Deep Trap Effects of GaN HEMTs
Wen Yang, Jiann-Shiun Yuan, Balakrishnan Krishnan, A.J. Tzou, Wen-Kuan Yeh
SiC Device Fabrication & Reliability  
Session Chairs: Victor Veliadis, PowerAmerica  
Anant Agarwal, The Ohio State University

3:15 PM – 3:40 PM  
New Short Circuit Failure Mechanism for 1.2kV 4H-SiC MOSFETs and JBSFETs  
Kijeong Han, Ajit Kanale, B. Jayant Baliga, Bahji Ballard, Adam Morgan, Douglas C. Hopkins

3:40 PM – 4:05 PM  
Avalanche Rugged 1200 V 80 mΩ SiC MOSFETs with State-of-the-Art Threshold Voltage Stability  
Martin Domeij, Jimmy Franchi, Benedetto Buono, Kwangwon Lee, K-S Park, C-S Choi, Swapna Sunkari, Hrishikesh Das

4:05 PM – 4:30 PM  
Short Circuit Ruggedness of New Generation 1.2 kV SiC MOSFETs  
Bhagyalakshmi Kakarla, Thomas Ziemann, Roger Stark, Philipp Natzke, Ulrike Grossner

4:30 PM – 4:55 PM  
Analysis of 1.2 kV 4H-SiC Trench-Gate MOSFET with Thick Trench Bottom Oxide  
Aditi Agarwal, Kijeong Han, B. Jayant Baliga

Friday, November 2, 2018  
TECHNICAL SESSION 2

GaN Device Characterization and Gate Drive  
Session Chairs: Kevin Bai, University of Tennessee, Knoxville  
Dong Cao, North Dakota State University

10:00 AM – 10:25 AM  
Substrate Bias Effect on E-Mode GaN-on-Si HEMT COSS Losses  
Jia Zhuang, Grayson Zulauf, Juan Rivas-Davila

10:25 AM – 10:50 AM  
Quantitative Analysis of Different Operating Conditions' Effect on Dynamic on-Resistance in Enhancement-Mode GaN HEMTs  
Fei Yang, Chi Xu, Bilal Akin

10:50 AM – 11:15 AM  
Self-Powered Gate Driver Design for a Gallium Nitride Based Phase Shifted Full Bridge DC-DC Converter for Space Applications  
Victor Turriate, Brandon Witcher, Dushan Boroyevich, Rolando Burgos

11:15 AM – 11:40 AM  
Switching Transients in Gate Drive Loops of Hybrid GaN HEMTs and SiC MOSFET  
Liyan Zhu, Hua Bai, Alan Brown, Matt McAmmond
High Efficiency SiC-based Power Converters
Session Chair: Leon Tolbert, University of Tennessee, Knoxville
Fang Luo, University of Arkansas

10:00 AM – 10:25 AM
A New Series Hybrid DC-DC Converter for Wide Input Range with SiC
Liu Yang, Ming Xu, Han Peng

10:25 AM – 10:50 AM
Electrified Powertrain SiC Inverter Loss Sensitivity to Design and Operation Parameter Assumptions
Jun Kikuchi, Ming Su, Chingchi Chen

10:50 AM – 11:15 AM
Design of 20 kW Full-SiC, Three-Level, Three-Phase Uninterruptible Power Supply
Sungjae Ohn, Paul Rankin, Jianghui Yu, Rolando Burgos, Dushan Boroyevich, Harish Suryanarayana, Christopher Belcastro

11:15 AM – 11:40 AM
A High-Efficiency SiC Three-Phase Four-Wire Inverter with Virtual Resistor Control Strategy Running at V2H Mode
Yongsheng Fu, Yang Huang, Hua Bai, Xi Lu, Ke Zou, Chingchi Chen

SiC Device Characterization
Session Chairs: Anant Agarwal, Ohio State University
Victor Veliaidis, PowerAmerica

10:00 AM – 10:25 AM
Characterization of Intrinsic Capacitances of Power Transistors Under High Current Conduction Based on Pulsed S-Parameter Measurements
Cristino Salcines, Bernhard Holzinger, Ingmar Kallfass

10:25 AM – 10:50 AM
Soft-Switching Characterization of 3.3 kV Reverse-Blocking SiC Devices
Xiangyu Han, Rajendra Prasad Kandula, Karthik Kandasamy, Deepak Divan, Maryam Saeedifard

10:50 AM – 11:15 AM
Comparison of 22kHz and 85 kHz 50 kW Wireless Charging System Using Si and SiC for Electric Vehicle
Moinul Shahidul Haque, Mostak Mohammad, Jason L. Pries, Seungdeog Choi

11:15 AM – 11:40 AM
Static and Dynamic Characterization of a 2.5 kV SiC MOSFET
Sarah El-Helw, Joseph Kozak, Rolando Burgos, Khai Ngo, Dushan Boroyevich
Friday, November 2, 2018

TECHNICAL SESSION 3

GaN Soft Switching and Multilevel Applications
Session Chair: Qiang Li, Virginia Polytechnic Institute and State University

1:00 PM – 1:25 PM
A High Frequency High Efficiency GaN Based Bi-Directional 48V/12V Converter with PCB Coupled Inductor for Mild Hybrid Vehicle
Bin Li, Wei Qin, Yuchen Yang, Qiang Li, Fred Lee, Dong Liu

1:25 PM – 1:50 PM
Evaluation of GaN Based Multilevel Converters
Suvankar Biswas, David Reusch

1:50 PM – 2:15 PM
Optimal Operation of Multilevel Modular Resonant Switched-Capacitor Converter
Yanchao Li, Ze Ni, Dong Cao

2:15 PM – 2:40 PM
Analysis of Calculation Models for Device Resonance in Critical Mode Converters
Feng Qi, Zhan Wang, Yifeng Wu

GaN Device Integration and Performance
Session Chair: Bob Kaplar, Sandia National Laboratories
Sameh Khalil, Infineon Technologies

1:00 PM – 1:25 PM
Monolithically Integrated E-Mode GaN-on-SOI Gate Driver with Power GaN-HEMT for MHz-Switching
Yuki Yamashita, Steve Stoffels, Niels Posthuma, Stefaan Decoutere, Kazutoshi Kobayashi

1:25 PM – 1:50 PM
Multi-Stage Cascode in High-Voltage AlGaN/GaN-on-Si Technology
Richard Reiner, Patrick Waltereit, Stefan Moench, Michael Dammann, Beatrix Weiss, Rüdiger Quay, Oliver Ambacher

1:50 PM – 2:15 PM
Instabilities by Parasitic Substrate-Loop of GaN-on-Si HEMTs in Half-Bridges
Stefan Moench, Beatrix Weiss, Richard Reiner, Patrick Waltereit, Rüdiger Quay, Oliver Ambacher, Ingmar Kallfass

2:15 PM – 2:40 PM
Non-Linear Input Capacitance Determination of WBG Power FETs Using Gate Charge Measurements
Holger Gerstner, Achim Endruschat, Thomas Heckel, Christopher Joffe, Bernd Eckardt, Martin März
ORAL PRESENTATION SCHEDULE

Practical Considerations in SiC-based Power Converters
Session Chair: Subhashish Bhattacharya, North Carolina State University
            Mahshid Amirabadi, Northeastern University

1:00 PM – 1:25 PM  EMI Analysis of a High Power Silicon Carbide Two-Level Inverter
                    Mark Scott, Wilson Guo, Patrick Doran, Will Perdikakis, Alexander Sheets

1:25 PM – 1:50 PM  Maximizing Potentials of SiC Inverters for Permanent Magnet Synchronous Motor
                    Control by Using FPGA
                    Fanning Jin, Hua Bai, Dingguo Lu, Bing Cheng

1:50 PM – 2:15 PM  Comparison of Three-Level and Two-Level Converters for AFE Application
                    Marzieh Karami, Rangarajan Tallam, Robert Cuzner

2:15 PM – 2:40 PM  A Voltage-Edge-Rate-Limiting Soft-Switching Inverter for Wide-Bandgap Devices
                    Minyu Cai, Oleg Wasynczuk, Maryam Saeedifard

Friday, November 2, 2018
TECHNICAL SESSION 4

GaN Power Module and Package
Session Chair: Babak Parkhideh, University of North Carolina at Charlotte
            Dong Cao, North Dakota State University

3:00 PM – 3:25 PM  On Integrating Non-Intrusive Current Measurement Into GaN Power Modules
                    Andreas Lauer, Shahriar Jalal Nibir, Mehrdad Biglarbegan, Marc Hiller, Babak Parkhideh

3:25 PM – 3:50 PM  Thermal and Thermomechanical Modeling to Design a Gallium Oxide Power
                    Electronics Package
                    Paul Paret, Gilbert Moreno, Bidzina Kekelia, Ramchandra Kotecha, Xuhui Feng, Kevin Bennion, Barry Mather, Andriy Zakutayev, Sreekant Narumanchi, Samuel Kim, Samuel Graham

3:50 PM – 4:15 PM  Thermal Characterization and Design for a High Density GaN-Based Power Stage
                    Edward Jones, Michael de Rooij

4:15 PM – 4:40 PM  Design Considerations for a Gallium Nitride Based Phase Shifted Full Bridge DC-DC
                    Converter for Space Applications
                    Victor Turriate, Brandon Witcher, Dushan Boroyevich, Rolando Burgos
SiC Power Modules and Devices for High Performance
Power Converters
Session Chair: Jin Wang, Ohio State University
Mohammad Shadmand, Kansas State University

3:00 PM – 3:25 PM  Parasitic Capacitors’ Impact on Switching Performance in a 10 kV SiC MOSFET Based Converter
Xingxuan Huang, Shiqi Ji, James Palmer, Li Zhang, Leon Tolbert, Fred Wang

3:25 PM – 3:50 PM  6.5kV SiC JFET-Based Super Cascode Power Module with High Avalanche Energy Handling Capability
Bo Gao, Adam Morgan, Yang Xu, Xin Zhao, Bahji Ballard, Douglas Hopkins

3:50 PM – 4:15 PM  Constraint-Aware Algorithms for Heterogeneous Power Module Layout Synthesis and Reliability Optimization
Imam Al Razi, Quang Le, Alan Mantooth, Yarui Peng

4:15 PM – 4:40 PM  Surge Current Capability of SiC MOSFETs in AC Distribution Systems
Rostan Rodrigues, Yuzhi Zhang, Taosha Jiang, Eddy Aeloiza, Pietro Cairoli
Poster Session and Banquet  
Session Chairs: Dong Cao, North Dakota State University  
Victor Veliadis, PowerAmerica

- A Novel Characterization Technique to Extract High Voltage – High Current IV Characteristics of Power MOSFETs from Dynamic Measurements  
  Cristino Salcines, Aleksei Kruglov, Ingmar Kallfass

- Experimental Comparison of the Efficiency, Power Density and Thermal Performance of Two BIPV Converter Prototypes  
  Simon Ravyts, Mauricio Dalla Vecchia, Giel Van Den Broeck, Johan Driesen

- Lateral GaN JFET Devices on 200 mm Engineered Substrates for Power Switching Applications  
  Travis Anderson, Lunet Luna, Andrew Koehler, Marko Tadjer, Karl Hobart, Francis Kub, Ozgur Aktas, Vladimir Odnoblyudov, Cem Basceri

- Degradation Detection of Thermally Aged SiC and Si Power MOSFETs Using Spread Spectrum Time Domain Reflectometry (SSTDR)  
  Abu Hanif, Faisal Khan

- Power Cycling of Commercial SiC MOSFETs  
  Thomas Ziemann, Ulrike Grossner, Jürg Neuenschwander

- SiC MOSFET Based Modular Universal Power Electronics Regulators  
  Sheng Zheng, Madhu Sudhan Chinthavali, Zhiqiang Wang, Rong Zeng

- Loss Characterization and Analysis of High Voltage E-Mode GaN HEMT in Soft-Switching Application  
  Nikhil Korada, Ziwei Yu, Raja Ayyanar

- A Three-Level Boost Converter with an Extended Gain and Reduced Voltage Stress Using WBG Devices  
  Nour Elsayad, Hadi Moradisizkoohi, Osama Mohammed

- Thermally Triggered SiC MOSFET Aging Effect on Conducted EMI  
  Shi Pu, Enes Ugur, Fei Yang, Chi Xu, Bilal Akin

- Power Efficiency Improvement of Dual-Buck Inverter with SiC Diodes Using Coupled Inductors  
  Min-Kwon Yang, Yu-Jin Kim, Woo-Young Choi

- Asynchronous Microgrid Power Conditioning System Enabled by Series Connection of Gen-3 SiC 10 kV MOSFETs  
  Ashish Kumar, Sanket Parashar, Nithin Kolli, Subhashish Bhattacharya
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PowerAmerica’s mission is to save energy and create U.S. manufacturing jobs by accelerating the development and large-scale adoption of wide bandgap semiconductor technology made with silicon carbide and gallium nitride in power electronics systems. We fund projects that advance WBG technology and bring together many of the world’s leading wide bandgap semiconductor manufacturers and end users with experts from top research universities and government agencies. Our objective is to reduce the cost and perceived risk inherent with this new technology, while creating an educated workforce and enabling American industry to develop innovative power electronics products and systems. PowerAmerica is one of 14 federal Manufacturing USA institutes, and is backed by the U.S. Department of Energy.

InnoCit LLC is a technology transfer and product development company focused on advanced power electronic converters and technologies. InnoCit is capable of designing and prototyping various power electronic converters ranging from Watts to Mega-Watts using Si, SiC, and GaN switch technologies. InnoCit has low- and medium-voltage design capabilities. Also, reliability testing including thermal cycling, humidity testing, harsh environment testing, mechanical vibration, and surge voltage testing are among our standard testing capabilities. InnoCit LLC is a member of Missouri Energy Initiative and PowerAmerica and has had successful Phase I and II SBIRs from DOE and NSF. InnoCit LLC provides industrial design and prototyping services offering the transfer of all the rights and IPs.
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GanPower is a Vancouver, Canada based private company with a focus on developing Gallium Nitride (GaN) based technology in power electronics. GaNPow...
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Reedholm Systems offers a spectrum of test systems for reliability, device characterization, process control monitoring, die sort, and final test that help you ensure WBG devices work. With the addition of select probe stations, fixtures, thermal environments, and yield software, Reedholm provides customers with a single source integration option that satisfies power semiconductor test system requirements.

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Signatone has been providing manual and semi-automatic probing solutions to semiconductor and materials research community worldwide for 50 years. SignatonePowerPro/PowerPack product lines encompass ambient and hot/cold probing of SiC, GaN, and silicon power devices and modules in the power range of 20kV, 500A (pulsed) and thermal range of -60°C to 300°C. Please come visit our booth at WiPDA 2018 and discuss how we can assist you with your high power probing needs.
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Focused Test, Inc. (FTI) was founded in 2006, with the mission to apply a ‘focused technology’ approach to the design of engineering and production test systems for Power Discrete Devices, Power IC’s and Intelligent Power Modules. Our goal is to offer targeted test solutions that meet our customers’ needs for low-cost test equipment for targeted product segments including Wide Band Gap test applications such as GaN HEMT and SiC discrete devices. In this way, we provide the lowest acquisition price and highest throughput, along with an impressive array of test engineering tools.

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Dr. Donald A. Gajewski

Wolfspeed, A Cree Company

“SiC Power Device Reliability”

Speaker Biography

Dr. Donald A. Gajewski is the Manager of Reliability and Failure Analysis for Wolfspeed, a Cree Company, covering GaN-on-SiC HEMT-MMICs for RF and microwave applications, SiC power MOSFETs, SiC Schottky power diodes, and SiC power modules. He has been in the semiconductor industry reliability profession for 18 years, with previous tenures at Nitronex, Freescale and Motorola. He has experience with other semiconductor technologies including highly integrated silicon CMOS including SiGe HBT and SmartMOS; magnetoresistive random access memory (MRAM); and advanced packaging including flip-chip and redistributed chip package (RCP). He completed a National Research Council Postdoctoral Research Fellowship at the National Institute of Standards and Technology, in the Semiconductor Electronics Division, in Gaithersburg, MD. He earned the Ph.D. in physics from the University of California, San Diego, partially under the auspices of a National Science Foundation Fellowship.

Abstract:

SiC power devices offer performance advantages over competing Si-based power devices, due to the wide bandgap and other key materials properties of 4H-SiC. For example, SiC can more easily be used to fabricate MOSFETs with very high voltage ratings (up to 10 kV), and with lower switching losses. The reliability of SiC power devices is excellent and has continued to improve due to continuing advancements in SiC substrate quality, epitaxial growth capabilities, and device processing. This has enabled the continually accelerating growth of SiC power device commercial adoption. I will review the wear-out mechanisms and intrinsic reliability performance of power SiC devices as characterized by time-dependent dielectric breakdown (TDDB), accelerated life test high temperature reverse bias (ALT-HTRB), bias/temperature instability (BTI), terrestrial neutron exposure, and power cycling. I will review failure mechanisms that have been characterized and addressed through technological advances. I will show qualification data on a wide variety of product families, including discrete devices up to 50 A rated current. Finally, I will show field return data that demonstrates less than 5 FIT (fails per billion device hours) for commercially produced SiC MOSFETs and Schottky diodes, with over 2 trillion device field hours.
Wednesday, October 31, 2018, 10:00 AM

Mr. Qingyun Huang

University of Texas at Austin

“How to Design High Efficiency and High Density GaN Switching Power Supply”

Speaker Biography

Qingyun Huang received the B.Sc. degree in electrical engineering from Southwest Jiaotong University, Chengdu, China, in 2010, and the M.Sc degree in electrical engineering from Xi’an Jiaotong University, Xi’an, China, in 2013. From 2013 to 2017, he was a PhD research assistant student in FREEDM Systems center, Department of Electrical and Computer Engineering, North Carolina State University, Raleigh, NC. He is currently working toward the Ph.D. degree in Department of Electrical and Computer Engineering, The University of Texas at Austin, Austin, Texas. His current research interests include wide bandgap devices’ applications, isolated/non-isolated DC-DC converters, grid-tied inverters, bridge-less PFC rectifiers, multi-level converters, soft-switching power converters, and digital control applied to power electronics and system modeling of power converters.

Abstract:

GaN (Gallium Nitride) HEMTs (High Electron Mobility Transistors) have the capability of faster switching and lower on resistance comparing to Silicon FETs. In many cost and space sensitive applications, high power density power conversion can be achieved by GaN HEMTs. This tutorial presents how to design a high density and high efficiency all GaN HEMTs solution for 240VAC to 48Vdc 3.2kW power supply unit (PSU). The developed PSU consists of a 300kHz to 1.5MHz dual-phase interleaved GaN totem-pole power factor corrector (PFC) with triangular current mode (TCM) as the front-end stage. The DC/DC stage is a 500 kHz LLC resonant converter with 650V GaN HEMTs and 80V GaN HEMTs synchronous rectifiers. Zero voltage switching (ZVS) can be achieved for both PFC and LLC resonant converter which enables the increase of the PSU switching frequency as well as the power density. Maximum efficiency of 99% and 98.5% can be achieved by the PFC front-end and LLC resonant converter respectively. This 3.2kW PSU prototype demonstrated a power density of 60W/inch3. All the key design considerations such as the mixed signal controller design, the high speed current sensing, the ZVS control, the SR control, the thermal management, the magnetic component design and the power density optimization will be discussed in this tutorial.
Dr. Jin Wang
Ohio State University

“Developing High Power, Medium Voltage Silicon Carbide based Power Electronics”

Speaker Biography

Jin Wang received a B.S. degree from Xi’an Jiaotong University, in 1998, an M.S. degree from Wuhan University, in 2001, and a Ph.D. from Michigan State University, East Lansing, in 2005, all in electrical engineering. From Sept., 2005 to Aug. 2007, he worked at the Ford Motor Company as a Core Power Electronics Engineer. Currently, he is a Professor at The Ohio State University. His research interests include wide bandgap power devices and their applications, high-voltage and high-power converter/inverters, integration of renewable energy sources, and electrification of transportation. Dr. Wang received the IEEE Power Electronics Society Richard M. Bass Young Engineer Award and the National Science Foundation’s CAREER Award, both in 2011. Dr. Wang has over 150 peer-reviewed journal and conference publications and six patents. He initiated and served as the General Chair for the 1st IEEE Workshop on Wide Bandgap Power Devices and Applications in 2013.

Dr. Mark J. Scott
Miami University

Speaker Biography

Mark J. Scott received his B.S., M.S., and Ph.D. degrees in Electrical Engineering from The Ohio State University. His work experience includes developing and installing industrial automation hardware and performing validation testing of power electronics. Currently, he is an assistant professor at Miami University. Dr. Scott researches the design trade-offs associated with using silicon carbide (SiC) and gallium nitride (GaN) power devices in isolated DC/DC converters, single phase inverters, and three phase inverters. His investigations focus on conducted electromagnetic interference generated by GaN and SiC based hardware. Additionally, he explores conditional monitoring techniques for power conversion hardware based on EMI signatures.
Dr. Haiwei Cai  
*Southeast University, Nanjing, China*

**Speaker Biography**

Haiwei Cai received his B.S. degree from South China University of Technology, Guangzhou, China, in 2010, and Ph.D. degree from The Ohio State University, Columbus, OH, USA, in 2015, both in electrical engineering. In 2016, he joined ANSYS, Inc., Ann Arbor, MI, USA, as an Application Engineer. Since 2018, he has been with Southeast University, Nanjing, China, as an Associate Professor. His research interests include design, analysis and control of electric machines for a wide range of applications such as vehicle electrification, renewable energy conversion and robotics. Dr. Cai is a member of Electric Machine Committee of IEEE/IAS.

**Abstract:**

This tutorial presents design strategies for developing high power, medium voltage, power electronics using Silicon Carbide (SiC) devices. The introduction covers the development status of current SiC devices and their applications in modern electrical systems. Then, the tutorial explores obstacles designers face when implementing low voltage (<3.3 kV) SiC devices. This section includes issues with gate drive design, high dv/dt caused by reflective waves, and electromagnetic interference. Next, it demonstrates how Numerical Modeling Methods (NMM), such as Finite Element Methods, are applied to overcome these hurdles and validate design strategies prior to production. A 1.7 kV SiC based sub-module for a 1 MVA SiC modular multilevel converter (MMC) is used as case study for this portion of the talk. Afterwards, the tutorial presents challenges faced when designers utilize medium voltage (3.3 kV to 15 kV) SiC devices. It discusses topics on insulation requirements, auxiliary power supply designs, fast short circuit protection, and partial discharge related design considerations. The tutorial also describes the role NMM plays during this development process of medium voltage applications. Multiple examples of 3.3 kV, 4.5 kV and 10 kV based circuit building blocks are included as case study examples.
Dr. Victor Veliadis

*PowerAmerica/North Carolina State University*

**“Silicon Carbide Power Devices: Making the Transition from Silicon”**

**Speaker Biography**

Dr. Victor Veliadis is Deputy Executive Director and CTO of Power America, which is a U.S. Department of Energy wide bandgap power electronics public-private Manufacturing Institute. Dr. Veliadis manages a budget in excess of $30 million per year, which he strategically allocates to over 35 industrial, University, and National-Laboratory projects, to enable US leadership in WBG power electronics manufacturing, work force development, job creation, and energy savings. Dr. Veliadis has given over 60 invited presentations/keynotes/tutorials, and is an IEEE Fellow and an IEEE EDS Distinguished Lecturer. He has 25 issued US patents, 3 book chapters, and 115 peer-reviewed technical publications to his credit. Dr. Veliadis is also Professor in Electrical and Computer Engineering at North Carolina State University. He received the Ph.D. degree in Electrical and Computer Engineering from Johns Hopkins University in 1995. Prior to being named Deputy Executive Director and CTO of Power America in 2016, Dr. Veliadis spent 21 years in the semiconductor industry where his work included design, fabrication, and testing of SiC SITs, JFETs, MOSFETs, Thyristors, and JBS, Schottky, and PiN diodes in the 1-12 kV range.

**Abstract:**

Silicon power devices have dominated power electronics due to their low cost volume production, excellent starting material quality, ease of processing, and proven reliability. Although Si power devices continue to make significant progress, they are approaching their operational limits primarily due to their relatively low bandgap and critical electric field, which result in high conduction and switching losses, and poor high temperature performance. In this tutorial, the favorable material properties of Silicon Carbide, which allow for highly efficient power devices with reduced form factor and relaxed cooling requirements, will be highlighted. Device fabrication will be taught with an emphasis on the processes that do not carry over from the mature Si manufacturing world and are thus tailored to SiC. In particular, the tutorial will stress the design and fabrication of SiC MOSFETs that are presently being inserted in the majority of SiC based power electronic systems. Common SiC Edge Termination techniques, which allow SiC devices to exploit their full high-voltage potential, will be presented and their impact on device performance will be outlined. The efforts of the PowerAmerica manufacturing Institute to bridge gaps in wide bandgap power technology to enable manufacturing job creation and energy savings will be briefly discussed.
“Measurement and Analysis Method of Parasitic Capacitance and Inductance in Power Device and Power Electronic Circuit”

Speaker Biography

Ryo Takeda is a solution architect at Automotive and Energy Solutions of Keysight Technologies. After joining Hewlett-Packard in 1989, he worked as an application development engineer and manager for semiconductor parametric test instruments for more than 10 years. Since moving over into product planning, he has guided Agilent’s power device analyzer product definition and performed activities that include market research, business planning and product management. He is currently working on a project unifying power device measurement, power device modeling and power circuit simulation. He is a member of JEDEC WBG (Wide Band Gap) working group. He holds a BSEE and MSEE from Keio University (Japan) in the area of semiconductor device physics.

Abstract:

Parasitic of power semiconductor device and electronics circuit board is increasingly important because the operation of power electronics circuit is significantly influenced by associated parasitic of power semiconductor device, circuit schematic and layout. Switching waveform distortion, ringing, overshoot, unexpected surge current, etc. are primarily caused by interaction of fast current/voltage change and parasitic (i.e. stray inductance and capacitance) in the circuit. Employment of fast switching device like WBG device makes this issue even harder. Measurement of junction or stray capacitances, and stray inductance of power device is therefore very important for selecting appropriate device for a circuit and for accurate device model creation. Taking circuit board layout into analysis is another important element for accurate power circuit simulation especially for circuit with WBG devices.

We will discuss basic measurement method of parasitic capacitance and inductance on power semiconductor device and module through impedance measurement and s-parameter measurement. It also covers how to evaluate reverse transfer capacitance (Crss) with bias (i.e. on-state Crss). The electromagnetic analysis on board layout is also discussed with some example circuit simulation and analysis results. This tutorial session treats in-depth techniques and is intended for power circuit designers as well as power device engineers.
Wednesday, October 31, 2018, 3:30 PM

Dr. Fang Luo  
*University of Arkansas*

“Advanced Power Module Packaging: From Design to Validation”

**Speaker Biography**

Dr. Fang Luo is Assistant Professor in Electrical Engineering Department at the University of Arkansas, he is also affiliated with NSF ERC POETS (Center for Power Optimization of Electric-Thermal Systems). His research interests include high power-density converter design, high-density EMI filter design and integration, and power module packaging/integration for wide band-gap devices. He is the lead PI of the high voltage SiC module-packaging project supported by ARL. Prior to joining Arkansas, Dr. Luo was with the Center for High Performance Power Electronics (CHPPE) at The Ohio State University. He has initiated and has been leading power module packaging and integration research at the OSU. He is also the lead PI of “Turboelectric Propulsion System for Aircraft” research project at the Ohio State University. Dr. Luo is a senior member of IEEE. He holds two US patents and has authored/co-authored more than 20 journal papers and more than 50 peer-reviewed conference papers.

Dr. David Huitink  
*University of Arkansas*

**Speaker Biography**

Dr. David Huitink is an Assistant Professor in Mechanical Engineering Department at the University of Arkansas, he is also affiliated with NSF ERC POETS (Center for Power Optimization of Electric-Thermal Systems). David brings expertise on thermal and reliability analysis, with focuses on characterizing, modeling and predicting thermomechanical interactions in device and packaging. Dr. Huitink’s relevant experience in industry at Intel Corporation provides him with a unique perspective on the performance and reliability and thermal management of electronic devices, where he also was a project manager and lead scientist on topics ranging from heterogeneous device integration to materials development for advanced functionality for electronic packages.
Dr. Yarui Peng  
*University of Arkansas*

**Speaker Biography**

Dr. Yarui Peng is an Assistant Professor in Computer Science and Computer Engineering Department at the University of Arkansas, he is also affiliated with NSF POETS ERC. His research interests are in the areas of computer-aided design, analysis, and optimization for VLSI circuits and emerging technologies, including 2.5D and 3D ICs, high band-gap power electronics and systems, and high-efficiency digital designs and memory systems. He is working on improving electro-thermal reliability in power systems such as multi-chip power modules (MCPMs) by performing MCPM layout synthesis and simultaneously optimizing heat dissipation and electrical performance.

**Abstract:**

This three-section tutorial is offered to audiences with basic/intermedia knowledge background in power electronics packaging. The first part will introduce the latest development on a physical design automation tool at University of Arkansas namely PowerSynth. PowerSynth utilizes an optimization framework, including fast & accurate electrical and thermal models, to perform layout optimization. It enables module design evolution from experienced-based time to CAD automation era, and can potentially formalize the heterogeneous integration of technologies present in power packaging. The second part give a review on the state-of-the-art for SiC/GaN power module packaging including its structures, material systems, integration scheme and thermal management. This talk will include latest development of 3D integrated modules, and ultra-high-voltage (>10 kV) SiC Module at Arkansas. The last part will cover packaging reliability discussions regarding layout and material failure mechanisms from a thermal-mechanical-electrical coupled point of view. Specific attention will be given to extreme use conditions in electric vehicle operation, with an overview of acceleration models and a discussion of qualification methods appropriate to power packaging in EV systems. Participants in this tutorial will gain an overview of the history for power module packaging, as well as the most up-to-date development trend in WBG era.
Dr. Sriram Krishnamoorthy joined the Department of Electrical and Computer Engineering at the University of Utah in 2017. He received his bachelors degree in physics and electrical engineering from Birla Institute of Technology and Science, Pilani, India. He received his PhD degree from The Ohio State University, where he received the OSU presidential fellowship. His research interests include wide band gap materials epitaxy and devices (high electron mobility transistors, ultra violet and visible light emitting diodes), power electronics and high temperature electronics. He has published 48 journal publications and over 100 conference papers, including 8 journal papers (first report of delta doping in Gallium Oxide, High current density MOSFETs) in the emerging area of ultra-wide band gap Gallium Oxide devices and materials.

Abstract:
Wide band gap materials and power devices with superior figures of merit compared to silicon have been widely researched in the last few decades. More recently, a class of ultra-wide band gap materials (UWBG) with band gaps larger than GaN and SiC has attracted attention owing to the large predicted Baliga Figure of Merit. In principle, such UWBG devices are expected to exhibit superior unipolar figure of merit. Beta- Gallium Oxide is an emerging UWBG material with the availability of high quality native substrates grown using potentially inexpensive melt-based techniques. Within the last few years, tremendous progress has been achieved in epitaxy, selective area doping (ion implantation) and lateral/vertical device demonstrations. In this tutorial, the material properties of Gallium oxide relevant to power devices will be presented. A survey of material synthesis/processing, gate dielectrics and power device demonstrations (Power MOSFETs, SBDs, MODFETs) will be presented and benchmarked against existing WBG technology. In addition to Gallium Oxide, high Al content AlGaN and Aluminum Nitride-based device reports will also be reviewed and presented. This tutorial is intended for a basic/intermediate audience with expertise in devices or power electronic circuits and systems.
SPEAKER INFORMATION
It is mandatory that each technical speaker meet with the session chair in the designated room during the Session Setup Period to transfer the presentation files to the computer. The session setup periods occur before the morning technical session and again before the afternoon technical session. Please consult the schedule.

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