2017 WiPDA

Albuquerque, NM | October 30 – November 1

5th Annual IEEE Workshop on Wide Bandgap Power Devices & Applications

Hyatt Regency Tamaya Resort, Albuquerque, New Mexico, USA

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WELCOME FROM THE GENERAL CHAIR

Dear Colleagues,

The IEEE workshop on Wide-bandgap Power Devices and Applications (WiPDA) is a relatively new workshop venue, but it has demonstrated real value to the wide-bandgap power electronics community and is already growing very quickly. I have had the pleasure of attending this valuable workshop each of its previous four years, and I am happy to join you in the American Southwest for the 5th installment of WiPDA.

This year, we are proud to host this workshop on the Santa Ana Pueblo, just North of Albuquerque, NM. Nestled in the heart of New Mexico along both the Camino Real and Route 66, Albuquerque is one of the most unique cities in our country, standing as a synthesis of modern urbanity, bygone eras, and the wild west. Historic Santa Fe, NM, the second-oldest city in the United States (established in 1607) is only an hour's drive north. While Albuquerque was founded in 1706 by Spanish colonists, settlements throughout New Mexico thrived for centuries before that, resulting in a rich heritage and archaeological landscape throughout the state. There are currently 23 Native American Tribes in New Mexico: Nineteen pueblos, one of which, the Santa Ana Pueblo, houses the Hyatt Regency Tamaya Resort and Spa; the Navajo Nation, which spans three states; and three Apache tribes.

New Mexico also carries with it a legacy of technological innovation dating back to the 1940s. New Mexico is home to two national laboratories, Sandia National Laboratories and Los Alamos National Laboratory. Also, in Albuquerque, the University of New Mexico boasts a student body of over 25,000 students. Finally, New Mexico's largest manufacturer is Intel, which has had a presence in New Mexico for 37 years.

This year's workshop covers the full span of topics important for wide-bandgap power electronics. The heart of the workshop is the technical program, which as in past years is focused on both wide-bandgap power devices as well as applications of those devices. One of the primary themes of this workshop is to promote communication and collaboration 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 has been arranged with great care and thought regarding maximizing the experience for every attendee. A poster session held in conjunction with our banquet, on the grounds of the Tamaya resort, provides another opportunity for attendees to view high-quality work in the area of wide-bandgap power electronics. Further, in addition to the contributed papers, eight keynote talks given by recognized experts in the field, covering both devices and applications, complement the technical program.

WELCOME FROM THE GENERAL CHAIR

This year also features an expanded tutorial program consisting of seven talks, again covering both devices and applications, as well as SiC and GaN technologies. This year's schedule allowed these talks to be arranged in a sequential order, rather than in parallel, so that tutorial attendees may attend all of the sessions. Additionally, this year's workshop will feature two discussion panels, one devoted to SiC and the other to GaN. Like the keynotes and tutorials, 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. Also, WiPDA again features an exciting line-up of exhibitors.

I would like to express my sincere thanks to our technical and financial sponsors, IEEE and PSMA, for their support of this workshop, as well as to my own institution, Sandia National Laboratories, for hosting WiPDA this year. Thanks also go to all of our corporate patrons, whose support is an integral element of the workshop's success. I also thank the entire organizing committee, as well as our keynote and invited speakers and panelists, without whose steadfast dedication and hard work the workshop would not be possible. Thanks of course also go to the many authors who submitted abstracts, and to all of you attending this workshop, who have made WiPDA a centerpiece of the vibrant and dynamic field of wide-bandgap power electronics.

Bob Kaplar
General Chair, 2017 WiPDA

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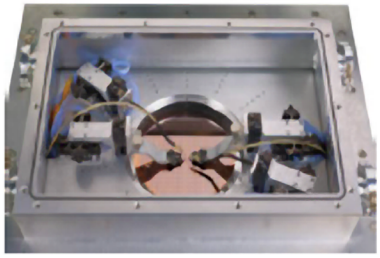
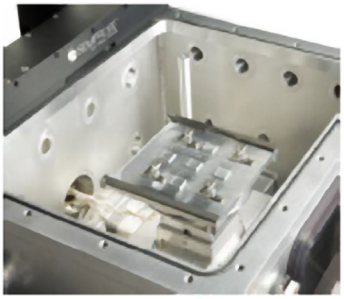


The probe system platen accommodates individual manipulators as well as probe cards. Up to 8 motorized/programmable manipulators can be placed inside the chamber and operated remotely.



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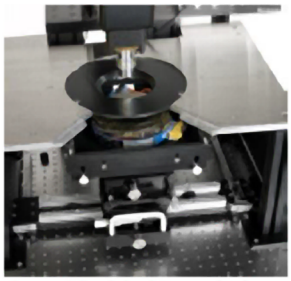
SemiProbe's Volterus™ family of probe systems addresses the unique challenges of testing high power devices at wafer level prior to packaging. Available in manual, semi and fully automatic configurations, Volterus can test and characterize power devices up to 10 kV or 100 A (pulsed). Based on the PS4L Adaptive Architecture, Volterus can test individual die or wafers from 100 mm to 300 mm using manipulators or probe cards and at temperatures from -65° C to 300° C in a fully guarded and shielded environment.



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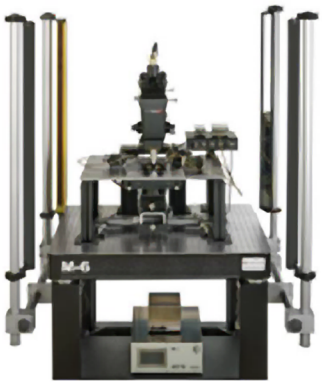


SemiProbe offers a variety of both manual and semiautomatic configurations packaged in either a light curtain or dark box configuration to insure operator safety

SCHEDULE AT A GLANCE: SUNDAY

October 29, 2017

Start	End	Agenda Item
2:00 PM	5:30 PM	ITRW Meeting

IEEE POWER ELECTRONICS SOCIETY
Powering a Sustainable Future

ITRW
International Technology Roadmap on Wide Bandgap Semiconductors

MISSION

The **I**nternational **T**echnology **R**oadmap for **W**ide 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.

Event Location Key:

Tamaya Ballroom	Wolf	Hawk	Badger	Offsite or Location Listed

SCHEDULE AT A GLANCE: MONDAY

October 30, 2017

Start	End	Agenda Item
9:00 AM	10:00 AM	Tutorial "SiC Power Devices: Physics, Current Status, and Future Trends" JAMES COOPER, *Purdue University*
10:00 AM	11:00 AM	Tutorial "HV SiC Devices Enabled MV Power Converters applications and Circuit Topologies – Opportunities and Challenges" SUBHASHISH BHATTACHARYA, *North Carolina State University*
11:00 AM	12:00 PM	Tutorial "200 kW, 1050 V_{DC} SiC Dual Inverter for Heavy-Duty Vehicles" BRIJ SINGH, *John Deere*
12:00 PM	2:00 PM	Lunch The Feast Buffet at Santa Ana Casino Transportation to be provided
2:00 PM	3:00 PM	Tutorial "Pursuing the Performance Entitlement of Wide Band-Gap Semiconductors: Opportunities and Challenges" ANDREW LEMMON, *University of Alabama*
3:00 PM	4:00 PM	Tutorial "GaN Reliability for Power Devices and Applications" SANDEEP BAHL, *Texas Instruments*
4:00 PM	5:00 PM	Tutorial "GaN-Based High-Efficiency High-Density Power Converters for Future Data Center" QIANG LI, *Virginia Tech*
5:00 PM	6:00 PM	Tutorial "The Pros and Cons of Using GaN HEMTs in PFC Circuit Applications" ERIC PERSSON, *Infineon Technologies*
6:00 PM	7:30 PM	Vendor Exhibits and Social Reception

Event Location Key:

Tamaya Ballroom	Wolf	Hawk	Badger	Offsite or Location Listed

SCHEDULE AT A GLANCE: TUESDAY

October 31, 2017

Start	End	Agenda Item
8:00 AM	8:15 AM	Welcome Address Bob Kaplar, Sandia National Laboratories
8:15 AM	8:45 AM	Keynote "Current and Future Directions in Power Electronic Devices and Circuits based on Wide Bandgap Semiconductors" ISIK KIZILYALLI, *Department of Energy ARPA-E*
8:45 AM	9:15 AM	Keynote "Electrical and Thermal Considerations for Wide Bandgap Power Electronics" ANDREW ALLEYNE, *University of Illinois, Urbana-Champaign*
9:15 AM	9:40 AM	Break Coffee, Tea, and Refreshments provided by Wolfspeed
9:45 AM	10:30 AM	Panel Session "High Voltage SiC Technology: Present Status and Challenges" MIKE MCMILLAN, *Global Power Technology* BOB STAHLBUSH, *NRL* DAVE GRIDER, *Wolfspeed* LAUREN BOTELER, *ARL* JIN WANG, *The Ohio State University*
10:30 AM	11:15 AM	Panel Session "Commercialization of GaN Devices in High-Frequency Power Electronic Applications" ALEX HUANG, *The University of Texas at Austin* YUANZHE ZHANG, *EPC* NICK FICHTENBAUM, *Navitas Semiconductor* LARRY SPAZZIANI, *GaN Systems*
11:15 AM	1:15 PM	Lunch Buffet provided by Wolfspeed

Event Location Key:

Tamaya Ballroom	Wolf	Hawk	Badger	Offsite or Location Listed

SCHEDULE AT A GLANCE: TUESDAY

October 31, 2017

Start	End	Agenda Item		
1:15 PM	1:45 PM	Keynote "600V GaN Power Devices: The Long Journey to Market Success" ALAIN CHARLES, *Infineon Technologies*		
1:45 PM	2:15 PM	Keynote "Electrification and Electronification Goes Wide" STEPHANIE BUTLER, *Texas Instruments*		
2:15 PM	2:45 PM	Keynote "Enabling the Development of Power Electronics Applications through Advancements in SiC Power Devices" RONALD GREEN, *U.S. Army Research Laboratory*		
2:45 PM	3:15 PM	Break/Session Setup Period Coffee, Tea, and Refreshments provided by Wolfspeed		
3:15 PM	5:20 PM	Technical Session 1		
		SiC Inverters/ Converters	GaN Technology, Device Optimization, and Reliability	Design and Optimization
6:00 PM	9:00 PM	Conference Banquet and Poster Session The Cottonwoods Pavilion Transportation provided		

Event Location Key:

Tamaya Ballroom	Wolf	Hawk	Badger	Offsite or Location Listed

SCHEDULE AT A GLANCE: WEDNESDAY

November 1, 2017

Start	End	Agenda Item		
8:00 AM	8:30 AM	Keynote "Addressing Gaps in Technology to Enable Large-Volume WBG Manufacturing" VICTOR VELIADIS, *PowerAmerica*		
8:30 AM	9:00 AM	Keynote "GaN Power ICs: Device Integration Delivers Application Performance" NICK FICHTENBAUM, *Navitas Semiconductor*		
9:00 AM	9:30 AM	Keynote "SiC-based Automotive Power Converters, Opportunities and Challenges" CHINGCHI CHEN, *Ford Motor Co.*		
9:30 AM	10:00 AM	Break/Session Setup Period Coffee, Tea, and Refreshments provided by SemiProbe		
10:00 AM	11:40 AM	Technical Session 2		
		GaN Inverters/ Converters	SiC Device/Process Optimization	GaN Characterization
11:40 AM	1:00 PM	Lunch Santa Ana Casino Transportation to be provided (12:30 PM – 1:00 PM: Session Setup Period)		
1:00 PM	2:40 PM	Technical Session 3		
		Gate Drivers/ Overcurrent Protection	SiC Characterization	Wide Bandgap Packaging and Assembly
2:40 PM	3:00 PM	Break/Session Setup Period Coffee, Tea, and Refreshments provided by SemiProbe		

Event Location Key:

Tamaya Ballroom	Wolf	Hawk	Badger	Offsite or Location Listed

SCHEDULE AT A GLANCE: WEDNESDAY

November 1, 2017

3:00 PM	4:40 PM	Technical Session 4		
		RF / Wireless Power	SiC Reliability	Wide Bandgap Circuit / Assembly Interaction
4:40 PM	5:00 PM	Wrap-up Session BOB KAPLAR, *Sandia National Laboratories*		

Event Location Key:

Tamaya Ballroom	**Wolf**	**Hawk**	**Badger**	Offsite or Location Listed

Dr. Isik C. Kizilyalli

Advanced Research Projects Agency – Energy (ARPA-E)

"Current and Future Directions in Power Electronic Devices and Circuits based on Wide Band-Gap Semiconductors"

Tuesday, October 31, 2017, 8:15 AM

Speaker Biography:

Dr. Isik C. Kizilyalli currently serves as a Program Director at the Advanced Research Projects Agency–Energy (ARPA-E), Department of Energy. Kizilyalli's focus at ARPA-E includes high efficiency power conversion, power electronics, grid reliability, reliable semiconductors for extreme environments, instrumentation for intrinsically safe nuclear energy, and enhanced geothermal systems. Prior to joining ARPA-E, Kizilyalli served as founder, Chief Executive Officer, and Chief Technical Officer of Avogy Inc., a venture backed start-up focused on GaN power electronics, energy efficiency, and power systems. Previously, he was with Bell Laboratories, followed by Nitronex Corporation, and solar PV startup Alta Devices where his team holds the world record for single junction solar cell conversion efficiency Kizilyalli was elected a Fellow of the Institute of Electrical and Electronics Engineers (IEEE) in 2007 for his contributions to Integrated Circuit Technology. He also received the Bell Laboratories' Distinguished Member of Technical Staff award and the Best Paper Award at the International Symposium on Power Semiconductors and Integrated Circuits in 2013. Kizilyalli holds his B.S. in Electrical Engineering, M.S. in Metallurgy, and Ph.D. in Electrical Engineering from the University of Illinois Urbana-Champaign. He has published more than 100 papers and holds 119 U.S. patents.

Abstract:
Electricity generation currently accounts for 40% of primary energy consumption in the U.S., and over the next 25 years is projected to increase more than 50% worldwide. Electricity continues to be the fastest growing form of end-use energy. Power electronics are responsible for controlling and converting electrical power to provide optimal conditions for transmission, distribution, and load-side consumption. Estimates suggest that the fraction of electricity processed through power electronics could be as high as 80% in the US by 2030 (including generation and consumption), approximately a twofold increase over the current proportion. The U.S. Department of Energy's Advanced Research Project Agency for Energy (ARPA-E) was established in 2009 to fund creative, out-of-the-box, transformational energy technologies that are too early for private-sector investment, at make-or break points in their technology development cycle. ARPA-E's investment portfolio aims to generate options to address specific energy challenges that could provide dramatic benefits for the nation. Development of advanced power electronics with unprecedented functionality, efficiency, reliability, and reduced form factor will provide the U.S. a critical technological advantage in an increasingly electrified world economy. Fast switching power semiconductor devices are the key to increasing the efficiency and reducing the size of power electronic systems. Recent advances in wide-band gap semiconductor materials, such as silicon carbide (SiC) and gallium nitride (GaN) are enabling a new generation of power semiconductor devices that far exceed the performance of silicon-based devices. Past ARPA-E programs (ADEPT, Solar ADEPT, SWITCHES) have focused on challenges associated with fabricating WBG high-performance switching devices. Program developments led to a new generation of devices that operate at much higher powers, voltages, frequencies, and temperatures than traditional silicon-based semiconductor devices. Two most recent programs recently launched by ARPA-E in the area of power electronics are CIRCUITS and PNDIODES. The projects that comprise ARPA-E's CIRCUITS (Creating Innovative and Reliable Circuits Using Inventive Topologies and Semiconductors) program seek to accelerate the development and deployment of a new class of efficient, lightweight, and reliable power converters, based on wide-bandgap (WBG) semiconductors. CIRCUITS projects build on the earlier ARPA-E programs by designing circuit topologies and building blocks optimally suited for WBG attributes to maximize overall electrical system performance and reliability. In addition, a reduced form factor (size and weight) will drive adoption of higher performance and more efficient power converters relative to today's state-of-the-art systems. Innovations stemming from CIRCUITS projects have the potential to affect high-impact applications wherever electrical power is generated or used, including the electric grid, industrial motor controllers, automotive electrification, heating, ventilation, air conditioning, solar and wind power systems, datacenters, aerospace control surfaces, wireless power transfer, and consumer electronics. PNDIODES (Power Nitride Doping Innovation Offers Devices Enabling SWITCHES) funds transformational advances and mechanistic understanding in the process of selective area doping in the III-Nitride wide band gap (WBG) semiconductor material system and the demonstration of arbitrarily placed, reliable, contactable, and generally useable p-n junction regions that enable high-performance and reliable vertical power electronic semiconductor devices. The microscopic mechanistic understanding and transformational technologies will address the major obstacle in the fabrication of vertical GaN power electronic devices.

Dr. Andrew Alleyne

University of Illinois, Urbana-Champaign

"Electrical and Thermal Considerations for Wide Bandgap Power Electronics"

Tuesday, October 31, 2017, 8:45 AM

Speaker Biography:

Professor Alleyne received his B.S. in Engineering Degree from Princeton University in 1989 in Mechanical and Aerospace Engineering. He received his M.S. and Ph.D. degrees in Mechanical Engineering in 1992 and 1994, respectively, from The University of California at Berkeley. He joined the Mechanical Science and Engineering Department at the University of Illinois, Urbana-Champaign in 1994 and is also appointed in Electrical and Computer Engineering and the Coordinated Science Laboratory of UIUC. He currently holds the Ralph M. and Catherine V. Fisher Professorship in the College of Engineering and is the Director for the NSF Engineering Research Center on Power Optimization for Electro-Thermal Systems (POETS). His academic record includes supervision of over 80 M.S. and Ph.D. students and approximately 400 conference and journal publications. He is the recipient of a CAREER award by the National Science Foundation, has been a Distinguished Lecturer of the Institute for Electronic and Electrical Engineers (IEEE), and a National Research Council (NRC) Associate. He is a Fellow of the American Society of Mechanical Engineers (ASME) and has received the Gustus Larson Award, the Charles Stark Draper Award for Innovative Practice, and the Henry Paynter Outstanding Investigator Award. He was a Fulbright Fellow to the Netherlands and has held visiting Professorships at TU Delft, University of Colorado, ETH Zurich, and Johannes Kepler University. He has held several editorial positions for ASME, IEEE, and the International Federation of Automatic Control. He recently chaired the ASME Dynamic Systems and Controls Division, is a member of the IEEE Controls Systems Society Board of Governors, and has been active in several external advisory boards for universities, industry and government including the Scientific Advisory Board for the U.S. Air Force. His record of campus service includes the Associate Dean for Research in the College of Engineering and the Associate Head for Undergraduate Programs in Mechanical Science and Engineering. In addition to research and service, he has a keen interest in education and has earned the College of Engineering's Teaching Excellence Award, the UIUC Campus Award for Excellence in Undergraduate Education and the UIUC Campus Award for Excellence in Graduate Student Mentoring. Further information may be found at http://arg.mechse.illinois.edu or http://mechanical.illinois.edu/directory/faculty/alleyne .

Abstract:
Modern electronic systems for mobile applications have seen steadily increasing demands for power density. A key barrier to higher power density is the thermal limits for current semiconductor devices. Wide bandgap devices promise higher operating temperatures and greater efficiencies. However, these promises can be achieved only by optimal integration of the power electronic design considerations with the thermal management and materials considerations. Optimization in the design phase should be matched by optimization in the operation of these systems as well. This talk will give an overview of several such activities underway within the National Science Foundation Engineering Research Center on Power Optimization of Electro-Thermal Systems (POETS) that seek to integrate the management of power and energy flow in both the electrical and thermal domains. The topics will cover design and integration from the component and module level up to the overall system level. POETS is a multi-disciplinary center, founded in 2015, that seeks to bring together multiple technical fields with the primary goal of increasing power density.

Dr. Alain Charles

Infineon Technologies

"600V GaN Power Devices: The Long Journey to Market Success"

Tuesday, October 31, 2017, 1:15 PM

Speaker Biography:

Dr. Charles is a 30 years semiconductor industry veteran. He received his Ph.D in 1989 from the Institut National des Sciences Appliquées de Touluse (France). His international career went from driving Optical lithography efforts at Motorola Mesa(Az) and later STM factories in the US (Carrollton, TX) to pioneering 300mm Silicon manufacturing in Dresden, (Germany) Motorola-Siemens Joint venture, to manage Fab5 and Fab3 engineering teams at Silicon Foundry Chartered Semiconductor in Singapore, to heading silicon power device technology development team at International Rectifier for 12 years, based in Newport (Wales, UK). After Infineon acquisition of International Rectifier, he became in charge of the GaN technology development initiative within the company, based out of El Segundo in California.

Abstract:
It has been now 25 years that the proof of a two dimensional electron gas at the AlGaN/GaN interface was disclosed. Over the years, claims of superior performance of AlGaN/GaN based HEMT power devices vs. silicon incumbent, have created excitement. Yet the market success of 600V GaN based power devices has been slow to materialize and market forecaster had sadly to revise their numbers down year after year.
Besides the fact that competition for GaN 600V got stronger due to the impressive improvements of Superjunctions, like CoolMOSTM, and the advent of SiC power MOSFETs, the main delays in adopting GaN HEMT power devices were primarily instigated by HEMT devices not meeting the market expectations in terms of overall performance gain at the system level but also and mainly because of reliability. In this keynote we will go through the different key attributes that are the must have for GaN to become successful in the market and show that Infineon's CoolGaNTM meets all requirements for market success.
All starts with the device type choice (Cascoded HEMT, MIS-HEMT, p-GaN HEMT, GIT, HD-GIT) and the optimization of that device. The figure of merit (threshold voltage, on resistance, capacitances, saturation current), the stability of these under stress (current collapse, Rdson shift), the gate drive scheme and its constraints or limitations, are all factors to consider carefully. The presentation will show why the choice of HD-GIT was made for our 600V CoolGaNTM device, as well as some of the work done to ensure optimum device performance. We will show that the HD-GIT device basically allows eliminating Rdson shift. The gate drive of our Ohmic p-GaN gate GIT might be complex due to the Dc current drive and negative gate voltage requirements, but that is offset by the reliability it provides as the Schottky breakdown voltage limitation is avoided and no clamp circuitry, which induces more drive loss, is required. We will also show that the gate drive power vs. frequency is very comparable to Schottky gate device requiring complex clamp circuitry.
Having a good and stable device is a necessary condition but it is not sufficient for success. Evidently, reliability is paramount to GaN adoption. Most commercially available GaN devices have been released based on "JEDEC" Silicon device qualification standards. This is clearly insufficient to ensure the device will meet a targeted lifetime in customer application and at a customer tolerable failure rate. The paper will describe the methodology employed by Infineon so as to allow prediction of useful life in customer application with target cumulative failure. Example will be shown through a comparison of High Temperature Reverse Bias (HTRB) result between our former normally on Cascoded device and our current e-mode HD-GIT pointing to the strength of the latest.
Once the device performance and reliability are achieved, the value proposition will come from the potential advantage in the application, meaning either better efficiency, or higher power density or overall lower bill of material cost, or any combination of these three attributes, as the higher component cost of the GaN device must be offset. In this keynote we will show some applications results using our 600V CoolGaNTM device. It is clear here that the next stage is to push the potential advantage that GaN can bring when using resonant topologies at high frequencies due to low gate charge and low and linear Qoss. We will show that our 600V CoolGaNTM HD-GIT properties provide great flexibility to route high current and as such has great capabilities at high frequencies even without integrating the gate drive and switch monolithicaly thus leaving ability to tune gate drive circuit for EMI.
Through these past year learnings, tremendous rate of progress of GaN based 600V power devices has been achieved and our 600V CoolGaNTM platform provides a very credible solution for market success.

Dr. Stephanie Butler

Texas Instruments

"Electrifications and Electronification Goes Wide"

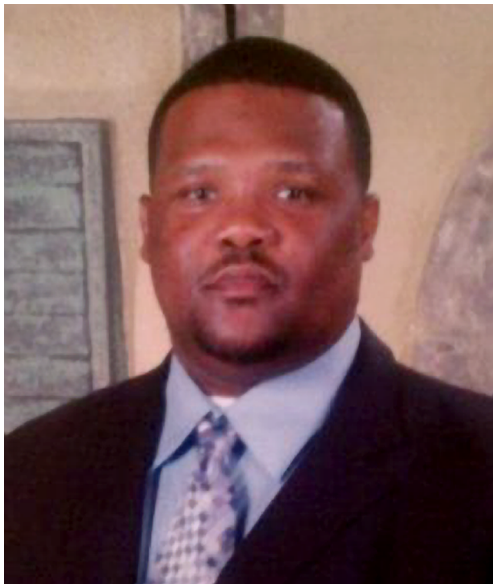
Tuesday, October 31, 2017, 1:45 PM

Speaker Biography:

Stephanie Watts Butler, Ph.D., P.E., is the Technology Innovation Architect in High Voltage Power at Texas Instruments (TI), driving new high voltage and isolation technology innovations from concept to revenue by leading partnerships with TI's technology organizations, manufacturing sites, universities, and product development teams. She has produced innovations in the areas of control, process and package development, R&D management, and new product development. The result is power semiconductors that enable TI's customers to make smaller, lighter, and more energy efficient products. Dr. Butler has authored more than 40 papers and 16 U.S. patents. She is the Co-Chair of GaNSPEC and a Fellow of the AVS. SWE honored Dr. Butler with their 2016 Lifetime Achievement Award. Business Insider named Dr. Butler to their most powerful female engineers list of 2017. Dr. Butler also serves on the TxGCP Champion Board and UT Austin Department of Chemical Engineering Advisory Council.

Abstract:
Renewable energy is an obvious driver for electrification, and the associated electronification, of the energy grid. In Oct 2016, the International Energy Agency said in the previous year, renewable sources represented more than half of the new power capacity added around the world. However this phenomenal growth in renewable energy is only one of the factors driving the electrification and electronification of energy generation, transmission, distribution, and consumption. Similarly, electrification alone is not the sole driver of electronification, not even of the energy grid. As sensors and intelligence spread into a wide array of applications, from the energy grid to factories to cars to washing machines, so do power electronics applications increase. Wide bandgap power semiconductors provide an impressive boost in performance, efficiency, and power density. This talk will examine how the growth in electrification and electronification is driving and is being driven by wide bandgap semiconductors

Dr. Ronald Green



U.S. Army Research Laboratory

"Enabling the Development of Power Electronics Applications through Advancements in SiC Power Devices"

Tuesday, October 31, 2017, 2:15 PM

Speaker Biography:

Dr. Ronald Green is an electronics engineer at the U.S. Army Research Laboratory (ARL), Sensors and Electron Devices Directorate (SEDD). Ron's research focus includes reliability physics of wide bandgap (WBG) semiconductors, experimental validation and analyses of silicon carbide (SiC) and gallium nitride (GaN) power devices, characterization and testing of WBG power modules, and development of reliability test methods for standardization of WBG semiconductors for power conversion applications. Prior to joining ARL, Ron worked with Motorola Corporation in Phoenix, Arizona as a manufacturing engineer, and then later as a process engineer for ON Semiconductor. At ON, Ron made significant contributions to the successful startup of a 150 mm silicon rectifier fab in Guadalajara, Mexico, and the successful technology transfer of key processes into ON's factory in Roznov, Czech Republic. In 2010, Ron was awarded the Department of the Army's Research and Development Achievement Award for Technical Excellence in the successful development, testing, and demonstration of an all-SiC MOSFET power converter. Ron holds his B.S. in Electrical Engineering, and D.E. in Electrical Engineering from Morgan State University. Ron also serves on the Advisory Board in the Department of Electrical and Computer Engineering at Morgan State. He has published a number of journal and conference papers and his research interests are power semiconductor device testing and modeling, device reliability physics, and the development of suitable testing methods for standardization of WBG power components designed for military, space, and industrial applications.

Abstract:
The U.S. Army Research Laboratory (ARL) has had an active interest in the development of silicon carbide (SiC) power devices since its inception in 1992, and has been at the forefront in the development of this wide bandgap technology since the early 2000s. Led by Mr. Skip Scozzie, ARL became a key supporter in the successful development of SiC power MOSFETs, which were first commercialized in 2011. ARL has also supported the successful development of high-voltage SGTOs and PiN diodes for pulse power applications. This support has included a joint ManTech with the Navy and OSD, which led to the successful development of low-defect, high-quality six-inch SiC wafers, along with significant improvements in SiC power device performance and reliability at both the 650-V to 1,200-V range, as well as at high voltages above 10 kV—for both continuous and pulse-power applications. Although ARL's support initially was focused on Cree as the low-risk path to prove out SiC power device technology, in more recent years ARL's support has broadened to include other, smaller device companies as well in an attempt to widen the U.S. SiC industrial technology base. Most of these smaller companies employ a fabless model, wherein the actual device manufacturing is done at automotive-quality silicon (Si) fabs with excess capacity, such as X-Fab in Lubbock, TX, giving the hope of dramatically reducing manufacturing costs, thereby leading to dramatic decreases in the average cost per ampere of these power devices. These device developmental programs with ARL's key industrial partners have resulted not only in widening the SiC technology base, but also in significantly improved performance, along with the successful scaling of devices to higher voltages and currents to meet the power-density requirements for existing and future Army power systems. This paper will provide an update of advances in the development of various SiC power devices, such as MOSFETs, diodes, IGBTs, and SGTOs, with blocking voltage ratings from 650 V to over 20 kV, and discuss their utility for relevant Army applications.

Dr. Victor Veliadis

Power America

"Addressing Gaps in Technology to Enable Large-Volume WBG Manufacturing"

Wednesday, November 1, 2017, 8:00 AM

Speaker Biography:

Victor Veliadis received the Ph.D. degree in Electrical and Computer Engineering from Johns Hopkins University in 1995. From 1996 to 2000, he was with start-up Nanocrystals Imaging Corporation where he developed quantum-dot phosphors for imaging applications. From 2000 to 2003, he was with Lucent Technologies where he designed InP-based tunable photonic integrated circuits for telecommunication applications. In 2003, Victor was Adjunct Physics Professor at Ursinus College and St. Joseph's University. After a brief military service, Victor joined Northrop Grumman Electronic Systems in 2004 where he designed, fabricated, and tested SiC SITs, JFETs, MOSFETs, Thyristors, and JBS, Schottky, and PiN diodes in the 1-12 kV range. In 2016 Victor was appointed CTO and in 2017 Deputy-Director/CTO of Power America, which is a U.S Department of Energy wide bandgap device Manufacturing Institute managed by NCSU. In 2016, Victor also became Professor in Electrical and Computer Engineering at NCSU. Victor has given over 60 invited presentations/keynotes/tutorials, authored/co-authored 108 peer-reviewed technical articles, authored 3 book chapters, and has 24 issued patents to his credit. He is a Senior Member of IEEE, an IEEE EDS Distinguished Lecturer, and has served in the ECSCRM, ICSCRM, WiPDA, and ISPSD organizing committees

Abstract:
The U.S Department of Energy launched the PowerAmerica (PA) Institute under the initiative of "National Network of Manufacturing Institutes" to accelerate commercialization of SiC and GaN wide bandgap (WBG) power devices. PowerAmerica started operations in 2015 with $140M funds over 5 years, and is managed by North Carolina State University in Raleigh, NC. PowerAmerica addresses gaps in technology to enable manufacturing that contributes to its mission of realizing manufacturing jobs creation and energy savings through accelerated large-scale adoption of WBG semiconductor devices in power electronic systems.
To achieve its goals, PowerAmerica funds strategic projects and brings together a range of companies – from startups to major corporations – as well as national labs and universities that work on every facet of the supply chain, from research and development to manufacturing and commercialization. Through membership in the PowerAmerica institute, industry members grow their business by accelerated wide bandgap product introduction to market, and University members gain by engaging in collaborative projects with industry.
Projects in the 2016-2017 funding period covered low cost WBG device fabrication, reliability, and a range of promising power electronics applications including a faster circuit breaker, a fast charger, electric vehicle traction drives, photovoltaic inverters, more efficient data centers, and heavy-duty vehicle electrification.
PowerAmerica's largest project to date has focused on lowering the barrier to market entry for fabless SiC device companies, thereby contributing to building a stronger overall manufacturing ecosystem for this technology. The PA Institute partnered with Texas-based X-Fab to form the world's first "open foundry" capable of supporting 6-inch SiC wafers. By leveraging mature Si fabrication practices and qualifying SiC specific processes, XFAB has enabled high-yield volume manufacturing at the economy scale of silicon. This capability enables fabless semiconductor companies to economically fabricate silicon carbide devices and compete in new ways. The conversion of an existing silicon factory into one capable of additionally fabricating SiC has produced significant benefits for the SiC ecosystem. In addition to facilitating volume manufacturing, PA is accelerating WBG adoption by training the workforce through short course offerings and tutorials, and by preparing the next generation of high-skilled WBG technologists through hands-on projects at leading US Universities.
The presentation will outline models for low cost SiC manufacturing in the US, and describe select projects that exemplify the performance advantages of SiC and GaN based power electronic systems.

Dr. Nick Fichtenbaum

Navitas Semiconductor

"GaN Power ICs: Device Integration Delivers Application Performance"

Wednesday, November 1, 2017, 8:30 AM

Speaker Biography:

Nick Fichtenbaum is a Co-Founder and VP of Engineering at Navitas Semiconductor and brings with him over 10 years of experience developing GaN materials and devices. Prior to Navitas, Nick was a VP at the private investment firm Malibu IQ, which led to the creation of Navitas. As an early employee of Transphorm, Nick served as both a member of the technical staff and Manager of Material Engineering, where he developed the GaN-on-Si epi technology. Nick has 40 peer-reviewed published articles based upon his GaN research, and has been awarded 20 patents related to GaN power electronics. He holds a BA in Physics from Denison University, a BS in Electrical Engineering from Washington University in St. Louis, and a PhD in Electrical Engineering from the University of California, Santa Barbara, USA.

Abstract:

Early GaN implementations (e.g. cascoded dMode or discrete eMode) need complex, expensive control and protection circuits, which restrict device performance and so limit application advances and market adoption. The AllGaN™ process design kit (PDK) is a new, application-focused approach to deliver easy-to-use, high-speed, "digital-in, power-out" 650 V GaN Power ICs. The monolithic integration of logic, drive and powertrain to drive speed and efficiency in power conversion means that designers can achieve 3x power density increases at the same or lower BOM costs vs. typical old and slow Si systems.

Dr. Chingchi Chen

Ford Motor Company

"SiC-based Automotive Power Converters, Opportunities and Challenges"

Wednesday, November 1, 2017, 9:00 AM

Speaker Biography:

Chingchi CHEN received a Ph.D. degree in 1994 from the University of Wisconsin-Madison, in Electrical Engineering. Since then, he has been with the Ford Research & Advanced Engineering, leading power electronics research for on-vehicle applications. He has been working on various areas in power electronics for automotive applications, including topology evaluation, dynamic analysis, reliability assessment, WBG technology evaluation, and package design.

Abstract:

In this presentation, key aspects of SiC-based automotive power converters compared with the Si ones will be discussed, including optimal operating conditions to achieve best performance, efficiency improvement with the required supporting factors, major component sizing methodologies and constraints, impact on reliability / durability, tolerance and protection requirements against extreme operating conditions, etc. Acceptable SiC cost on the die- and converter-levels for automotive applications will be described. Finally, even many SiC manufactures have released impressive reliability verification results, expectations / requests from the automotive industry on SiC reliability / failure rate will be reviewed.

ORAL PRESENTATION SCHEDULE

Tuesday, October 31, 2017

TECHNICAL SESSION 1

SiC Inverters/Converters — WOLF

Session Chair: Jason Neely, *Sandia National Laboratories*

3:15 PM – 3:40 PM **Evaluation of SiC Based Inverter Drives**
Sneha Narasimhan, Marzieh Karami, Rangarajan Tallam, Mrinal Das

3:40 PM – 4:05 PM **Safe Integration of Depletion Mode SiC VJFET Power Modules Into a Commercial Motor Drive**
Michael Mazzola, James Gafford, Brian Sullivan

4:05 PM – 4:30 PM **Dead-Time Optimization for SiC Based Voltage Source Converters Using Online Condition Monitoring**
Jacob Dyer, Zheyu Zhang, Fred Wang, Daniel Costinett, Leon Tolbert, Benjamin Blalock

4:30 PM – 4:55 PM **Multilayer Busbar Design for a Si IGBT and SiC MOSFET Hybrid Switch Based 100 kW Three-Level T-Type PEBB**
Amol Deshpande, Fang Luo

4:55 PM – 5:20 PM **SiC-Based Automotive Traction Drives, Opportunities and Challenges**
Chingchi Chen, Ming Su, Zhuxian Xu, Xi Lu

GaN Technology, Device Optimization, and Reliability — HAWK

Session Chair: Yasuhiro Uemoto, *Panasonic Corp.*

3:15 PM – 3:40 PM **Design Optimization of GaN Vertical Power Diodes and Comparison to Si and SiC**
Jack Flicker, Robert Kaplar

3:40 PM – 4:05 PM **Optimization of ALD High-K Gate Dielectric to Improve AlGaN/GaN MOS-HFET DC Characteristics and Reliability**
Faisal Azam, Bongmook Lee, Veena Misra

4:05 PM – 4:30 PM **Reverse Bias Lifetime Analysis of 600V Enhancement Mode GaN Devices**
Hari Kannan, Deepak Veereddy, Zhaofeng Wang, Sameh Khalil, Alain Charles, Hyeongnam Kim, Mohamed Imam

4:30 PM – 4:55 PM **Low Temperature Epitaxial Deposition of GaN on LTCC Substrates**
Dimiter Alexandrov, Jonny Tot, Robert Dubreuil, Valentin Videkov, Svetozar Andreev, Boriana Tzaneva, Francisco Miguel

4:55 PM – 5:20 PM **Investigation of Performance Degradation in Thermally Aged Cascode GaN Power Devices**
Chi Xu, Enes Ugur, Bilal Akin, Chingchi Chen, Ming Su, Zhuxian Xu, Xi Lu

Design and Optimization — BADGER

Session Chair: Andrew Lemmon, *University of Alabama*

3:15 PM – 3:40 PM **Design and Control Methodology for Improved Operation of a HV Bipolar Hybrid Switched Capacitor Converter**
Jarod Delhotal, James Richards, Josh Stewart, Jason Neely, Jack Flicker, Robert Brocato, Lee Rashkin, Jane Lehr

3:40 PM – 4:05 PM **An Integrated PEBB Using e-GaN FETs and Nanocrystalline Inductors for Multiple DC-DC, ACDC and DC-AC Applications**
Nour Elsayad, Alberto Berzoy, Osama A. Mohammed

4:05 PM – 4:30 PM **Insulation Design for Wide Bandgap (WBG) Device Based Voltage Source Converter Fed Motors**
Ajay Morya, Hamid Toliyat

4:30 PM – 4:55 PM **Prediction of Pareto-Optimal Performance Improvements in a Power Conversion System Using GaN Devices**
Bo Zhang, Scott Sudhoff, Steve Pekarek, Rob Swanson, Jack Flicker, Jason Neely, Jarod Delhotal, Robert Kaplar

4:55 PM – 5:20 PM **Comparison of Methods for Current Measurement in WBG Systems**
Christopher New, Andrew Lemmon, Ali Shahabi

Wednesday, November 1, 2017

TECHNICAL SESSION 2

GaN Inverters / Converters — WOLF

Session Chair: Jack Flicker, *Sandia National Laboratories*

10:00 AM – 10:25 AM **A Comparison of GaN-Based Power Stages for High-Switching Speed Medium-Power Converters**
Ashwath Hegde, Yu Long, Jennifer Kitchen

10:25 AM – 10:50 AM **High Power-Density Photovoltaic Boost Converter and Inverter Using GaN and AlGaN Devices Housed in 3D Printed Packages**
Robert Brocato

10:50 AM – 11:15 AM **Designing a 1kW GaN PFC Stage with Over 99% Efficiency and 155W/in3 Power Density**
Serkan Dusmez, Zhong Ye

11:15 AM – 11:40 AM **GaN-Fet Based Grid-Connected Solar Microinverter: Some Design Insights**
Ankit Gupta, Sudip Mazumder

ORAL PRESENTATION SCHEDULE

SiC Device/Process Optimization — HAWK

Session Chair: Bob Kaplar, *Sandia National Laboratories*

10:00 AM – 10:25 AM **Optimization of the JFET Region of 1.2kV SiC MOSFETs for Improved High Frequency Figure of Merit (HF-FOM)**
Woongje Sung, Kijeong Han, B. J. Baliga

10:25 AM – 10:50 AM **Thermal-Oxidation-Free Dielectrics for SiC Power Devices**
Rahul P Ramamurthy, Dallas Morisette, Voshadhi Amarasinghe, Leonard Feldman

10:50 AM – 11:15 AM **New Generation 6.5 kV SiC Power MOSFET**
Shadi Sabri, Edward Van Brunt, Adam Barkley, Brett Hull, Michael O'Loughlin, Al Burk, Scott Allen, John Palmour

GaN Characterization — BADGER

Session Chair: Ayanori Ikoshi, *Panasonic Corp.*

10:00 AM – 10:25 AM **A Simple Calorimetric Technique for High-Efficiency GaN Inverter Transistor Loss Measurement**
He Li, Xiao Li, Zhengda Zhang, Jin Wang, Liming Liu, Sandeep Bala

10:25 AM – 10:50 AM **Effect of Substrate Termination on Switching Loss and Switching Time Using 600 V GaN-on-Si HEMTs with Integrated Gate Driver in Half-Bridges**
Stefan Moench, Richard Reiner, Beatrix Weiss, Patrick Waltereit, Rüdiger Quay, Oliver Ambacher, Ingmar Kallfass

10:50 AM – 11:15 AM **Substrate Biasing Effects in a High-Voltage, Monolithically-Integrated Half-Bridge GaN-Chip**
Beatrix Weiss, Richard Reiner, Vladimir Polyakov, Patrick Waltereit, Rüdiger Quay, Oliver Ambacher, Dragan Maksimović

11:15 AM – 11:40 AM **Evaluation of 600 V Direct-Drive GaN HEMT and a Comparison to GaN GIT**
Yousef Abdullah, He Li, Jin Wang

Wednesday, November 1, 2017

TECHNICAL SESSION 3

Gate Drivers/Overcurrent Protection — WOLF

Session Chair: Michael Mazzola, *University of North Carolina at Charlotte*

1:00 PM – 1:25 PM **A Fast Overcurrent Protection Scheme for GaN GITs**
Edward Jones, Paige Williford, Fred Wang

1:25 PM – 1:50 PM **Short-Circuit Performance of Multi-Chip SiC MOSFET Modules**
Arun Kadavelugu, Eddy Aeloiza, Christopher Belcastro

1:50 PM – 2:15 PM **An Overview of Advances in High Reliability Gate Driving Mechanisms for SiC MOSFETs**
Nazmus Sakib, Madhav Manjrekar, Abasifreke Ebong

2:15 PM – 2:40 PM **Comparative Study on the Turn-Off Capability of Multiple Si and SiC Power Devices**
Liqi Zhang, Kai Tan, Xiaoqing Song, Alex Q. Huang

SiC Characterization — HAWK

Session Chair: Jeramy Dickerson, *Sandia National Labs*

1:00 PM – 1:25 PM **SiC Power Module Loss Reduction by PWM Gate Drive Patterns and Impedance-Optimized Gate Drive Voltages**
Holger Gerstner, Thomas Heckel, Achim Endruschat, Andreas Roßkopf, Bernd Eckardt, Martin März

1:25 PM – 1:50 PM **Improvement of the Modified Opposition Method Used for Accurate Switching Energy Estimation of WBG Transistors**
Hans Sathler, Bernardo Cougo

1:50 PM – 2:15 PM **Study of 1200 V SiC JFET Cascode Device**
Ren Xie, Yanjun Shi, Hui Li

2:15 PM – 2:40 PM **Characterization and Evaluation of 4.5 kV 40 a SiC Super-Cascode Device**
Boxue Hu, Zhuo Wei, He Li, Xintong Lyu, Diang Xing, Risha Na, Jin Wang

Wide Bandgap Packaging and Assembly — BADGER

Session Chair: Sameh Khalil, *Infineon Technologies*

1:00 PM – 1:25 PM **Response Surface Modeling for Parasitic Extraction for Multi-Objective Optimization of Multi-Chip Power Modules (MCPMs)**
Quang Le, Tristan Evans, Shilpi Mukherjee, Yarui Peng, Tom Vrotsos, H. Alan Mantooth

1:25 PM – 1:50 PM **A 200 kVA Electric Vehicle Traction Drive Inverter Having Enhanced Performance Over its Entire Operating Region**
Kraig Olejniczak, Ty McNutt, David Simco, Ajith Wijenayake, Tom Flint, Brandon Passmore, Robert Shaw, Dan Martin, Aus...

1:50 PM – 2:15 PM **An Improved SiC MOSFET-Gate Driver Integrated Power Module with Folded Layout and Ultra Low Stray Inductance**
Liqi Zhang, Pengkun Liu, Alex Q. Huang, Suxuan Guo, Ruiyang Yu

2:15 PM – 2:40 PM **Efficient Single-Phase Cooling Techniques for Durable Power Electronics Module**
Darshan Pahinkar, Waylon Puckett, Samuel Graham, Lauren Boteler, Dimeji Ibitayo

ORAL PRESENTATION SCHEDULE

Wednesday, November 1, 2017

TECHNICAL SESSION 4

RF/Wireless Power — WOLF

Session Chair: Jane Lehr, *University of New Mexico*

3:00 PM – 3:25 PM **Output Capacitance Losses in 600 V GaN Power Semiconductors with Large Voltage Swings at High- and Very-High-Frequencies**
Grayson Zulauf, Wei Liang, Kawin Surakitbovorn, Juan Rivas-Davila

3:25 PM – 3:50 PM **A Very-High-Power-Transfer-Density GaN-Based Capacitive Wireless Power Transfer System**
Sreyam Sinha, Brandon Regensburger, Ashish Kumar, Khurram Afridi

3:50 PM – 4:15 PM **How eGaN® FETs Are Enabling Large Area Wireless Power Transfer**
Yuanzhe Zhang, Michael de Rooij

4:15 PM – 4:40 PM **Prospects for Photoconductive Solid State (PCSS) Switches: A Survey**
Jane Lehr, J. Dana Teague, Timothy Wolfe

SiC Reliability — HAWK

Session Chair: Deepak Veereddy, *Infineon Technologies*

3:00 PM – 3:25 PM **Reliability Aspects of 1200V and 3300V Silicon Carbide MOSFETs**
Leonid Fursin, Xueqing Li, Zhongda Li, Mathew O'Grady, William Simon, Anup Bhalla

3:25 PM – 3:50 PM **Real-Time Degradation Monitoring of SiC-MOSFETs Through Readily Available System Microcontroller**
Shi Pu, Enes Ugur, Bilal Akin

3:50 PM – 4:15 PM **Detection of Gate Oxide and Channel Degradation in SiC Power MOSFETs Using Reflectometry**
Abu Hanif, Sourov Roy, Faisal Khan

4:15 PM – 4:40 PM **A Novel Characterization Method for Blocking Characteristics of High Voltage 4H-SiC Power Devices**
In-Hwan Ji, Avinash S. Kashyap, Linda Starr, Bruce Odekirk, Dumitru Sdrulla

Wide Bandgap Circuit/Assembly Interaction — BADGER

Session Chair: Maryam Saeedifard, *Georgia Tech*

3:00 PM – 3:25 PM **Comparison of SiC MOSFETs and GaN HEMTs Based High-Efficiency High-Power-Density 7.2kW EV Battery Chargers**
Guanliang Liu, Kevin Bai, Matt McAmmond, Allan Brown, Philip Mike Johnson, Allan Taylor, Juncheng Lu

3:25 PM – 3:50 PM **Operation of PCB-Embedded, High-Voltage Multilevel-Converter GaN-IC**
Beatrix Weiss, Richard Reiner, Patrick Waltereit, Rüdiger Quay, Oliver Ambacher

3:50 PM – 4:15 PM **Protruding Ceramic Substrates for High Voltage Packaging of Wide Bandgap Semiconductors**
Hugo Reynes, Cyril Buttay, Hervé Morel

4:15 PM – 4:40 PM **Electrically Thin Approach to Switching Cell Design for Flying Capacitor Multilevel Converters**
Nathan Pallo, Tomas Modeer, Robert Pilawa-Podgurski

POSTER PRESENTERS

Poster Session and Banquet

Tuesday, October 31, 2017, 6:00 PM – 9:00 PM
Cottonwoods Pavilion

- **Critical Short-Timescale Transient Processes of a GaN+Si Hybrid Switching Module Used in Zero-Voltage-Switching Applications**
  Guanliang Liu, Kevin Bai, Matt McAmmond, Allan Brown, Philip Mike Johnson, Juncheng Lu

- **Application-Related Characterization and Theoretical Potential of Wide-Bandgap Devices**
  Achim Endruschat, Thomas Heckel, Holger Gerstner, Christopher Joffe, Bernd Eckardt, Martin März

- **Evaluation of Measurement Techniques for High-Speed GaN Transistors**
  Suvankar Biswas, David Reusch, Michael de Rooij, Tom Neville

- **Application of a 100A Normally-on GaN-Based Device in a 2kW/400Vinput Half-Bridge Non-Isolated DC-DC Configuration**
  Mauricio Dalla Vecchia, Giel Van Den Broeck, Simon Ravyts, Johan Driesen

- **Comprehensive Switching Behavior Characterization of High Speed Gallium Nitride E-HEMT with Ultra-Low Loop Inductance**
  Han Peng, Ramanujam Ramabhadran, Robert Thomas, Michael Schutten

- **Optimization of an Enhancement-Mode AlGaN/GaN/AlGaN DHFET Towards a High Breakdown Voltage and Low Figure of Merit**
  Andrew Binder, Jiann-Shiun Yuan

- **Motor Loss and Temperature Reduction with High Switching Frequency SiC-Based Inverters**
  Koji Yamaguchi, Kenshiro Katsura, Takehiro Jikumaru

- **Pulsed Measurement of Sub-Nanosecond 1000 V/Ns Switching 600 V GaN HEMTs Using 1.5 GHz Low-Impedance Voltage Probe and 50 Ohm Scope**
  Stefan Moench, Philipp Hillenbrand, Philipp Hengel, Ingmar Kallfass

- **Breakdown Voltage Improvement and Analysis of GaN HEMTs Through Field Plate Inclusion and Substrate Removal**
  Alberto Berzoy, Christopher Lashway, Hadi Moradisizkoohi, Osama A. Mohammed

- **A Resonant Bi-Directional Buck-Boost Converter with Distributed Voltage Stress Using eGaN HEMTs**
  Hadi Moradisizkoohi, Nour Elsayad, Osama A. Mohammed

POSTER PRESENTERS

- **Design and Optimization of High Conversion Ratio Quasi Square Wave Buck Converters**
  Yashar Naeimi, Alex Q. Huang

- **SiC MOSFETs Designed and Evaluated for Linear Mode Operation**
  Heather O'Brien, Aderinto Ogunniyi, Damian Urciuoli, Qingchun Jon Zhang, Brett Hull

- **Comparison of GaN Based Switched-Tank Converter and Cascaded Voltage Divider**
  Xiaofeng Lyu, Yanchao Li, Dong Cao, Shuai Jiang, Chenhao Nan

- **Thin Layer Ag-Sn Transient Liquid Phase Bonding Using Magnetron Sputtering for Chip to Baseplate Bonding**
  Philipp Natzke, Ulrike Grossner, Jolanta Janczak-Rusch, Lars Jeurgens

- **A Multivariable Turn-On/Turn-Off Switching Loss Scaling Approach for High-Voltage GaN HEMTs in a Hard-Switching Half-Bridge Configuration**
  Ruoyu Hou, Jianchun Xu, Di Chen

- **A Comprehensive Comparison of the Static Performance of Commercial GaN-on-Si Devices**
  Samuel Perkins, Anastasios Arvanitopoulos, Konstantinos Gyftakis, Neophytos Lophitis

- **Mixed-Mode Circuit Simulation to Characterize Ga2O3 MOSFETs in Different Device Structures**
  Inhwan Lee, Avinash Kumar, Ke Zeng, Uttam Singisetti, Xiu Yao

- **Investigation of EM Radiation Changes in SiC Based Converters Throughout Device Aging**
  Shi Pu, Enes Ugur, Bilal Akin, Hakan Akca

- **GaN Based Inverter with High Conversion Ratio and Sinusoidal Output for Motor Drive Applications Stress Analysis**
  Jalen Johnson, Dong Cao, Xiaofeng Lyu, Ze Ni

- **Using Ultra-Low Parasitic Hybrid Packaging Method to Reduce High Frequency EMI Noise for SiC Power Module**
  Yue Xie, Yuxiong Li, Zhizhao Huang, Teng Liu, Yi Zhang, Yifan Tan, Cai Chen, Yong Kang

- **Effect of Capacitive Current on Reverse Recovery of Body Diode of 10kV SiC MOSFETs and External 10kV SiC JBS Diodes**
  Ashish Kumar, Kasunaidu Vechalapu, Subhashish Bhattacharya, Victor Veliadis, Edward Van Brunt, David Grider, Shadi Sa

High Voltage SiC Technology

Tuesday, October 31, 2017, 9:45 AM

SiC power devices in the 1-2 kV range are in production and gaining ground in lower voltage power electronic applications. High voltage devices are not presently commercially available and their market introduction and adoption necessitates development in several areas. These include high quality thick epitaxial films with low defect densities, processing innovations, high voltage modules, circuit models, gate drives, remedy of the high dV/dt and EMI/EMC issues, and insertion in power systems. The panel will discuss current technology status, and obstacles that need to be overcome for commercial success.

Moderator

- Victor Veliadis, *PowerAmerica*

Panelists

- Mike McMillian, *Global Power Technology*
- Bob Stahlbush, *NRL*
- Dave Grider, *Wolfspeed*
- Lauren Boteler, *ARL*
- Jin Wang, *The Ohio State University*

Commercialization of GaN Devices in High-Frequency Power Electronic Applications

Tuesday, October 31, 2017, 10:30 AM

For years, market studies have predicted exponential growth in GaN revenue in power electronic applications. There are a few high-performance power supplies beginning to emerge on the market, but these are typically not operating at high frequency. What are the key challenges, developments, needs that will lead to success and pave the way to broader market adoption?

Moderator

- Eric Perrson, *Infineon Technologies*

Panelists

- Alex Huang, *The University of Texas at Austin*
- Yuanzhe Zhang, *EPC*
- Nick Fichtenbaum, *Navitas Semiconductor*
- Larry Spazziani, *GaN Systems*

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Accel-RF specializes in the development, design, and production of reliability and burn-in test systems for GaN and SiC, as well as RF compound semiconductor devices. Leveraging its decades-long heritage as the premier test equipment provider for RF semiconductors, Accel-RF is quickly setting the standard for power electronics testing, offering the most flexible and accurate power switching platform available. These systems are turnkey integrated instruments that provide a cost effective, high value proposition for device manufacturers, fab-less device suppliers, testing-service providers, original equipment manufacturers, system integrators, and research and development laboratories. Accel-RF solutions decrease product development time, ensure exceptional reliability, and accelerate income opportunities.

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Efficient Power Conversion (EPC) is the leader in enhancement-mode gallium nitride based power management technology. EPC was the first to introduce enhancement-mode gallium-nitride-on-silicon (eGaN) FETs as power MOSFET replacements in applications such as DC-DC converters, wireless power transfer, envelope tracking, power inverters, 3-D imaging and sensing technology (LiDAR), and Class-D audio amplifiers with device performance many times greater than the best silicon power MOSFETs. EPC also has a growing portfolio of eGaN-based integrated circuits that provide even greater space, energy, and cost efficiency.

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Monday, October 30, 2017, 9:00 AM

Dr. Jim Cooper

Purdue University

"SiC Power Devices: Physics, Current Status, and Future Trends"

Speaker Bio:

James A. Cooper is Jai N. Gupta Professor Emeritus of Electrical and Computer Engineering at Purdue University and President of Sonrisa Research, Inc., a 501(c)3 corporation doing government contract research. He received his Ph.D. from Purdue in 1973 and was a member of technical staff at Bell Laboratories, Murray Hill, NJ from 1973 until 1983, when he joined the Purdue faculty. His research group at Purdue is responsible for a number of advances in SiC technology including the first DMOS power transistors, the oxide-protected UMOS power transistor, the self-aligned short-channel DMOSFET, and the first n-channel IGBTs on free-standing epilayers. Professor Cooper was elected Fellow of the IEEE in 1993. He served on the editorial boards of IEEE Transactions on Electron Devices and IEEE Proceedings, and was Technical Program Co-Chair for the International Conference on Silicon Carbide and Related Materials in September 2017. He has coauthored over 250 referred journal articles and presentations, and the textbook Fundamentals of Silicon Carbide Technology (Wiley, 2014).

Abstract:

Silicon carbide (SiC) has long been recognized as an ideal semiconductor for power electronics because of its wide bandgap, high critical field, high-quality native oxide (SiO2), and the availability of single-crystal SiC substrates. SiC diodes entered commercial production in 2002, and have accumulated hundreds of billions of hours in the field with a failure rate 10x lower than silicon parts they replace. SiC power MOSFETs entered production in 2011, and are now offered by multiple vendors in Europe, Asia, and the US. The worldwide SiC market is currently $300 million per year, and is projected to exceed $600 million by 2021. Spurring this growth is the availability of high-quality 150 mm 4H-SiC wafers that can be processed on fully depreciated 6" silicon production lines. SiC power devices have made great progress over the past several years, but SiC technology is still in its adolescence, and progress is expected to accelerate in coming years as material quality improves, production volume increases, and device innovation takes hold. In this tutorial I will discuss three SiC power devices: the JBS diode, power MOSFET, and IGBT. I will describe the operating physics and current status of each, review material and performance limitations, and highlight current research leading to the next generation of SiC power devices.

Monday, October 30, 2017, 10:00 AM

Dr. Subhashish Bhattacharya

North Carolina State University

"HV SiC Devices Enabled MV Power Converters Applications and Circuit Topologies – Opportunities and Challenges"

Speaker Bio:

Subhashish Bhattacharya received his B.E. (Hons), M.E. and PhD degrees in Electrical Engineering from Indian Institute of Technology-Roorkee (formerly University of Roorkee), India in 1986, Indian Institute of Science (IISc), Bangalore, India in 1988, and University of Wisconsin-Madison in 2003, respectively. He worked in the FACTS (Flexible AC Transmission Systems) and Power Quality group at Westinghouse R&D Center in Pittsburgh which later became part of Siemens Power Transmission & Distribution, from 1998 to 2005. He joined the Department of Electrical and Computer Engineering at North Carolina State University (NCSU) in August 2005, where he is the ABB Term Professor, and also a founding faculty member and co-PI of NSF ERC FREEDM systems center (www.freedm.ncsu.edu), Advanced Transportation Energy Center [ATEC] (www.atec.ncsu.edu) and the newly established DOE initiative on WBG based Manufacturing Innovation Institute –PowerAmerica -at NCSU. He has authored over 300+ peer-reviewed technical articles, 2 book chapters, and has 4 issued patents to his credit. A part of his PhD research on active power filters was commercialized by York Corp. for their air-conditioner chiller application. His research interests are Solid-State Transformers, MV power converters, FACTS, Utility applications of power electronics and power quality issues; high-frequency magnetics, active filters, and application of new power semiconductor devices such as SiC for converter topologies.

Abstract:

The tutorial will stress in-depth the advantages of SiC over other power electronic materials, and will introduce SiC devices currently developed for power applications. The opportunities for HV SiC devices for MV Power Converters and utility applications and the challenges to apply these HV SiC devices successfully will be presented in-depth with SiC device voltage ranges from 1200 V to 1700 V MOSFETs, and HV 10 kV-15 kV MOSFETs, JBS diodes, and 15 kV SiC IGBTs. The potential and challenges of the HV 10-15 kV devices to enable MV power conversion systems, including MV motor drives, FACTS and MVDC grids will be explored. Challenges in adopting these HV SiC devices for MV power conversion in terms of magnetics, capacitors, and insulation materials will be discussed. Prototype SiC-based power electronics systems will be shown and their numerous advantages will be articulated.

Monday, October 30, 2017, 11:00 AM

Dr. Brij Singh,

John Deere

"200 kW 1050 VDC SiC Dual Inverter for Heavy-Duty Vehicles"

Speaker Bio:

Brij N. Singh is a senior staff engineer in John Deere. He is leading DOE PowerAmerica funded project in John Deere to develop 200 kW SiC inverter for heavy-duty vehicle applications. Brij has earned B.E. in Electrical Engineering from Madan Mohan Malviya University of Technology in 1989, the M.E. in Electrical Engineering from the Indian Institute of Technology, Roorkee, in 1991, and the Ph.D. in Electrical Engineering from the Indian Institute of Technology, New Delhi, India, in 1996. In 1996, Brij joined the École de Technology Supérieure (School of Advanced Technology), Université du Québec (University of Quebec), Montreal, QC, Canada, as a Post-Doctoral Fellow. In 1999, Brij joined Concordia University, Montreal, QC, Canada as a Research Fellow. In 2000, Brij joined the Department of Electrical Engineering and Computer Science, Tulane University, New Orleans, Louisiana, as an Assistant Professor. In 2007, Brij joined John Deere in Fargo, North Dakota. Brij has published over 90 research papers in various Journals, such as IEEE Transactions and IET Journals. Brij has 12 US patents and numerous pending patents.

Abstract:

This presentation discusses publically known information related to John Deere project funded by the DOE-PowerAmerica Institute at North Carolina State University, Raleigh. Through PowerAmerica, John Deere has formed a collaboration with researchers from the Department of Energy National Renewable Energy Laboratory to develop a 200 kW 1050 VDC silicon carbide-based inverter. The inverter will convert vehicle engine power into electrical power needed for hybrid motors in heavy duty construction vehicles. In April 2017, the Fargo, North Dakota-based John Deere Electronic Solutions successfully demonstrated the SiC inverter in a John Deere 644K hybrid front loader vehicle, using the engine radiator fluid to cool the SiC power electronics. The SiC inverter technology demonstration took place at John Deere Dubuque Works in Dubuque, Iowa. DOE-PowerAmerica funding has helped accelerate the development of this technology. YouTube link related to JD 644K Hybrid front loader vehicle is; https://www.youtube.com/watch?v=j1g0NwhO4Fg

TUTORIAL SESSIONS OVERVIEW

Monday, October 30, 2017, 2:00 PM

Dr. Andrew Lemmon

University of Alabama

"Pursuing the Performance Entitlement of Wide Band-Gap Semiconductors: Opportunities and Challenges"

Speaker Bio:
Andrew N. Lemmon received the B.S. degree in electrical engineering from Christian Brothers University, Memphis, TN, in 2000; the M.S. degree in electrical and computer engineering from The University of Memphis in 2009; and the Ph.D. degree in electrical engineering from Mississippi State University, Starkville, MS, in 2013. From 2000 to 2010, he worked as an embedded systems design engineer at FedEx Corporation in Memphis, TN. From 2010 to 2013, he worked as a graduate research assistant in the Center for Advanced Vehicular Systems (CAVS) at Mississippi State University. He is currently an Assistant Professor at the University of Alabama, Tuscaloosa. His research interests include design of power electronics applications for wide band-gap devices, Simulation and modeling of power semiconductor devices and applications, and advanced control strategies for power electronics. Dr. Lemmon is a registered professional engineer and has been awarded four patents.

Abstract:
For many years, wide band-gap (WBG) semiconductors have been forecast to revolutionize the power electronics industry. Compared to silicon devices, WBG devices offer marked improvement in terms of conduction and switching losses, thermal performance, and switching speed. As a result, these devices have been shown to yield a substantial system-level performance advantage when designed into power electronics applications such as hybrid-electric vehicles, photovoltaic inverters, and power converters for large data centers. However, the market adoption of this technology has not been as rapid as expected by analysts, even though the device maturity has continued to improve rapidly over the past several years. A partial explanation for this trend is the challenge associated with integrating wide band-gap transistors into power electronics applications in a manner which takes full advantage of their capabilities while also satisfying reliability and regulatory requirements. Optimization of power electronics applications for WBG semiconductors often encounters unexpected challenges, which are found to result largely as a side-effect of significant spectral energy in the 1-30 MHz band. In traditional power electronics applications, the energy in this "Near-RF" regime is not significant and may be safely ignored. However, WBG-based circuits must be designed in anticipation of this spectral content, particularly if the performance entitlement of the WBG devices is to be achieved while addressing other system-level requirements. The implications of the increased spectral envelope of WBG-based systems are many; and these implications demand a revolution in the techniques and tools employed by power electronics engineers for application design. During this presentation, attention will be given to cataloging the implications, describing their system impacts, and explaining known methods for mitigating the underlying cause of "Near-RF" spectral content commonly found in high-performance WBG-based applications.

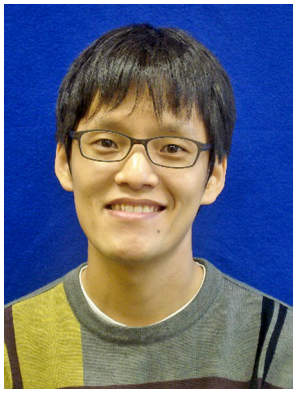
Monday, October 30, 2017, 3:00 PM

Dr. Sandeep Bahl

Texas Instruments

"GaN reliability for Power Devices and Applications"

Speaker Bio:
Sandeep Bahl is the GaN Reliability, Devices & Modeling manager of the High Voltage Power Business Unit of Texas Instruments. He graduated with a PhD in Electrical Engineering from the Massachusetts Institute of Technology. Sandeep has extensive experience with semiconductor technology development. His present focus is to bring reliable GaN products to market, and to develop the methodology to know that they will be reliable under actual-use conditions. He helped kickoff the standardization effort of the GaN industry and is presently participating on the GaNSPEC reliability committee as the switching reliability sub-team lead. He is also chairing the Wide Bandgap Committee of the IEEE International Reliability Physics Symposium (IRPS).



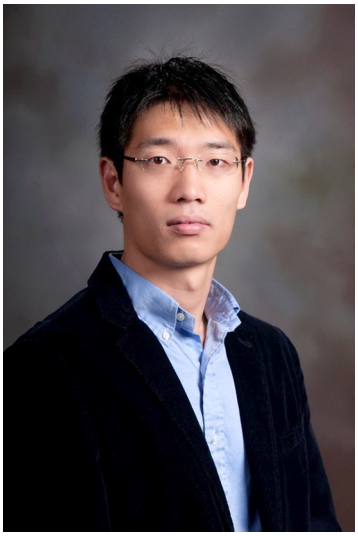
Dr. Jungwoo Joh

Texas Instruments

Speaker Bio:
Jungwoo Joh received his S.M. and Ph.D. degrees in Electrical Engineering from MIT. His thesis topic was on reliability physics of GaN HEMTs. He is currently with Texas Instruments, Dallas, TX, where he has been conducting research on GaN device physics and reliability

Abstract:
The talk will provide a tutorial on GaN reliability, both from the device and applications-use perspective. It will go over both device and application-use failure modes, summarizing learnings from the literature. You will learn about device TDDB, charge-trapping and hard-switching. You will also learn about what the traditional JEDEC qualification recipe means and why it does not assure application-relevant reliability. The tutorial will also summarize industry approaches to application reliability.

Monday, October 30, 2017, 4:00 PM



Dr. Qiang Li

Virginia Tech

"GaN-Based High-Efficiency High-Density Power Converters for Future Data Center"

Speaker Bio:

Qiang Li received the B.S. and M.S. degrees from Zhejiang University, China, in 2003 and 2006, respectively and the Ph.D. degree from Virginia Tech, Blacksburg, VA, in 2011. He is currently an assistant professor in Center for Power Electronics Systems at Virginia Tech. His research interests include high-frequency power conversion, magnetics and EMI, and high-density electronics packaging.

Abstract:

Majority of the data centers built to date were based on the available off-the-shelf silicon-based equipment and they consume a huge amount of energy – by 2020, it is estimated they will use as much as 10 percent of the world electricity. For future data centers, the distributed power conversion system have to be very efficient and with high power density. With recent advances made in Gallium-Nitride (GaN) power devices, this new generation of switches can be operated with significantly higher frequency compared to their silicon counterparts. It has been demonstrated that an increase of switching frequency by a factor of 10-20 is possible along with improved efficiency. In this presentation, two design examples of GaN based high-efficiency high-density DC/DC converters for data center applications will be discussed. The first one is a 1MHz 800W 380V/12V LLC converter with matrix transformer. It achieves a peak efficiency of 97.6% and a power density of 900W/in^3, which is the highest density has ever been reported for 380V/12V LLC. The second one is an 80W single stage 48V/1V converter. It is a quasi-parallel converter that uses a high efficiency unregulated LLC converter to deliver most power to the load with small power flowing through a buck converter responsible for regulating the output voltage. It achieves a peak efficiency of 93.4% and a power density of 420W/in^3. In both of these designs, the magnetics are distributed in the form of matrix transformers and are integrated with PCB winding with significantly improved manufacturability and reduced cost.

Monday, October 30, 2017, 5:00 PM

Eric Persson

Infineon Technologies

"The Pros and Cons of Using GaN HEMTs in PFC Circuit Applications"

Speaker Bio:

Eric Persson is a 37-year veteran of the power electronic industry. His career spans 20 years of hands-on power converter and inverter design, followed by 17 years in applications engineering in the semiconductor industry at International Rectifier, now Infineon Technologies. He is presently responsible for GaN Applications at Infineon. Eric has presented more than 80 tutorials and papers at various international conferences. He is a regular lecturer, presenting short courses and tutorials at UW Madison, the University of Minnesota and Purdue University. He is also Chairman, Board of Directors of the Power Source Manufacturers Association (PSMA), and General Chairman for APEC 2018. Mr. Persson holds 13 patents, and is a recipient of the IEEE Third Millennium Medal.

Abstract:

Since the turn of the century, the vast majority of all electronic equipment over 75 W that connects to the grid requires Power Factor Correction (PFC) to minimize harmonic currents. Early PFC circuits were based on a boost circuit topology, and operated in the range of 20 –50 kHz using planar Silicon MOSFETs and fast-recovery rectifiers in conjunction with a full-wave bridge rectifier on the input. As semiconductors improved and became more cost-effective, superjunction MOSFETs and SiC Schottky rectifiers began to replace the older Silicon technologies in PFC circuits. After many generational improvements in both superjunction and SiC technology in the past decade, this combination has become the de-facto standard for the power stage used in most bridge and semi-bridgeless PFC stages today. The technology is mature and the cost and reliability are well-known. Now GaN HEMTs are gaining traction and are starting mass production in high-performance power supplies. Yet adoption has been slow and questions remain about the real benefit of GaN versus conventional semiconductors for PFC applications: Is GaN rugged enough to reliably handle voltage surges and inrush current from lightning strikes, line-cycle dropouts, and other line disturbances? Is GaN cheaper now or will it be cheaper, when? How is deadtime and diode-mode conduction managed, and what controller options exist? Why is GaN typically used at low frequencies (<100 kHz) in PFC applications? Can density really be improved by moving to high-frequency (MHz)? This seminar provides answers to these questions and more, using examples from real-world designs operating at both low and high-frequencies.

GENERAL INFORMATION

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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Posters will be on display on Tuesday night during the conference banquet in The Cottonwoods Pavilion. It is mandatory that posters be displayed in advance of the poster presentation session and remain displayed during the entire session. A poster presenter must remain near the poster and be available to discuss during the entire session.

Poster presenters will be given the first shuttle leaving the lobby at 5:45 PM to accommodate setup.

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Throughout the duration of the conference, the registration desk will remain staffed for the convenience of the participants. Any conference or program questions, including at-conference registration, may be directed to this help desk; when the conference is not in session, The Hyatt Regency Tamaya staff is available to assist at the hotel's front desk.

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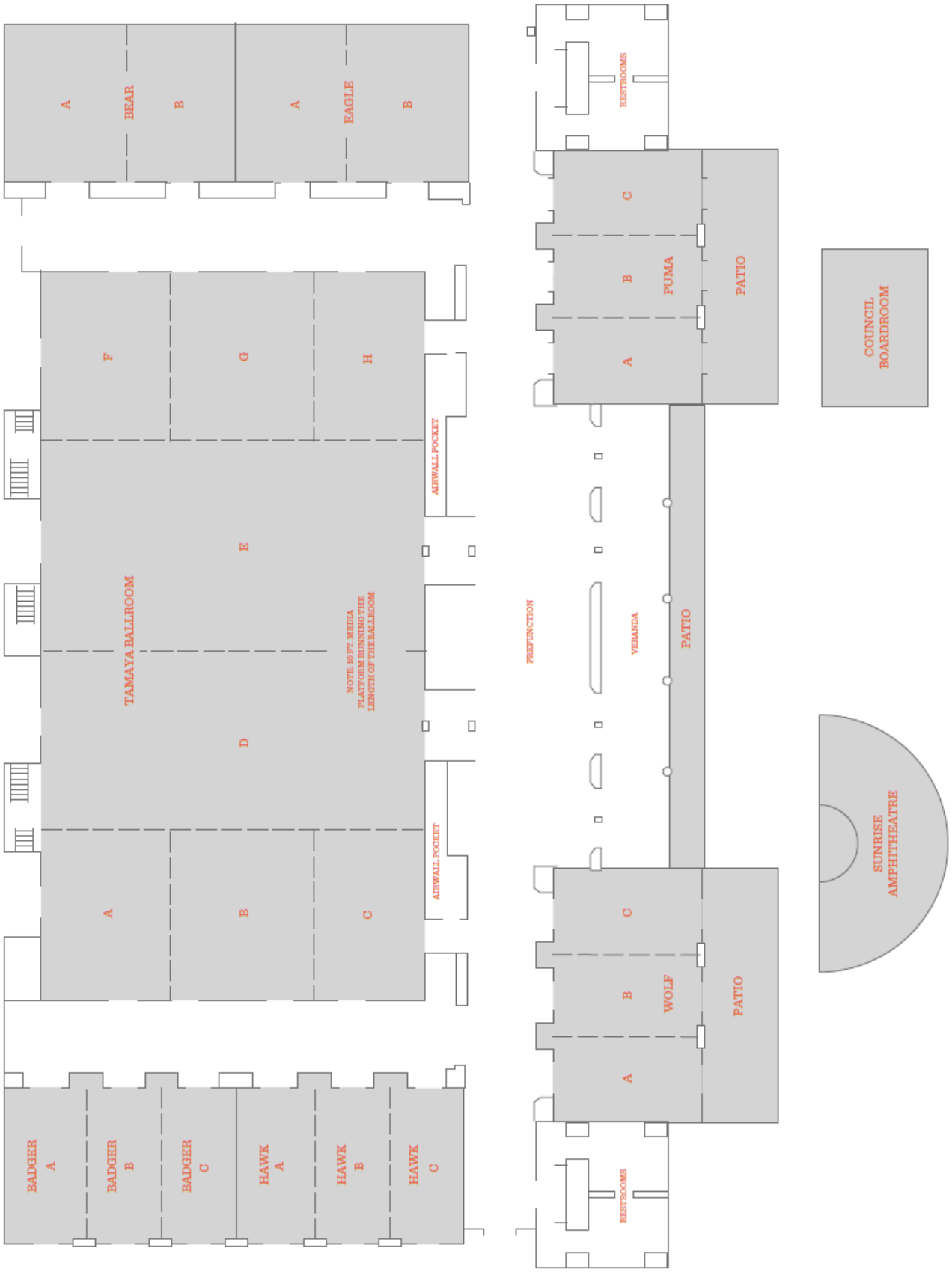
EVENT SPACE MAP



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