June 13 – 15, 2016
Raleigh, North Carolina

3D-PEIM

International Symposium on 3D Power Electronics Integration and Manufacturing

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"Innovations in Microelectronics"

PROGRAM OVERVIEW

Monday:
Tutorial
Additive Manufacturing
Thermal Management & System Integration

Tuesday:
Plenary Road Mapping
Multiphysics Modeling & Simulation
Materials
Manufacturability

Wednesday:
Embedding Technologies
Embedded Components
Quality & Reliability
Networking & NCSU Lab Tours

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Message from the Chairperson

Welcome to the *1st International Symposium on 3D Power Electronics Integration & Manufacturing (3D-PEIM)*. Your professional colleagues and the world's leading Packaging and Manufacturing societies and associations are launching this symposium to bring together world-class experts representing electrical, materials and manufacturing perspectives to help us all advance into the 3D power electronics systems of the future. Since this symposium is all about electrical-physical design and the manufacturing of power sources, we're offering both dialogue and lecture speakers the opportunity to display their hardware during the breaks and receptions. So please take advantage of the breaks and receptions to look, touch and feel the great technologies our presenters are talking about.

We also thank the *Power Sources Manufacturers Association (PSMA)* who is underwriting the event, along with the International Microelectronics Assembly and Packaging Society (IMAPS); the IEEE Components, Packaging and Manufacturing Technology Society (CPMT); North Carolina State University; the University of Maryland; and Virginia Tech.

Welcome to Raleigh, and we hope you gain rich rewards from the many interactions you'll have!

Sincerely,

Dr. Douglas C. Hopkins
General Chair
North Carolina State University

GENERAL CHAIR

Dr. Douglas C. Hopkins, *NC State University*

TECHNICAL PROGRAM CHAIRS

Dr. Patrick McCluskey, *University Of Maryland*

Dr. Guo-Quan Lu, *Virginia Tech*

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Brian Narverson, *PSMA*
Leona Liu, *Virginia Tech*
Adam Morgan, *NC State University*
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Wayne Johnson, *Tennessee Tech*
Thomas Lei, *Ford*
Zhenxian Liang, *ORNL*
Ty McNutt, *Wolfspeed*
Paul McCloskey, *Tyndall*
Govindarajan Muralidharan, *ORNL*
Sreekant Narumanchi, *NREL*
Kai Ngo, *Virginia Tech*
Ernie Parker, *Crane A&E*
Katsuaki Suganuma, *Osaka University*
Eckhard Wolfgang, *ECPE*

	Monday, Jun.13th
7:30 AM – 5:30 PM	**Registration Open**
7:30 AM – 8:00 AM	**Breakfast**
8:00 AM – 12:15 PM	***Tutorials: The World of Packaging Technologies and the Critical Issues***
8:00 AM – 9:15 AM	***3D Power Electronics & Additive Manufacturing*** By Dr. Douglas C. Hopkins, Professor *North Carolina State University* With the recent availability of essentially chip-scale packaged GaN, the onus is on power electronics designers to expand their packaging understanding to incorporate high-density devices at the module and board level. New post-silicon power devices, i.e. SiC, GaN and GaAs, are performing at unprecedented voltages and current densities, with switching speeds approaching gigahertz, and operating temperatures pushing above 225˚C. Though electro-physical design (packaging) follows established electrical and manufacturing "design rules," newer processes, such as 3D stacking and 3D printing, can now expand the "design rules" to provide higher densities in speed, weight, and volume. This tutorial systematically introduces fundamental understanding and resulting "design rules" for circuit and module that push the envelope in speed and density. Fundamental topics include characteristics of the evolving post-silicon devices, such as MosFETs, Cascode JFETs, variations in FET devices, IGBTs and ultra-high-speed diodes; reviews new power electronics packaging techniques for high performance circuits being developed at PREES; summaries new 3D printed power-packaging opportunities for creating 3D and integrated power electronic converters, and gives a case study in using multiphysics modeling before committing to circuit fabrication.
9:15 AM – 9:30 AM	**Break**
9:30 AM – 10:45 AM	***Materials & Assembly for 3D Integration*** By Dr. Guo-Quan (GQ) Lu, Professor *Virginia Tech* Researchers in the field of power electronics continuously strive to improve efficiency and power density of switch-mode converters through circuit design and functional integration. Electronic packaging of power devices and modules is critical for sustaining the technology trend of the field. Recent advances in wide bandgap semiconductor devices offer new challenges and opportunities for power electronic packaging. Innovative materials and assembly technologies are needed to enable high switching frequency and reliable operation at high temperatures. In this tutorial, I will present an overview of CPES's research efforts on development of power module packaging materials and assembly technologies including (1) 3D power module assembly for lowering parasitic inductance and achieving double-side cooling, (2) nanosilver material technology for high-reliability and high-temperature interconnection, and (3) reliability of sintered silver joints and direct-bond metal-ceramic substrates.
10:45 AM – 11:00 AM	**Break**
11:00 AM – 12:15 PM	***Thermal & Reliability Issues in 3D Integration*** By Dr. Patrick McCluskey, Professor *University of Maryland* Power electronics are becoming ubiquitous in engineered systems, such as home appliances, cell phone towers, aircraft, wind turbines, automobiles, smart grids, and data centers. Recently, the development of highly efficient power electronic devices and systems based on wide bandgap (WBG) semiconductors have allowed these power systems to manage ever larger power levels at higher frequencies over

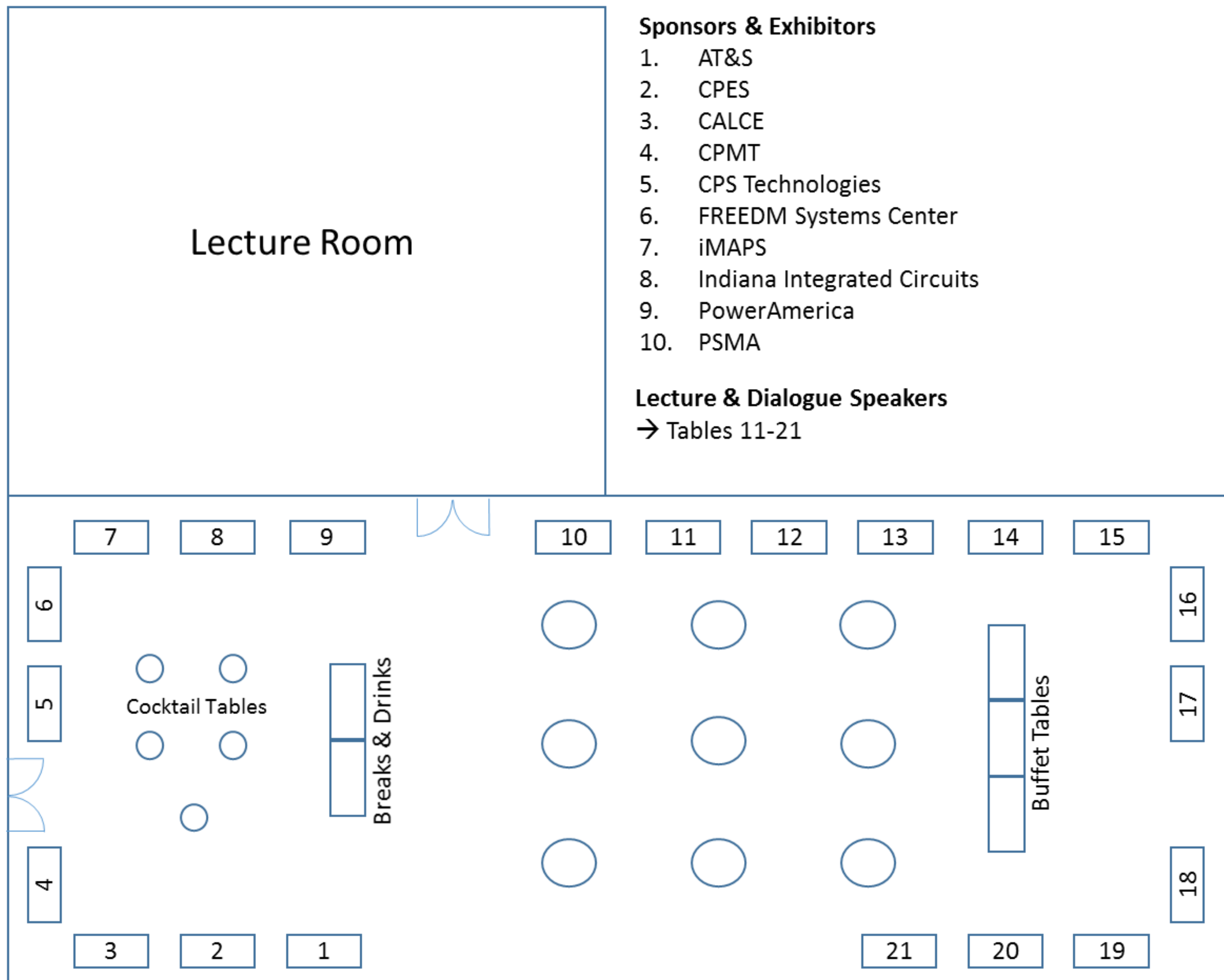
	wider temperature ranges with lower power loss. However, these increased power levels combined with increased power densities can lead to higher heat flux and resultant higher junction temperatures in power electronic systems, especially inside the switching module. Realizing these advantages requires new packaging structures. This tutorial will focus on the thermal management and reliability of the integrated packaging approaches that are being developed to make high packaging density, lower SWaP-C modules a reality. This includes the latest developments in air cooling, single phase liquid and two-phase cooling technologies, thermoelectrics, thermal isolation, and combined cooling schemes together with their interconnection. In addition, the tutorial will discuss the latest power electronics system reliability modeling, including new models for interconnect and cooler failure mechanisms. The tutorial will also discuss the latest techniques in prognostics, condition monitoring, and accelerated testing.
12:15 PM – 1:15 PM	**Lunch – Tutorial Attendees Networking**
1:15 PM – 1:25 PM	**Opening Remarks** **General Chair :** Dr. Douglas C. Hopkins, *NC State University*
1:25 PM – 3:10 PM	***Additive Manufacturing***
	Chairs: Ola Harrysson, *NC State University,* Govindarajan Muralidharan, *Oak Ridge National Laboratory* **Keynote Speaker:** ***"3D Printing Technology for Automotive Applications"*** Madhu Chinthavali, *Oak Ridge National Laboratory* **Lectures:** ***"Additive Manufacturing of Planar Inductor for Power Electronics Applications"*** Guo-Quan Lu, *Virginia Tech* ***"Thermal Response of Additive Manufactured Aluminum"*** Tong Wu, *Oak Ridge National Laboratory* ***"3D Printed Microchannel Heat Sink Design Considerations"*** Frank Wang, *Crane EG*
3:10 PM – 3:35 PM	**Break**
3:35 PM – 5:30 PM	***Thermal Management & Systems Integration***
	Chair: Sreekant Narumanchi, *National Renewable Energy Laboratory* **Keynote Speaker:** ***"Design for Additive Manufacturing of Wide Band-Gap Power Electronics Components"*** Eric Dede, *Toyota Research Institute of North America* **Lectures:** **"Thermal Management and Reliability of Power Electronics and Electric Machines"** Sreekant Narumanchi, *National Renewable Energy Laboratory* **"A High Power-Density Three-Phase Inverter Adopting Double-End Sourced Power Module Structure"** Dr. Fang Luo, *The Ohio State University* **"Novel Packaging and Thermal Measurement for 3D Heterogeneous Stacks"** Theodore Harris, *NC State University*
5:30 PM – 7:30 PM	***Welcome Reception & Vendor Exhibits***

	Tuesday, Jun.14th
7:30 AM – 5:30 PM	**Registration Open**
7:30 AM – 8:00 AM	**Breakfast**
8:00 AM – 9:55 AM	***Plenary Road Mapping***
	Chair: Brian Narveson, *PSMA* **Keynote Speakers:** ***"2017 iNEMI Roadmap Process and a Preview of Selected IoT/Wearables, Packaging & Board Assembly Chapter Highlights"*** Chuck Richardson, *iNEMI* ***"International Technology Roadmap for Wide Band-gap Power Semiconductors"*** Bram Ferreira, *Technical University of Delft* ***"Heterogeneous Integration for IoT, Cloud and Smart Things"*** Bill Chen, *ASE-US and IEEE CPMT*
9:55 AM – 10:20 AM	**Break**
10:20 AM – 12:15 AM	***Multiphysics Modeling & Simulation***
	Chair: Zhenxian Liang, *Oak Ridge National Laboratory* **Keynote Speaker:** ***"Automatic Thermal Calibration of Detailed IC Package Models"*** John Wilson, *Mentor Graphics* **Lectures:** **"Parasitic Induction Extraction and Verification for 3D Planar Bond All Module"** Fei Yang, *University of Tennessee, Knoxville* **"FEA-Based Thermal-Mechanical Design Optimization for DBC Based Power Modules"** Yang Xu, *NC State University* **"Decomposition and Electro-Physical Model Creation of the CREE 1200V, 50A 3-Ph SiC Module"** Adam Morgan, *NC State University*
12:15 PM – 1:15 PM	**Lunch – Networking**
1:15 AM – 3:10 PM	***Materials***
	Chair: Thomas Lei, *Ford* **Keynote Speaker:** ***"Ag Sinter Joining and Stress Migration Bonding for WBG Die Attach"*** Katsuaki Suganuma, *Osaka University* **Lectures**: **"Materials for 3D Integration"** Patrick McCluskey, *University of Maryland* **"Photocurable Dielectrics for Electronic Packaging and Encapsulant Applications"** Wuttichai Reainthippayasakul, *Penn State*

3:10 PM – 3:35 PM	**Break**
3:35 PM – 5:30 PM	***Manufacturability***
	Chair: Jared Hornberger , *Wolfspeed* **Keynote Speaker:** ***"Towards Better Power Electronic Building Blocks"*** Bram Ferreira, *Technical University of Delft* **Lectures***:* **"Design and Manufacturability of a High Power Density M2C Inverter"** Joseph Kozak, *University of Pittsburgh* **"3D System in a Package (3D SiP) with Embedded Chip, Providing Integration Solutions for Power Applications"** Lee Smith, *UTAC* **"Parametric Power Electronic Module Design Techniques for Rapid Analysis, Prototyping, and Transition to Manufacturing"** Brice McPherson, *Wolfspeed*
5:30 PM – 7:30 PM	***Networking Reception Interactive Presentations & Vendor Exhibits***
	"Advanced Multi-physics Simulation for High Performance Power Electronic Design" Xin Zhao, Yang Xu, *NC State University* **"Application of 3D Printing for Rapid Prototyping of Adv. Power Electronic Modules"** Yang Xu, *NC State University* **"A Folded GaN VRM with High Electrical and Thermal Performance"** Bo Gao, *NC State University* **"Developments for Copper-Graphite CTE-Matched Thermal Cores for High Reliability GaN Systems"** David Saums, *DS&A, LLC* **"Metallic TIM Testing and Selection for IC, Power, and RF Semiconductors"** David Saums, *DS&A, LLC* **"Enabling High Reliability Power Modules: A Multidisciplinary Task"** Li Ran, *University of Warwick*
	Wednesday, Jun.15th
7:30 AM – 5:30 PM	**Registration Open**
7:30 AM – 8:00 AM	**Breakfast**
8:00 AM – 9:55 AM	***Embedding Technologies***
	Chair: Paul McCloskey, *Tyndall National Institute, University of Cork* **Keynote Speakers:** ***"Power System-in-Package"*** Cian O'Mathuna, *Tyndall National Institute, University of Cork* **"Significant developments and trends in embedded substrate and component technologies for power applications"** Brian Narveson, *PSMA* **"On Size and Magnetics: Why Small Efficient Power Inductors Are Rare"** Charlie Sullivan ,*Dartmouth*

9:55 AM – 10:20 AM	**Break**
10:20 AM – 12:25 AM	***Embedded Components***
	Chair: Khai Ngo, *Virginia Tech* **Lectures**: **"Batch Fabrication of Radial Anisotropy Toroidal Inductors"** Charlie Sullivan, *Dartmouth* **"Small, Fast Voltage Regulators using Heterogeneous Integration"** Greg Miller, *Sarda Tech* **"High Efficiency Power Solutions by Chip Embedding"** Kay Essig, *ASE-EU* **"High performing vertical Silicon Capacitors for RF power modules"** Catherine Bunel, *Ipdia* **"Increase Power Density and Simplify Designs with 3D SiP Modules"** Jim Moss, *Texas Instruments*
12:25 PM – 1:15 PM	**Lunch – Networking**
1:15 AM – 3:10 PM	***Quality & Reliability***
	Chair: Patrick McCluskey, *University of Maryland* **Keynote Speaker:** ***"An Overview of Die Attach and Wire Bond Fatigue Models and Test Results"*** Craig Hillmann, *DFR Solutions* **Lectures**: **"An Evaluation of BME C0G Multilayer Ceramic Capacitors as Building Blocks for DC-Link Capacitors in 3D Power Electronics"** John Bultitude, *Kemet* **"Heavy Cu Wedge Bonding Ready for Mass Production"** Bill Maldonado, *Hesse-Mechatronik* **"Development of a Particle Erosion Model for Silicon Microchannel Coolers"** David Squiller, *University of Maryland*
3:10 PM – 3:35 PM	**Break**
3:35 PM – 5:30 PM	***Networking & NCSU Lab Tours***
	Laboratory For Packaging Research In Electronic Energy Systems (PREES) www.prees.org **Center For Additive Manufacturing & Logistics (CAMAL)** www.camal.ncsu.edu

ROOM LAYOUT



REGISTRATION

Registration Type	Description	Before 23 May 2016	After 23 May 2016
IEEE Member IMAPS Member PSMA Member	**Full Registration** Excludes Tutorials	$495	$595
Students & IEEE/IMAPS Life Members	**Full Registration** Excludes Tutorials	$195	$195
Non-Member	**Full Registration** Excludes Tutorials	$650	$750
Tutorials	**Monday Morning (Day 1)** Optional for All Attendees	$195	$195