

# CIPS 2024

## **Digital Twin and Virtual Release of Automotive Electronics**

Chairs: Nando Kaminski (University of Bremen, Germany), Andreas Lindemann (University of Magdeburg, Germany)

- Digital Twin and Virtual Release of Automotive Electronics..... 1**  
 Florian Loos, Johannes Schatzgy, Martin Obermayr, Markus Tauscher, Libor Sova and Milada Krejcová (ZF Friedrichshafen AG, Germany)

## **Design Automation for Power Electronics: a path towards realization**

Chairs: Nando Kaminski (University of Bremen, Germany), Andreas Lindemann (University of Magdeburg, Germany)

- Design Automation for Power Electronics: a path towards realization..... 8**  
 Kevin Hermanns (PE-Systems gmbh, Germany)

## **Potential of Monolithically-Integrated Bidirectional GaN Devices in Isolated DC/DC Converters and Soft- and Hard-Switched Inverters**

- Unlocking the Opportunities of Bidirectional GaN Devices in Isolated DC/DC Converters and Multilevel Inverters ..... 15**  
 Marco Liserre and Reza Barzegarkhoo (Christian-Albrechts-Universität zu Kiel, Germany)

## **Automotive Plug&Play Gate-Driver for 1200V Automotive SiC/IGBT Modules**

Chairs: Klaus Hoffmann (Helmut-Schmidt-Universität, Germany), Regine Mallwitz (Technische Universität Braunschweig, Germany)

- Automotive Plug&Play Gate-Driver for 1200V Automotive SiC/IGBT Modules ..... 25**  
 Michael Hornkamp (Power Integrations GmbH, Germany)

## **About the perplexing functionality of soft magnetic components in the field despite all the manufacturing and material tolerances and inaccuracies in the calculations**

Chairs: Klaus Hoffmann (Helmut-Schmidt-Universität, Germany), Regine Mallwitz (Technische Universität Braunschweig, Germany)

- Soft Magnetic Components: Functional in Practice Despite Tolerances and Calculation Inaccuracies..... 35**  
 Dennis Kampen (City University of Applied Sciences Bremen, Germany); Michael Owzareck, Sascha Langermann and Lukas Fräger (BLOCK Transformatoren-Elektronik GmbH, Germany)

## **The latest material technology to support power module packaging**

Chairs: Klaus Hoffmann (Helmut-Schmidt-Universität, Germany), Regine Mallwitz (Technische Universität Braunschweig, Germany)

- The latest material technology to support power module packaging..... 40**  
 Koji Makihara (Company of Material & Sumitomo Bakelite Co., Ltd., Japan)

## Paradigm Shift in Power Electronics Towards Circular Economy Compatibility

**Life-Cycle Carbon Footprints of Low-Voltage Motor Drives with 600-V GaN or 650-V SiC Power Transistors .....** 44

Jonas E. Huber, Luc Imperiali and David Menzi (ETH Zurich, Switzerland); Franz Musil (Fronius International GmbH, Austria); Johann. W. Kolar (ETH Zurich, Switzerland)

### Poster Sessions

**Interest of high frequency decoupling inductors for reducing common mode current in high speed switching cells.....** 54

Nicolas Botter (University of Lille, France); Yvan Avenas (Grenoble Université, France); Jean-Luc Schanen and Jean-Michel Guichon (University Grenoble Alpes, France); Wendpanga-Abdoul Bikinga (Université Grenoble Alpes, France)

**Investigating the Effect of Voltage and Current Stress on Temperature Dependent On-State Resistance in GaN HEMT Power Devices .....** 62

Tianyu Li (Otto Von Guericke University Magdeburg, Germany); Andreas Lindemann (University of Magdeburg, Germany)

**An Improved Approach for an Intermediate Measurement Routine of Dynamic on-state Resistance for GaN Power devices.....** 69

Maximilian Goller and Joerg Franke (Chemnitz University of Technologies, Germany); Gengqi Li and Josef Lutz (Chemnitz University of Technology, Germany); Gilberto Curatola and Samir Mouhoubi (Huawei Nuremberg Research Center, Germany); Thomas Basler (Chemnitz University of Technology, Germany)

**Single Supply High Voltage Module with no Auxiliary Bootstrap Network .....** 74

Claudio Villani (Università Degli Studi di Pavia, Italy & Infineon Technologies, Italy); Stefano Ruzza (Infineon Technologies, Italy); Piero Malcovati and Edoardo Bonizzoni (University of Pavia, Italy)

**Evaluation of a Rogowski-based di/dt sensing for temperature monitoring of SiC MOSFET in TO-247 package .....** 81

Julien Morand (Mitsubishi Electric R&D Centre Europe, France); Arthur Jamois (Mitsubishi Electric R and D Centre Europe, France)

**Integration of controllable inductors in hardware in the loop systems.....** 89

Herbert Maier, Jonas Pfeiffer and Michael Schmidhuber (SUMIDA Components & Modules GmbH, Germany)

**Wide Bandwidth PCB Rogowski Coil Current Sensor with Droop Suppression and DC Restoration for In-Situ Inverter Measurements .....** 95

Simon Quergfelder, Julian Sax, Thomas Heckel and Bernd Eckardt (Fraunhofer Institute for Integrated Systems and Device Technology, Germany); Martin März (Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany)

**Evaluation of the thermal fatigue and failure mechanisms on Power Modules with different types of substrates (DBC / IMS) .....** 103

Chiara Spano and Giulio Galfrè (Polytechnic of Turin, Italy); Emilio Mattiuzzo and Lorenzo Dancona (Vishay Semiconductor Italiana, Italy); Valentina Bertana (Politecnico di Torino, Italy); Luciano Scaltrito and Sergio Ferrero (Polytechnic of Turin, Italy)

**Performance Test of a 450 V Polymer Aluminium Electrolytic Capacitor.....** 110

Thomas Ebel and Shova Neupane (CIE SDU, Denmark); Rando Rassmann (University of Applied Science Kiel, Germany); Ulf Schümann (University of Applied Sciences Kiel, Germany); Matthias Hammerl (Vitesco Technologies GmbH, Germany); Andreas Greif (Vitesco, Germany)

<b>Optimized Super Cascode Circuit for Electrical Testing under High Frequencies, Voltages, and Pulse Steepness .....</b>	<b>115</b>
Christian Hüther (CRW Engineering, Germany); Tobias Raulf (Engineer at CRW, Germany); Sebastian Wels (Universität Kassel, Germany); Felix Fehmer (University Kassel, Germany)	
<b>Thermomechanical characterisation of soft potting materials and stress reduction by compressibility .....</b>	<b>119</b>
Martin Rüters and Jonas Wirries (Fraunhofer IFAM, Germany)	
<b>Nickel as Phase Growth Accelerator in Ternary Solder Systems .....</b>	<b>125</b>
Jessica Richter (University of Applied Sciences Düsseldorf, Germany); Benjamin Schellscheidt (Hochschule Düsseldorf - University of Applied Sciences, Germany); Anna Kopczynski (University of Applied Sciences Düsseldorf, Germany); Thomas Licht (Hochschule Düsseldorf, Germany)	
<b>Examination of the Pore Structure of Copper Sintered Die Attach Layers by Local Thickness Analysis and Scratch Test .....</b>	<b>131</b>
Olaf Rämer (Technische Universität Berlin & Fraunhofer IZM, Germany); Matthias Hutter (Fraunhofer IZM, Germany); Martin Schneider-Ramelow (Fraunhofer IZM & TU Berlin, Germany)	
<b>Evaluation of accuracy and performance of an optimized simulation model by measuring a manufactured test vehicle.....</b>	<b>139</b>
Gerald Weis and Janagan Pappeti Devarajulu Deenadayalan (AT & S Austria Technologie & Systemtechnik Aktiengesellschaft, Austria)	
<b>Development of High-speed Current Switch Box for Transient Thermal Characterization of SiC Power Modules .....</b>	<b>145</b>
Shuhei Fukunaga and Tsuyoshi Funaki (Osaka University, Japan)	
<b>Fast Two-Step Sintering Process with High Strength.....</b>	<b>150</b>
Benjamin Schellscheidt (Hochschule Düsseldorf - University of Applied Sciences, Germany); Anna Kopczynski and Jessica Richter (University of Applied Sciences Düsseldorf, Germany); Thomas Licht (Hochschule Düsseldorf, Germany)	
<b>Testing of SiC MOSFETs for short over-current pulses of 1 ms.....</b>	<b>153</b>
Shubhangi Bhadaria (KTH Royal Institute of Technology, Sweden); Hans-Peter Nee (KTH Royal Institute of Technology & EES/E2C, Sweden)	
<b>Analytical Design of a Finite Input Inductance 34.5 MHz Class E Inverter for Wireless Power Transfer .....</b>	<b>159</b>
Matthieu Beley, Mohamed El-Khattabi, Loris Pace and Arnaud Breard (Univ Lyon, Ecole Centrale de Lyon, INSA Lyon, Université Claude Bernard Lyon 1, CNRS, Ampère, UMR5005, 69130 Ecully)	
<b>Systematic evaluation of DC-link capacitors for GaN applications .....</b>	<b>167</b>
Tobias Fricke (TU Braunschweig, Germany); Regine Mallwitz (Technische Universität Braunschweig, Germany)	
<b>Exploring coupling coil integration in Power Semi-Conductor Modules environment for sensing in Railway traction .....</b>	<b>175</b>
Yannick Dumollard (Alstom, France); Vincent Escrouzailles (ALSTOM SA, France); Emmanuel Batista (ALSTOM, France); Damien Tisne-Grimaud (Alstom, France)	

<b>Why the 3dB bandwidth of a current sensor does not provide an exact statement about its measurement capability .....</b>	<b>182</b>
Hauke Lutzen (University of Bremen, Germany); Philipp Ziegler (University of Stuttgart, Germany); Jonas Müller (University of Bremen, Germany); Jörg Roth-Stielow (University of Stuttgart, Germany); Nando Kaminski (University of Bremen, Germany)	
<b>A high voltage DC/AC unipolar converter to drive a piezoelectric actuator with controlled response times .....</b>	<b>190</b>
Nassim Bennacer (University Claude Bernard Lyon 1, France); Christian Martin (Univ Lyon, UCB Lyon 1, CNRS, AMPERE, France); Loris Pace (Ecole Centrale de Lyon, France)	
<b>Balanced core fluxgate DC current transducers for high precision measurement up to 10 MHz .....</b>	<b>196</b>
Roland Buerger ( & Danisense, Germany); Morten Birkerod Lillholm and Henrik Elbæk (Danisense, Denmark)	
<b>Voltage-Sensorless Control and GaN Multilevel Converter for Charging Non-Linear and Lossy Electrocaloric Capacitors.....</b>	<b>202</b>
Stefan Mönch, Richard Reiner, Michael Basler, Patrick Waltereit and Rüdiger Quay (Fraunhofer IAF, Germany); Kilian Bartholomé (Fraunhofer IPM, Germany)	
<b>Technique for Measuring the Capacitance-Voltage Characteristics of GaN and SiC Bidirectional Power Switches .....</b>	<b>208</b>
Michael Bosch, Dominik Koch, Jeremy Nuzzo and Ingmar Kallfass (University of Stuttgart, Germany)	
<b>Optimal parameters design of bidirectional buck-boost three-level DC-DC converter based on Pareto front for electrochemical energy storage .....</b>	<b>213</b>
Zechun Dou, Bo Tan, Le Wentao, Yu Qi and Yanping Chen (CRRC, China)	
<b>A Systematical and Analytical Driver Layout Design Procedure for Parallel GaN GIT Power Semiconductors.....</b>	<b>220</b>
Moritz Peinsipp (Fraunhofer Institute for Energy Economics and Energy Systems Technology, Germany); Bikash Sah (Hochschule Bonn-Rhein-Sieg, Germany); Sebastian Sprunck (Fraunhofer Institute for Energy Economics and Energy Systems Technology, Germany); Marco Jung (Fraunhofer Institute for Energy Economics and Energy System Technology, Germany)	
<b>Influence of Vds Bias on SiC MOSFET Dynamic Gate Stress .....</b>	<b>228</b>
Mathias Gebhardt and Gabriel Lieser (SET GmbH, Germany)	
<b>Investigation of TSEPs for junction temperature estimation of GaN and SiC devices in power cycling tests .....</b>	<b>233</b>
Dennis Wöhrlé and Daniel Wattenberg (Fraunhofer Institute for Solar Energy Systems ISE, Germany); Bruno Burger (Fraunhofer-Institut für Solare Energiesysteme ISE, Germany); Oliver Ambacher (University of Freiburg, Germany)	
<b>Challenges of Junction Temperature Calibration of SiC MOSFETs for Power Cycling - a Dynamic Approach .....</b>	<b>239</b>
Jakob Breuer and Fabian Dresel (Fraunhofer IISB, Germany); Andreas Schletz and Johannes Klier (SCHLETZ GmbH, Germany); Jürgen Leib (Fraunhofer-Institut für Integrierte Systeme und Bauelementetechnologie, Germany); Martin März (Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany); Bernd Eckardt (Fraunhofer Institute for Integrated Systems and Device Technology, Germany)	
<b>A Fast Source to Drain Voltage Measurement in Bridge Topologies Using a Freewheeling Path for Dynamic Power Cycling Tests .....</b>	<b>246</b>
Kevin Muñoz Barón, Sarthak Swaroop Dash, Oleksandr Solomakha and Ingmar Kallfass (University of Stuttgart, Germany)	

**Evaluation of failure modes in film capacitors after accelerated lifetime testing compared to field returns..... 253**

Marco Rudolph (Fraunhofer Institute for Microstructures of Materials and Systems IMWS, Germany); Falk Naumann (Fraunhofer Institute for Microstructure of Materials and Systems IMWS, Germany); Bolko Mühs-Portius (Fraunhofer Institute for Microstructures of Materials and Systems IMWS, Germany); Sandy Klengel (Fraunhofer Institute for Microstructure of Materials and System, Germany); Jan Knoch (Electronicon Kondensatoren GmbH, Germany)

**Implementation of a Junction Temperature Cycle Recorder in a Battery Electric Vehicle and Accuracy Assessment by Road Testing ..... 259**

Marco Denk, Marvin Esau, Ole Ubben and Sascha Fritsch (University of Applied Sciences Coburg, Germany)

**Accelerated Quality Testing for Coatings in High Voltage Applications ..... 267**

Markus R. Meier, Helmut Schweigart and Mirco Eckardt (ZESTRON Europe, Germany)

**Condition Monitoring of Power Modules for SiC and GaN Semiconductors by Piezoelectric Effect..... 273**

Philipp Bickel (Hochschule Bonn-Rhein-Sieg and Siemens AG, Germany); Marco Jung (Bonn-Rhein-Sieg UAS, Germany); Albrecht Donat and Kai Kriegel (Siemens AG, Germany); Gerhard Mitic (Siemens, Germany); Christian Walbrecker-Baar (Siemens AG, Germany)

**A Novel Multi-Stage Ensemble Method for Online Junction Temperature Estimation of SiC MOSFETs ..... 281**

Zekun Li, Puzhen Yu and Bing Ji (University of Leicester, United Kingdom (Great Britain)); Wenping Cao (Anhui University, China)

**Reliability Analysis of Power Electronics Encapsulations using Electrochemical Impedance Spectroscopy ..... 287**

Paul Gierth, Uta Gierth, Michael Schneider and Lars Rebenklau (Fraunhofer IKTS, Germany); Markus R. Meier, Helmut Schweigart and Mirco Eckardt (ZESTRON Europe, Germany); Peter Schrems (IPS-Elektroniklabor GmbH, Germany)

**Reducing SMPS Size and Losses with a Novel Piezoelectric EMI Filter..... 292**

Florian Hubert (University of Freiburg, Freiburg, Germany); Daniel Kuebrich and Thomas Duerbaum (University of Erlangen Nuremberg, Germany); Stefan Rupitsch (Albert-Ludwigs-Universität Freiburg - IMTEK, Germany)

**A high-frequency performance and degradation study of adhesive conductive EMI shielding tapes during High-Temperature Storage ..... 297**

Norbert Seliger and Cordula Helmbrecht (Technische Hochschule Rosenheim, Germany)

**Adaptive Dead Time Control for GaN HEMTs Based on a Time-Discrete Extremum-Seeking System..... 304**

Tobias Fink (Universität Stuttgart, Germany); Dominik Koch and Ingmar Kallfass (University of Stuttgart, Germany)

**A three-phase coupled inductor for a medium voltage high power charging system ..... 310**

Christian Blaum (SUMIDA Components & Modules GmbH); Philemon Wrensch, Jonas Pfeiffer, Christoph Drexler and Michael Schmidhuber (SUMIDA Components & Modules GmbH, Germany); David Derix and Andreas Hensel (Fraunhofer ISE, Germany)

**Metal-Air-FR4 Electrical Field Management with Embedded Electrical Field Plates for PCB Embedded Power Electronics ..... 318**

Paul Bruyere (Univ Grenoble Alpes, CNRS, Grenoble INP\*, G2ELAB & Ecole Centrale de Lyon, INSA Lyon, Universite Claude Bernard Lyon 1, CNRS Ampère, France); Eric Vagnon (Ecole Centrale de Lyon, France); Yvan Avenas (Grenoble Université, France); Mohamed El-Khattabi (CNRS, France)

**Test bench for the characterization of two-phase passive immersion cooling of power electronic devices .....** **325**  
 Clément Hugon (Grenoble-INP & G2Elab, France); Yvan Avenas (Grenoble Université, France); Samuel Siedel (Grenoble Institute of Technology, France); Sébastien Flury (G2Elab, France)

**Stray Inductance of a Modular Switching Cell Designed for Easier Disassembly.....** **333**  
 Moises Ferber de Vieira Lessa (Université Grenoble Alpes & Universidade Federal de Santa Catarina, France); Paul Bruyere (Univ Grenoble Alpes, CNRS, Grenoble INP\*, G2ELAB & Ecole Centrale de Lyon, INSA Lyon, Universite Claude Bernard Lyon 1, CNRS Ampère, France); Nicolas Botter (University of Lille, France); Alejandro Emmanuel Can Ortiz (Universite Toulouse III - Paul Sabatier, France); Souhila Bouzerd (Université Gustave Eiffel, France); Jean-Michel Guichon (University Grenoble Alpes, France); Jean-Luc Schanen (Grenoble Electrical Engineering Laboratory, France); Alexis Derbey (G2Elab, France); Eric Vagnon (Ecole Centrale de Lyon, France); Celine Combettes (Université Toulouse III, France); Vincent Bley (Université de Toulouse UPS INPT LAPLACE, France); Emmanuel Sarraute (Université Toulouse, France); Laurent Dupont (Université Gustave Eiffel, France & Laboratoire SATIE, France); Yvan Avenas (Grenoble Université, France)

**Accelerated Voltage Endurance Test and Insulation Lifetime Estimation of Silicone-Gel Encapsulated Direct-Bond-Copper Substrates for Medium-Voltage Power Module Packaging.....** **341**  
 Yuan Gao (Aalborg University, Denmark); Zichen Zhang and Zachary Zintak (Virginia Tech, USA); Emmanuel Arriola (De La Salle University, Philippines); Thore Aunsborg and Stig Munk-Nielsen (Aalborg University, Denmark); Guo-Quan Lu (Virginia Tech, USA)

**Die-Level Series-Connection of SiC MOSFETs and Integration of Decoupling Capacitors .....** **346**  
 Tobias N Ubostad (Norwegian University of Science and Technology, Norway); Dimosthenis Peftitsis (Norwegian University of Science and Technology, NTNU, Norway)

**A Parasitic Extraction Strategy for Four-Terminal Power Devices.....** **353**  
 Mathias Carl Johannes Weiser and Ingmar Kallfass (University of Stuttgart, Germany)

**Evaluation of Different Diode Technologies in a Si-SiC Hybrid Switch Used in a 540V/30kVA Inverter.....** **361**  
 Marco V. T. Andrade and Bernardo Cougo (IRT Saint-Exupery, France); Lenin M. F. Morais (Universidade Federal de Minas Gerais, Brazil); Gustavo S. Zapulla (IRT Saint-Exupery, France)

**Investigation on failure mechanisms of a PCB based package using DC active power cycling .....** **368**  
 Rémi Perrin and Pierre-Yves Pichon (Mitsubishi Electric R&D Centre Europe, France); Julien Morand (Mitsubishi Electric R&D Centre Europe, France); Johan Le Leslé and Guillaume Lefevre (Mitsubishi Electric R&D Centre Europe, France)

**DC and AC Side Filter Design for Interleaved Three Phase Three Level ANPC High Power GaN-PV Inverters Using Coupled AC Inductors**  
 Fan Wang (Fraunhofer Institute for Energy Economics and Energy System Technology IEE, Germany); Valentin Wagner (University of Applied Sciences Cologne, Germany); Sebastian Sprunck (Fraunhofer Institute for Energy Economics and Energy Systems Technology, Germany); Christian Dick (TH Köln, Germany); Marco Jung (Fraunhofer Institute for Energy Economics and Energy System Technology, Germany)

**GaN power converter with low inductive hybrid PCB technology**  
 Gerrit Braun, Julian Wethmar and Jan-Thorben Kessler (SMA Solar Technology AG, Germany)

## S05: Solder and Sinter Reliability

<b>The Reliability of High Temperature Pb-Free Solder for High Power Semiconductor Device Packaging .....</b>	<b>392</b>
Maryam Khalilah Binti Mat, Thomas Grant, Muhammad Morshed and Yangang Wang (Dynex Semiconductor Ltd, United Kingdom (Great Britain))	
<b>Novel low temperature alloy for molded power module soldering to customized heatsinks.....</b>	<b>399</b>
Ryan W Mayberry and Joe Hertline (Indium Corporation, USA); Aaron Hutzler (BondPulse GmbH, USA)	
<b>AC Filter Capacitors Reliability and Lifetime in Grid-Tied Inverters .....</b>	<b>403</b>
Thang Nguyen and Francois Delince (Hitachi Energy, Belgium); Fabien Meinguet (Engie Research & Innovation & Laborelec, Belgium); Alaa Hilal and Ramon Garcia-Rojo (Hitachi Energy, Belgium)	
<b>Influence of hard encapsulation onto reliability of soldered die-attach in power modules.....</b>	<b>411</b>
Mario Sprenger, Freerik Forndran and Beyza Öztürk (Vitesco Technologies, Germany); Marcel Sippel (Siemens AG, Germany); Manuela Ockel (Friedrich-Alexander Universität Erlangen-Nürnberg, Germany); Christian Goth (Vitesco Technologies, Germany); Jörg Franke (FAU Erlangen-Nuremberg, Germany)	
<b>Estimation of thermo-mechanical Anand model parameters of die-attach materials for power electronics assemblies.....</b>	<b>416</b>
Naüm Fusté (IMB-CNM CSIC, Spain); Emma Solà (Instituto de Microelectrónica de Barcelona IMB-CNM, CSIC, Spain); Oriol Aviñó (IMB-CNM CSIC, Spain); Xavier Perpiñá (CSIC Tenured Scientist, Centre Nacional de Microelectrònica (CNM-IMB-CSIC), Spain); Miquel Vellvehi and Xavier Jordà (IMB-CNM CSIC, Spain)	

## S01: Components to be integrated

<b>Anti-ferroelectric MLCCs with high energy density for DC link applications.....</b>	<b>421</b>
Holger Neubert and Christian Molin (Fraunhofer Institute for Ceramic Technologies and Systems IKTS, Germany); Sylvia E. Gebhardt (Fraunhofer Institut für Keramische Technologien und Systeme, Germany)	
<b>Design, Characterisation and Implementation of PCB Based 3-Φ Coupled Inductors for High Power Density Interleaved DC-DC Converter.....</b>	<b>426</b>
Johan Le Leslé and Guillaume Lefevre (Mitsubishi Electric R&D Centre Europe, France)	
<b>Fabrication and characterization of low value embedded resistors for use in PCB embedded RC snubber for more integrated converter .....</b>	<b>435</b>
Alejandro Emmanuel Can Ortiz and Vincent Bley (Université Toulouse III - Paul Sabatier, France); Nicolas Botter (University of Lille, France); Yvan Avenas (Grenoble Université, France)	
<b>Multidimensional Switching Loss Analysis of Various 1200 V SiC - Power MOSFET Technologies .....</b>	<b>440</b>
Ruben Schnitzler, Erine Eliana Dos Santos Gomes, Dominik Koch, Petar Rasic and Ingmar Kallfass (University of Stuttgart, Germany)	
<b>Self-controlled driver circuit optimizing dead time in fast GaN converters .....</b>	<b>446</b>
Viktoria Schwarzott (TU Berlin, Germany); Carsten Kuring (Technische Universität Berlin, Germany); Sibylle Dieckerhoff and Nick Wieczorek (TU Berlin, Germany)	

## S05: Mission Profile

<b>Sulphide dendrite growth in semiconductor power modules: Toward mission profile calculations of temperature, humidity and H<sub>2</sub>S concentration dependences .....</b>	<b>453</b>
Tobias N Wassermann (Infineon Technologies AG, Germany); Oliver Schilling (Infineon AG, Germany)	
<b>A Methodology to Estimate On-Voltage Degradation of Power Devices According to a Power Cycling Mission Profile.....</b>	<b>462</b>
Alessandro Vaccaro (University of Padua, Italy); Paolo Magnone (University of Padova, Italy)	
<b>Mission-Profile-Related Evaluation of the Threshold-Voltage Stability of SiC MOSFETs.....</b>	<b>467</b>
Joao Oliveira, Regis Meuret and Fabio Coccetti (IRT Saint-Exupery, France); Roman Boldyrjew-mast, Clemens Herrmann and Thomas Basler (Chemnitz University of Technology, Germany); Herve Morel (Université de Lyon, INSA Lyon, Lab Ampère, CNRS, France)	
<b>Reliability Assessment of Modular Multilevel Converters: A Comparative Study of MIL and Mission Profile Methods .....</b>	<b>476</b>
Miad Ahmadi, Faezeh Kardan and Aditya Shekhar (Delft University of Technology, The Netherlands); Pavol Bauer (TU Delft, USA)	
<b>Modified Approach for the Rainflow Counting Analysis of Temperature Load Signals in Power Electronics Modules .....</b>	<b>483</b>
Sebastian Letz (Fraunhofer Institute for Integrated Systems and Device Technology IISB, Germany); Dawei Zhao (Friedrich-Alexander-Universität Erlangen-Nürnberg, Chair of Electron Devices, 91058 Erlangen, Germany); Martin März (Friedrich-Alexander-Universität Erlangen-Nürnberg, Chair of Power Electronics, 90429 Nürnberg, Germany); Bernd Eckardt (Fraunhofer Institute for Integrated Systems and Device Technology, Germany); Jürgen Leib (Fraunhofer-Institut für Integrierte Systeme und Bauelementetechnologie, Germany)	

## S02: The impact of materials

<b>Horizontal Cracks in PCB Embedded Semiconductor Devices: A Real Problem or a Ghost Hunt?.....</b>	<b>490</b>
Till Huesgen and Ankit Bhushan Sharma (Hochschule Kempten - University of Applied Science, Germany)	
<b>Cu-Si<sub>3</sub>N<sub>4</sub> AMB-substrates for circuit boards in power electronics .....</b>	<b>496</b>
Axel Rost (Fraunhofer IKTS, Germany); Maciej Kuczynski (AlzChem, Germany); Eveline Zschippang (Fraunhofer IKTS, Germany); Peter Dold (Fraunhofer IWKS, Germany); Sindy Mosch (Fraunhofer IKTS, Germany); Stefanie dos Santos (Aurubis Stolberg GmbH u Ko. KG, Germany); Paul Gierth (Fraunhofer IKTS, Germany); Jörg Winhauer (PVA IVS, Germany); Jan Pfeiffer (PVA LWT, Germany); Jochen Schilm and Mathias Herrmann (Fraunhofer IKTS, Germany)	
<b>The Attractions, Challenges, and Potential of Copper Sinter Paste for Power Electronics Applications.....</b>	<b>503</b>
Susanne Duch (Heraeus Electronics GmbH & Co. KG, Germany); Stefan Gunst (Heraeus Deutschland GmbH & Co. KG, Germany); Sascha Reh (Technische Hochschule Aschaffenburg, Germany)	
<b>Ultrasonic Rivet Welding as Signal Technology in Power-Modules.....</b>	<b>509</b>
Florian Dreps, Nils Zoellner, Georg Borghoff and Karsten Guth (Infineon Technologies AG, Germany); Guido Strotmann (Infineon Technologies, Germany)	
<b>Evaluating non-isolated chip-assembly with direct liquid cooling.....</b>	<b>515</b>
Martin Schulz and Lukas Kreiner (Littelfuse Europe, Germany); Ralf Klemmer (Littelfuse, Germany)	

## S05: Reliability Stressors

<b>Investigation of thermo-mechanical fatigue in lateral GaN power transistors with variable switching and conduction losses.....</b>	<b>519</b>
Lukas Hein and Thomas Basler (Chemnitz University of Technology, Germany); Christian Schwabe (Technical University of Chemnitz, Germany); Maximilian Goller (Chemnitz University of Technologies, Germany)	
<b>Aging of Insulation Materials under Repetitive Impulse Voltage Stress .....</b>	<b>526</b>
Albert Claudi (University of Kassel & CRW-Engineering UG, Germany); Tobias Raulf (University of Kassel, Germany); Felix Fehmer (University Kassel, Germany); Robert Klengel (Fraunhofer Institute for Microstructure of Materials and Systems IMWS, Germany)	
<b>Energy Balancing in Paralleled SiC MOSFETs During an Avalanche Event .....</b>	<b>532</b>
Clemens Herrmann, Mengdi He, Mohamed Alaluss and Thomas Basler (Chemnitz University of Technology, Germany); Rudolf Elpelt and Guang Zeng (Infineon Technologies AG, Germany)	
<b>Characterisation of 1200 V SiC-MOSFETs - Influence of Repetitive Short-Circuit Events on Device Parameters .....</b>	<b>540</b>
Sönke Brandt, Martin Rasch and Tim Wanagat (Helmut-Schmidt-University, Germany); Klaus Hoffmann (Helmut-Schmidt-Universität, Germany)	
<b>Investigation of Moisture Absorption and Drying Characteristics of HVIGBT Power Modules .....</b>	<b>547</b>
Yasuhiro Sakai, Kazuto Mikami, Kenji Hatori, Keiichi Nakamura and Daisuke Oya (Mitsubishi Electric Corporation, Japan); Nils Soltau (Mitsubishi Electric Europe B. V., Germany)	
<b>Step-Change in HV-H<sup>3</sup>TRB Performance of Latest Silicon IGBTs and Advanced Humidity Testing Methods.....</b>	<b>553</b>
Jan-Hendrik Peters, Michael Hanf, Sven Clausner and Nando Kaminski (University of Bremen, Germany)	

## S03: Design, modelling and testing of novel technologies

<b>Automatic Generation of Thermal Models for PCB-based Power Electronics .....</b>	<b>559</b>
Bahaeddine Ben Hamed (Mitsubishi Electric R&D Centre Europe, Laboratoire Ampère ( INSA Lyon FRANCE), France); Cyril Buttay (Université de Lyon Laboratoire Ampere CNRS UMR 5005 & Insa de Lyon, France); Ahmed Sabry Eltaher Ahmed (Mitsubishi Electric R&D Centre Europe & INSA Lyon, France); Guillaume Lefevre, Guillaume Regnat and Rémi Perrin (Mitsubishi Electric R&D Centre Europe, France); Jacques Jay (Université de Lyon, France)	
<b>Optimizing Power Modules by Enhancing Power Density, Ease of Implementation and Supporting Automotive Reliability Requirements.....</b>	<b>566</b>
Holger Müller (Infineon, Germany); Marco Stallmeister (Infineon Technologies AG, Germany); Dietmar Spitzerr (Infineon Technologies, Austria)	
<b>Thermo-mechanical and electromagnetic simulations of a Half-Bridge Insulated Prepackage for Modular Power Modules.....</b>	<b>574</b>
Saimir Frroku (Ca' Foscari University of Venice, Italy); Ankit Bhushan Sharma and Till Huesgen (Hochschule Kempten - University of Applied Science, Germany); Andrea Irace (University of Naples Federico II, Italy); Giovanni Salvatore (Ca' Foscari University of Venice, Italy)	
<b>Effect of local concavity of DBC substrate on junction-to-heatsink thermal resistance of power module designs.....</b>	<b>582</b>
Dániel Csiki and Máté Buza (Vincotech Kft, Hungary); Marius van Dijk (Fraunhofer IZM, Germany); Matthias Tauer (Vincotech GmbH, Germany); Olaf Wittler (Fraunhofer IZM, Germany)	

<b>Achieving High Heat Dissipation Power Module by Developing New Die Bonding Material.....</b>	<b>588</b>
Kenji Hayashi and Kohei Tanikawa (ROHM Co., Ltd., Japan); Oji Sato (ROHM Co., Ltd, Japan); Takuzazu Otsuka and Keisuke Wakamoto (ROHM Co., Ltd., Japan); Filsecker Felipe (ROHM Semiconductor GmbH, Germany); Tsuguki Noma (ROHM Co., Ltd., Japan); Mostafa Noah (ROHM Semiconductor GmbH, Germany); Masashi Hayashiguchi (ROHM Co. Ltd., Japan); Takaharu Ishibashi (Rohm Co. Ltd., Japan); Kotaro Shibata (ROHM, Japan)	

<b>Surge current test of SiC MOSFET with planar Assembly and Joining Technology... 592</b>	
Yijun Ye (University of Technology Chemnitz & Siemens AG, Germany); Alexander Hensler and Thomas Bigl (Siemens AG, Germany); Thomas Basler and Josef Lutz (Chemnitz University of Technology, Germany); Pietro Botazzoli and Ralf Schmidt (Siemens AG, Germany)	

## S05: Power Cycling

<b>Impact of VCE, sat Measurement Conditions on Cycle-to-failure Determination of IGBT Samples in Power Cycling Test .....</b>	<b>598</b>
Yichi Zhang, Yi Zhang, Bo Yao and Huai Wang (Aalborg University, Denmark)	

<b>Influence of Current Density on Power Cycling Test Results in DC Diode-Mode and Switching MOSFET-Mode Tests .....</b>	<b>603</b>
James Opondo Abuogo (Chemnitz University of Technology, Germany); Christian Schwabe (Technical University of Chemnitz, Germany); Josef Lutz and Thomas Basler (Chemnitz University of Technology, Germany)	

<b>Substantial increase of power cycling capability of SiC MOSFETs after Preconditioning .....</b>	<b>611</b>
Carsten Kempia and Andreas Lindemann (University of Magdeburg, Germany)	

<b>Milliseconds Power Cycling (PCmsec) driving bipolar degradation in Silicon Carbide Power Devices .....</b>	<b>619</b>
Sibasish Laha (Fraunhofer IISB); Jürgen Leib (Fraunhofer-Institut für Integrierte Systeme und Bauelementetechnologie, Germany); Andreas Schletz (Fraunhofer Institute for Integrated Systems and Device Technology IISB, Germany); Martin März (Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany); Christian Liguda, Firas Faisal and Davood Momeni (Nexperia Germany GmbH, Germany)	

<b>Improvement of PC ruggedness by AlN substrate in Easy power modules with Silicone Carbide technology.....</b>	<b>625</b>
Torsten Methfessel and Paul Salmen (Infineon Technologies AG, Germany); Meng-Meng Zhou (Infineon Technology AG, Germany); Ainhoa Puyadena Mier (Infineon Technologies AG Germany, Germany)	

<b>Impact of the Level of Negative Gate Voltage on the Temperature Measurement during Power Cycling Testing of SiC MOSFETs .....</b>	<b>630</b>
Patrick Heimler, Kristiane Reiter and Marco Günther (Chemnitz, University of Technology, Germany); Josef Lutz and Thomas Basler (Chemnitz University of Technology, Germany)	

## S04: System and application aspects/S06: Clean switching and EMI

<b>Recycling potential of power electronics solutions - an exemplary study about on-board chargers.....</b>	<b>637</b>
Christine Minke (Clausthal University of Technology, Germany); Regine Mallwitz (Technische Universität Braunschweig, Germany); Daiyi Hu (TU Braunschweig, Germany); Paula Burfeind (Clausthal University of Technology, Germany)	

**Current Ripple Reduction Approaches in a Heavy Duty Fuel Cell Truck..... 646**

Yavuz Gürlek (Automotive Industry & Daimler Truck AG, Germany); Thomas Basler (Chemnitz University of Technology, Germany); Martin Ackerl, Simon Sippl, Charlotte Lang, Kristina Pfeifer and Roland Dold (Automotive Industry and Daimler Truck AG, Germany); Stanislav Pirienko and Martin Neuburger (Esslingen, Germany)

**Time-Domain Simulation Based Multi-Domain Optimization of Gallium****Nitride-Based DC/DC Converters utilizing Spice Models ..... 654**

Jeremy Nuzzo, Dominik Koch and Michael Bosch (University of Stuttgart, Germany); Tobias Fink (Universität Stuttgart, Germany); Ingmar Kalfass (University of Stuttgart, Germany)

**Switching Behaviour of 3-Level Flying Capacitor GaN Half Bridge on a Multilevel****AMB Substrate with integrated DC-Link Capacitor..... 661**

Janusz Wituski and Alexander W. Kleimaier (University of Applied Sciences Landshut, Germany)

**Hyperbolic Segmentation of Gate Driver Output Transistors for a Clean Switching****of 650V GaN HEMTs Half Bridges..... 667**

Franco Fiori (Politecnico di Torino, Italy); Marcus Nübling and Frank Klotz (Infineon Technologies, Germany)

**Ensuring optimal switching of power MOSFET by compensating V<sub>th</sub> variations****using an integrated active gate driver..... 672**

Zhengyang Feng (Toshiba Europe Ltd., United Kingdom (Great Britain)); Manish Kumar and Sheng Wang (Cardiff University, United Kingdom (Great Britain)); Shusuke Kawai, Takeshi Ueno and Hiroaki Ishihara (Toshiba Corporation, Japan); Kohei Onizuka (Toshiba Europe Ltd, United Kingdom (Great Britain))

**Keynote topic 5 - Large-Scale Adoption of Silicon Carbide in the Automotive Sector: What is Missing?**

Chairs: Norbert Seliger (Technische Hochschule Rosenheim, Germany), Eckhard Wolfgang (ECPE e. V., Germany)

**Large-Scale Adoption of Silicon Carbide in the Automotive Sector:****What is Missing?..... 678**

Francesco Iannuzzo (Aalborg Univ, Denmark)

**Reliability of GaN power chip embedding in different stack up**

Chairs: Norbert Seliger (Technische Hochschule Rosenheim, Germany), Eckhard Wolfgang (ECPE e. V., Germany)

**Reliability of GaN power chip embedding in different stack up..... 684**

Matthias Hammerl (Vitesco Technologies GmbH, Germany); Alexander Sami (Infineon Technologies AG, Germany)

**D3GaN VM044 transfer molded power module for drive train inverter - Design challenges and construction**

Chairs: Shiori Idaka (Mitsubishi Electric Europe B. V., Germany), Jürgen H. Wilde (Universität Freiburg - IMTEK & Microsystems Engineering, Germany)

**Development and testing of GaN Power Modules for EV traction inverters..... 692**

Dima Novo (VisiC Technologies Ltd, Germany)

## **Is the Motor Insulation System really affected by high Voltage Transients?**

Chair: Reinhold Bayerer (Germany)

***Is the Motor Insulation System really affected by high Voltage Transients? ..... 699***  
 Markus Fürst and Mark Bakran (University of Bayreuth, Germany)

## **S02: Material related issues**

***Thermal Coupling Assessment for a PCB-based Package with Embedded Chips and Graphite Heat Spreader ..... 707***  
 Ahmed Sabry Eltaher Ahmed (Mitsubishi Electric R&D Centre Europe & INSA Lyon, France); Bahaeddine Ben Hamed (Mitsubishi Electric R&D Centre Europe, Laboratoire Ampère ( INSA Lyon FRANCE), France); Rémi Perrin, Guillaume Regnat and Guillaume Lefevre (Mitsubishi Electric R&D Centre Europe, France); Cyril Buttay (Université de Lyon Laboratoire Ampere CNRS UMR 5005 & Insa de Lyon, France); Jacques Jay (Université de Lyon, France)

## **S03: Design, modelling and testing of novel technologies**

***Double-Side Cooled 1.2kV, 300A SiC MOSFET Phase-leg Modules for 200 kW, > 100 kW/L Traction Inverters..... 714***  
 Emmanuel Arriola (De La Salle University, Philippines); Guo-Quan Lu and Zichen Zhang (Virginia Tech, USA); Yuan Gao (Aalborg University, Denmark); Aristotle Ubando (De La Salle University, Philippines); Dong Dong and Xingchen Zhao (Virginia Tech, USA)

## **S05: Reliability and availability: Plenar Session Thursday**

***Power Cycling of Discrete SiC Power MOSFET Packages:  
 Electro-Thermo-Mechanical Modeling of Bondwires ..... 719***  
 Ivana Kovacevic-Badstuebner (Advanced Power Semiconductor Laboratory, ETH Zurich, Switzerland); Fabian Hirth (Advanced Power Semiconductor Laboratory, Switzerland); Salvatore Race (Advanced Power Semiconductor Laboratory, ETH Zurich, Switzerland); Elena Mengotti (ABB Corporate Research, Switzerland); Enea Bianda (ABB Corporate Research Centre, Switzerland); Joni Jormanainen (ABB Drives Oy, Finland); Ulrike Grossner (Advanced Power Semiconductor Laboratory, ETH Zurich, Switzerland)

***Dynamic calibration: How to properly estimate junction temperature in SiC MOSFETs subject to body diode voltage shift..... 725***  
 Mostafa Noah, Carlos Fuentes and Filsecker Felipe (ROHM Semiconductor GmbH, Germany)