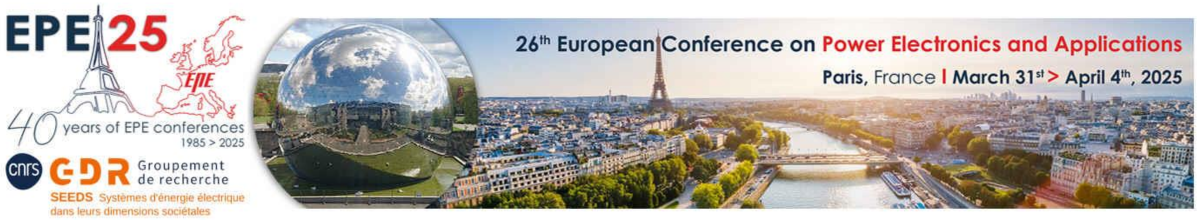

EPE’25 ECCE Europe – Call for Tutorials

Characterising GaN HEMTs & SiC MOSFETs – Device Characteristics and Characterisation

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Tutorial Objectives:

After providing a brief overview of GaN related device physics and explaining the fundamental datasheet characteristics of SiC-MOSFETs and GaN-HEMTs in comparison to Si-MOSFETs, this tutorial highlights the critical points regarding the characterisation of Wide Band Gap (WBG) power semiconductors. There will be a focus on the switching loss characterization, as it requires special attention. The influence of the applied sensing equipment on the measurement will be discussed. We investigate side effects of current and voltage probes on the DUT and provide possible solutions to get better results when characterising fast-switching WBG power semiconductors. The limits for the DPT method and estimates regarding the accuracy and applicability of the measurement principle are derived as well.

Target Audience:

This tutorial both targets participants that are new to WBG devices (or move from conventional devices to WBG devices) and the corresponding characterization techniques as well as experienced researchers and application engineers who want to get a closer look at the details and pitfalls of such measurements.

Topical Outline:

Introduction: (Estimated time: 5 minutes)

- What is the focus/content of the tutorial? What is (not) covered by the tutorial?

Topic 1: SiC and GaN Device Characteristics (Estimated time: 40 minutes)

- Explanation of different device architectures and semiconductor materials
- Comparison of datasheet parameters of Si-MOSFETs, SiC-MOSFETs, and GaN-HEMTs

Topic 2: SiC and GaN Device Characterization (Estimated time: 45 minutes)

- Pulsed characterization of output characteristic and transfer characteristic
- Static and dynamic on-state resistance

- Leakage currents and device capacitances vs drain and gate bias
- Classic threshold voltage characterization and trapping related threshold voltage shift

Topic 3: Overview to Switching Loss Measurements: (Estimated time: 45 minutes)

- Possibilities of switching loss measurements – transient and calorimetric
- Double Pulse Test in practice – setup, equipment, norms & standards
- Challenges due to fast switching Wide Band Gap devices

Topic 4: Correctly Measuring Transient Currents and Voltages: (Estimated time: 45 minutes)

- Overview of available probes
- Practical Hints for Measurements in a Double Pulse Test

Topic 5: Selecting the Right Probe for the Right Task (Estimated time: 90 minutes)

- From Rise Time to Bandwidth
- Rise Time and Bandwidth Across the Measurement Chain
- High Bandwidth Alone is Insufficient
- Bandwidth vs. (Transient) Energy Absorption
- Using Magnetic Coupling to Increase Bandwidth
- Discrete Low-Pass and High-Pass Filters
- Overview and Classification of Available Current Probes

Topic 6: Measuring Correctly vs. Measuring the Right Thing (Estimated time: 45 minutes)

- Qualitative Influence of Sensors on the Double Pulse Test
- Identification and Calculation of the influences and systematic errors

Topic 7: Available Sensors and their Suitability for Double Pulse Tests (Estimated time: 30 minutes)

- Application of the error analysis for available Sensors
- Development of a selection aid to select suitable Sensors

Topic 8: Possibilities for Error Minimizations (Estimated time: 30 minutes)

- Uncertainties caused during the Measurement
- Post Processing Error Compensation
- Influence of compensation on the switching Loss Calculation

Conclusions

- Conclusion and Discussion will be done during the individual presentations

Provisional Schedule of the Tutorial:

Schedule:

9:00 - 10:30: Introduction / Topic 1 / Topic 2

10:30 - 10:45: Coffee break

10:45 - 12:15: Topic 3 / Topic 4 /

12:15 - 13:15: Lunch break

13:15 - 14:45: Topic 5

14:45 - 15:00: Coffee break

15:00 - 16:45: Topic 6 / Topic 7 / Topic 8

About the Lecturers:

Benedikt KOHLHEPP did an apprenticeship as an electrician at Bosch Rexroth AG from 2007 to 2010. After that, he received the bachelor's degree in electrical engineering from the University of Applied Sciences, Aschaffenburg, Germany, in 2015, and the master's degree and Ph.D degree from the Friedrich-Alexander University of Erlangen-Nürnberg (FAU), Erlangen, Germany, in 2017 and 2024 respectively. Currently he is with the Technical University of Berlin, where he focusses on the characterization of GaN power semiconductors. He coordinates the DFG priority programme "GaNius", which faces the challenges and opportunities accompanied with GaN devices throughout the complete development chain – from substrates and epitaxy through devices fabrication and characterization to applications.

Marco JUNG completed an apprenticeship for communication electronics in 2003 and continued to study electrical engineering at the TH Mittelhessen University of Applied Sciences and at the University of Kassel, where he received his Diploma and M.Sc. degrees in 2008 and 2010, respectively. He continued his studies at the Leibniz University Hannover, where he received his Ph.D. degree in 2016. Parallel to his Ph.D. studies, he started working at the Fraunhofer IEE in 2010. Since 2017, he is head of the Converters and Drive Technology Department. In 2019, he additionally became a full Professor at the Bonn-Rhein-Sieg University of Applied Sciences, Sankt Augustin, Germany. At the Institute of Technology, Resource and Energy-Efficient Engineering, he is responsible for power electronics for renewable energies and electric vehicles. Mr. Jung is chairman of the IEEE Joint IES/IAS/PELS German Chapter since Jan. 1st, 2021. He is a member of the International Scientific Committee (ISC) of the European Power Electronics and Drives Association (EPE) and a member of the European Center for Power Electronics (ECPE).

Christian LOTTIS studied electrical engineering at the University of Kassel, Germany, from 2014 to 2021. He received his B.Sc. and M.Sc. degrees in 2019 and 2021, respectively. Since August 2021, he is working as a research assistant at the Bonn-Rhein-Sieg University of Applied Sciences, Sankt Augustin, Germany.

Hauke Lutzen studied electrical engineering at the University of Bremen from 2011 to 2018, obtaining his B.Sc. in 2015 and M.Sc. in 2018. Since November 2018, he has been working as a research assistant at the IALB at the University of Bremen in the department of Prof. Kaminski. His research focuses on current measurement techniques for fast transients, particularly the development of the M-shunt.