Wide Band-Gap Semiconductor Devices: State-of-the-Art and their Application Basics

Name(s) and Affiliation(s) of the Lecturer(s):

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Scope and Benefits:

Wide bandgap (WBG) semiconductors enable the next generation of power electronics. Due to their potentially lower conduction losses and lower switching losses SiC and GaN based devices pave the way towards more efficient and more compact power electronics systems. However, the devices have to be used properly to achieve the said advantages and to achieve a reliable operation. Circuit parasitics limit the achievable switching speed and chip cost force high current densities. On top come some peculiarities of the materials, which still have to be considered.

Contents:

The Tutorial will provide a wide overview of the state-of-the-art of WBG devices, their concepts and their limitations. Furthermore, an outlook will be given of what the next step in WBG devices will be like. A second part will provide an idea of critical layout features and gate drive requirements to fully utilise the devices' capabilities. Stray inductances and stray capacitances play an ever-increasing role on the path towards faster switching and even output capacitances of the WBG devices and alter the switching behaviour significantly. Thus, the usual hard switching cell comes to a limit and soft-switching might be the method of choice to overcome this barrier. The tutorial will look those aspects at least briefly.

Schedule:

The schedule is as follows:

Monday, 5 September 2022 - 1st Tutorial Day - Afternoon

14:00 - 14:20 Introduction: Why using WBG-devices?

- Material properties offer low on-resistance
- Limitations, temperature impact
- Fast switching offers low switching losses

14:20 - 14:35 SiC MOSFETs

- Concepts: no more JFETs et al., planar vs. trench gate, next step FinFET
- Challenges: Gate instability, short circuit capability, avalanche capability

14.35 - 14:50 SiC diodes

- pin diodes, bipolar degradation
- Schottky-diodes, JBS, MPS
- Integrated diodes, synchronous rectification

14:50 - 15:20 GaN devices

- Lateral HEMTs
- Challenges: current collapse, avalanche capability, short circuit
- Vertical devices, MISFETs, competition with SiC
- Diodes
- A step forward: Bidirectional switches, integration

15:20 - 15:45 Coffee break

15:45 - 15:55 Next generation WBG materials?

- Gallium oxide (Ga2O3)
- Diamond

15:55 - 16:40 Gate driving

- Driving voltages and currents
- "Driver + Supply in Package"
- Parasitic turn on

16:40 - 17:25 Packaging solutions

- Commutation Cell in Package: make handling parasitics easier
- Top side cooled semiconductors: enabling SMD assembly for power electronics
- Can WBG enable PCB winding inductors?

17:25 - 17:30 Discussion and End

Who should attend:

The tutorial is intended for a wide range of participants, from the PhD student just starting to work with WBG devices through advanced academic people all the way to industrial engineers employing WBG devices for more efficient and more compact power electronics. The participants should have some basic knowledge about semiconductor devices and power electronics circuitry. All required semiconductor physics and circuit basics will be explained in the tutorial. Nevertheless, it will be beneficial to attend the tutorial about silicon devices as well.

Technical Level:

Technical Level: advanced

About the Lecturers:

Eckart HOENE Since 1998 at Fraunhofer IZM as scientific assistant, Post Doc, group leader, business development, chief expert power electronics. PhD in 2001 at TU Berlin. Adjunct Professor at Aalborg University since 2014. His topics are packaging of power semiconductors, fast switching, parasitic effects and EMC, development in drive and solar inverters, on board chargers and others

Nando KAMINSKI received the Dipl.-Ing. (1994) and Dr.-Ing. (2001) from University of Bremen. He was PhD-candidate at the Daimler-Benz research institute in Frankfurt am Main, where he worked on SiC power devices.
From 1998 until 2008 he was with ABB Semiconductors. He worked on IGBTs, IGCTs, diodes, packaging, and reliability and finally he became head of the IGBT module fab.
2008 he joined the University of Bremen as full professor. His research interests include alternative semiconductors, material basics, device concepts, simulation, packaging, reliability, influence of parasitics, and EMC.