Power Modules

Packaging & Prototyping

Reliability & Lifetime

Fraunhofer IISB

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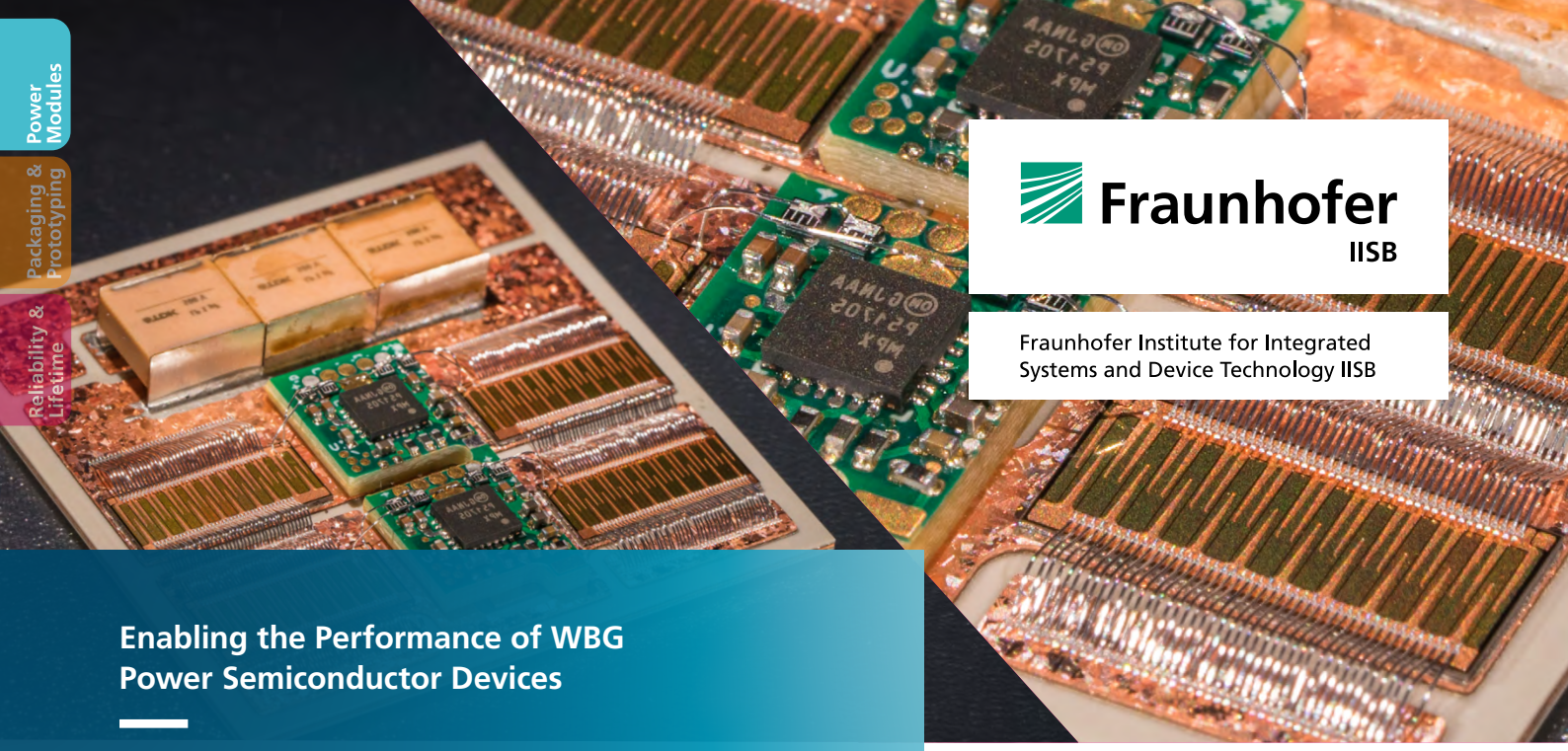


Enabling the Performance of WBG Power Semiconductor Devices

WBG Power Modules

Full GaN 400 V, 200 A half bridge power module with module integrated driver output stage © Thomas Richter / Fraunhofer IISB

Power module design

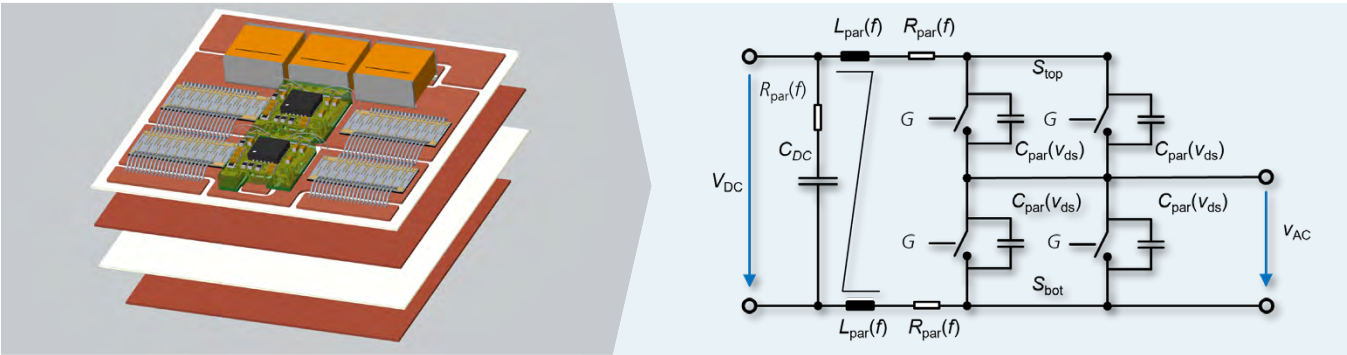
Compared to their silicon counterparts, Wide-Bandgap (WBG) power semiconductor devices require a reduced chip area to conduct a specific current value. These devices enable fast switching and consequently lower switching losses. However, the fast-switching capability directly corresponds with certain challenges during the design process of the switching cell. These challenges include:

- Compliance with the semiconductor voltage ratings
- Homogeneous current distribution in multi-chip power modules

Application and research

The Fraunhofer IISB R&D activities for customers cover circuit-simulation-supported design and validation of WBG switching cells:

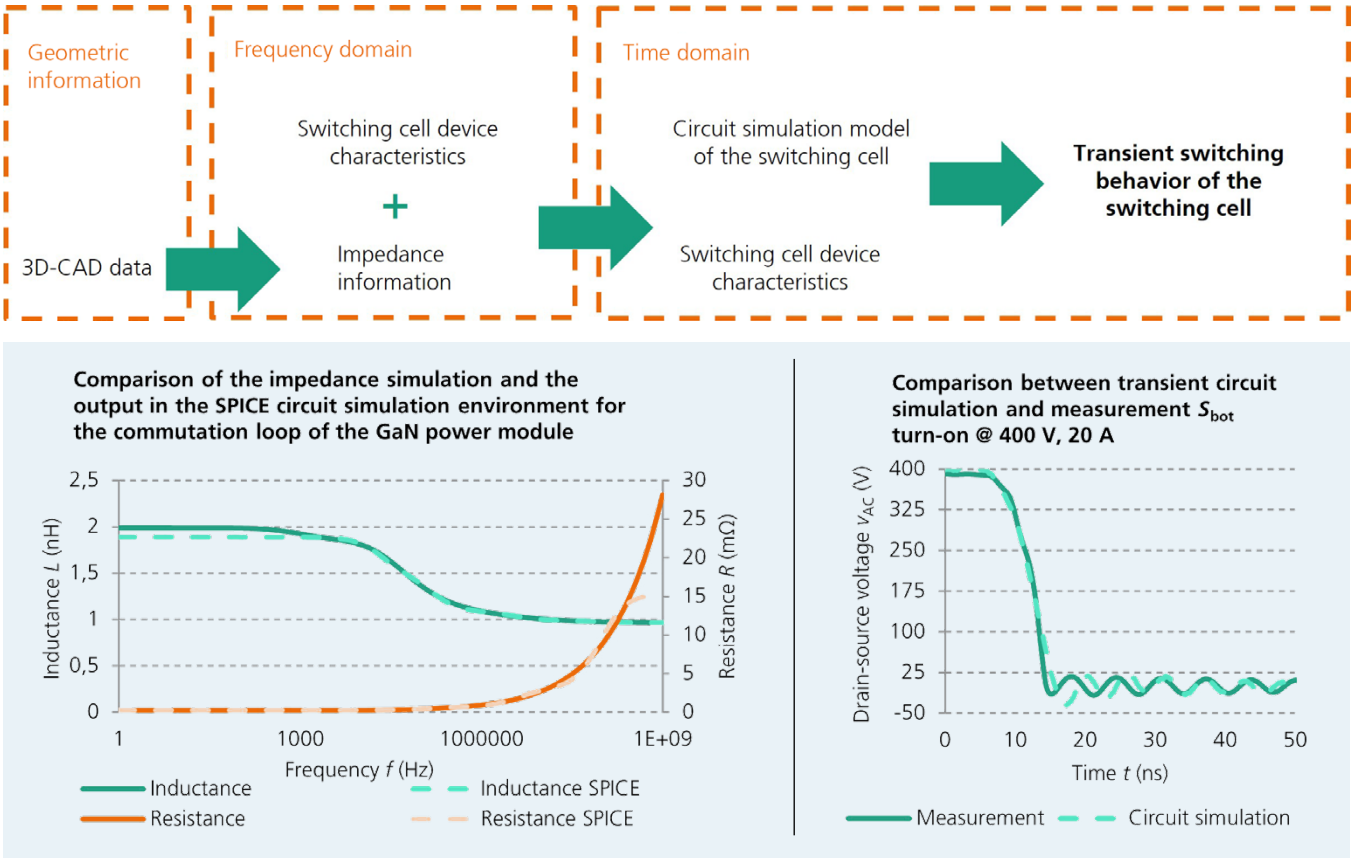
- Prediction of the switching behavior by circuit simulation models of the complete switching cell
- Application-oriented adaption of the current paths in order to generate valid switching cell designs
- Derivation of driving strategies to enable reliable operation of the power module with following validation on in-house test benches



Full GaN power module with multilayer DBC structure as solution for ultra-low inductive switching cell design. The 3D power module design is basis for the equivalent electric circuit. The circuit parameters are extracted from a Q3D RLCG frequency-dependent simulation. Frequency-dependent magnetic coupling between single current path is considered © Fraunhofer IISB

Switching cell modeling for electronic circuit simulation

Advanced packaging concepts often impede the validation and commissioning of switching cell concepts due to the inaccessibility of the power switch terminals.



Procedure for deriving the switching behaviour based on a geometric model of the power module © Fraunhofer IISB

In order to predict the current and voltage waveforms within a WBG power module during operation (right graph) the implementation of circuit simulation models with high accuracy requires detailed knowledge of the electric behavior of each individual component of the switching cell.

The information of different domains must be merged in a single time domain-based circuit simulation model of the switching cell. Using in-house developed algorithms (e.g., commutation loop, left graph) the information in the frequency domain is transformed to the time domain. Thereby, this process is compatible to all commercial EM simulation tools.

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