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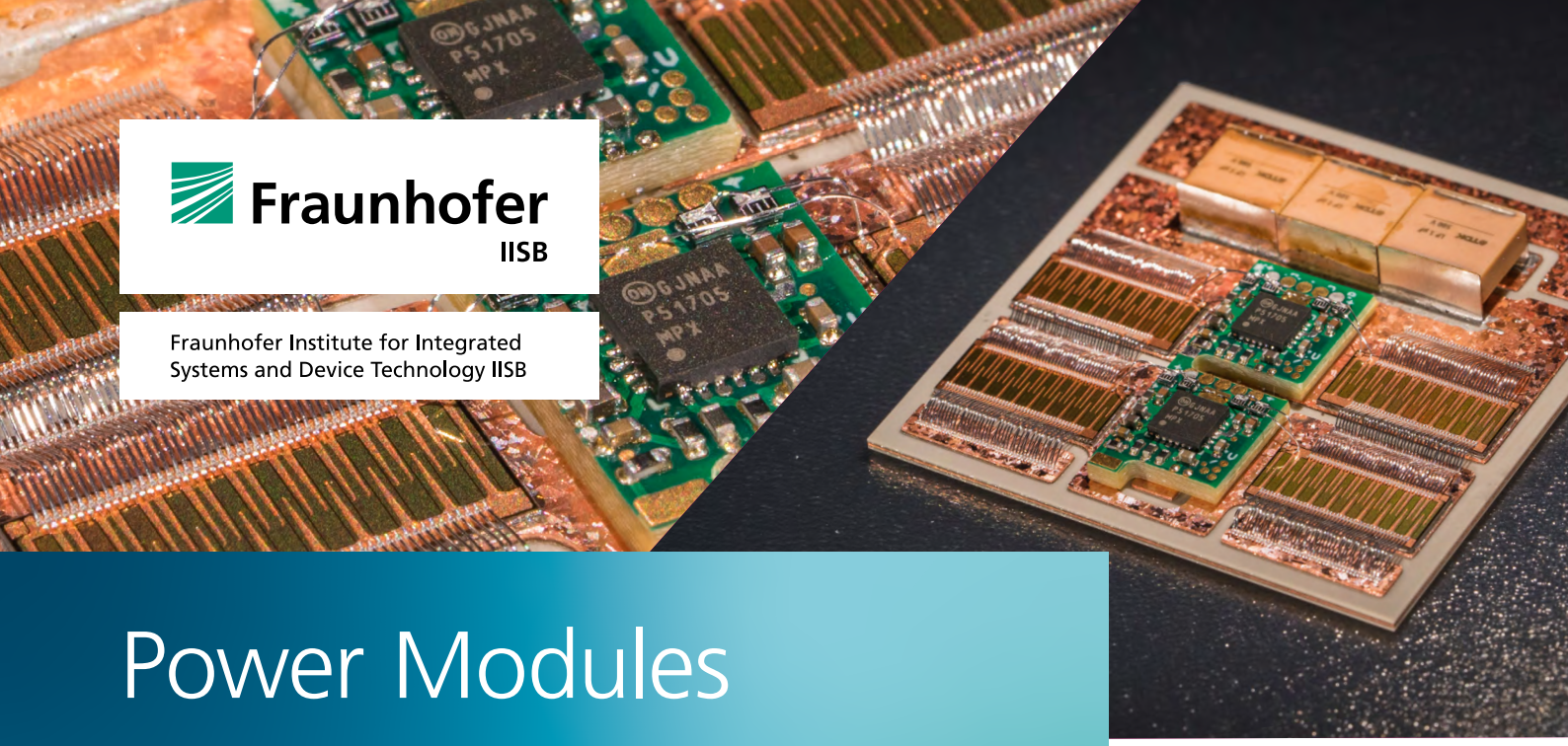

Power Modules

Enabling the Performance of WBG Power Semiconductor Devices

Full GaN 400 V, 200 A half bridge power module with driver output stage at the bottom switch
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Power Module Design

Compared to their silicon counterparts 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

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

Application and Research

The Fraunhofer IISB application and research 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

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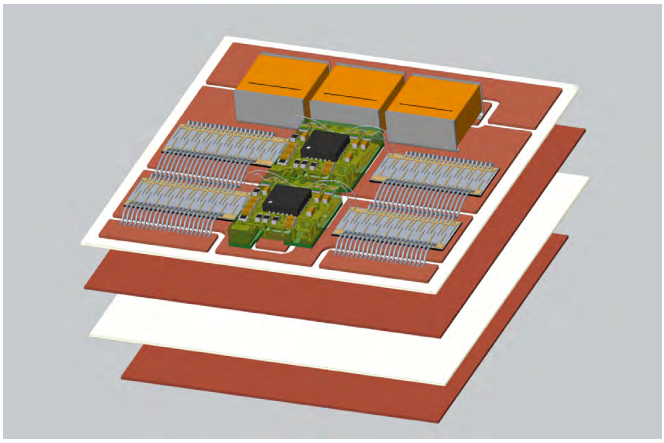
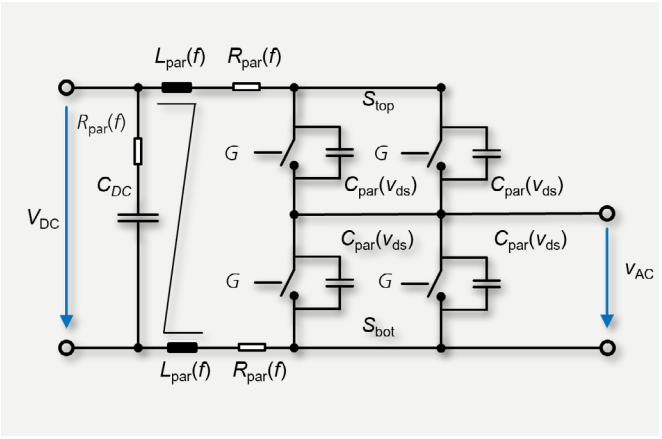


Overview of the CBC layer structure of the full GaN power module. The additional copper layer is used as the return path for an ultra-low inductive switching cell design



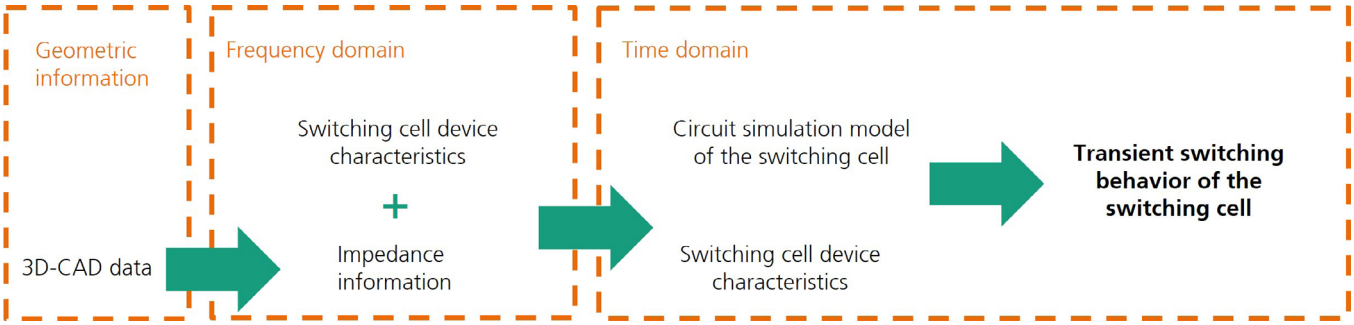
Exemplarily extracted equivalent circuit within a SPICE based simulation environment. The model contains the information from a Q3D RLCG frequency dependent simulation result and considers also the frequency dependent magnetic coupling between the single current paths

Switching Cell Modeling for Electronic Circuit Simulation

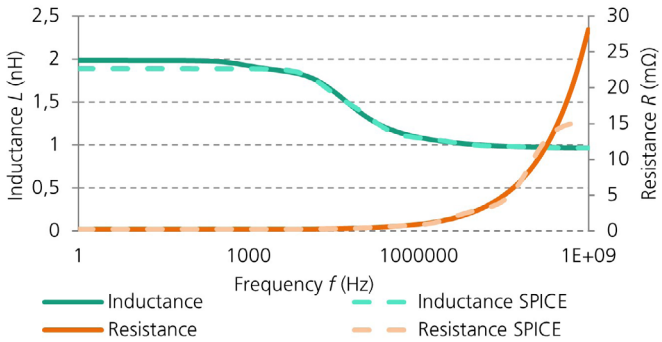
In order to predict the current and voltage waveforms within a WBG power module during operation (graph bottom right) the implementation of circuit simulation models with high accuracy requires detailed knowledge of the electric behavior of each individual component of the switching cell.

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, graph bottom left) the information in the frequency domain is transformed to the time domain. Thereby, this process is compatible to all commercial EM simulation tools.

The above-mentioned modeling process includes the following steps:



Comparison of the impedance simulation and the output in the SPICE circuit simulation environment for the commutation loop of the GaN power module



Comparison between transient circuit simulation and measurement S_{bot} turn-on @ 400 V, 20 A