Hochschule Kempten
University of Applied Sciences
Fakultät Elektrotechnik

Open Position: PhD Candidate in Power Electronics

Ampère

“Power PCB embedding for high-voltage applications”

Background

Embedding of power semiconductors in Printed Circuit Boards (PCB) is a promising technology to produce more compact, more efficient, and cheaper power converters. This is especially attractive for applications such as the electric car. Other possible applications include auxiliary supplies for high power systems (trains, HVDC converters, wind turbines), converters for the more electric aircraft, or for medical systems (X-Ray imaging, etc.).
Until now, research has focused on voltage levels below 1200V. For higher voltage levels, insulation becomes more important. The current design rules, such as described in the international standard IPC2221A are no longer applicable, as the spacing they impose is incompatible with the size of the power semiconductor devices. However, these standards were written for classical surface-mount or through-hole technology. They are probably too conservative in the case of components directly embedded within the PCB.
We propose to investigate the behaviour of PCB materials in the presence of high electric fields. Key challenges are the material selection and testing, and the design of appropriate packages.

Research Challenge

In detail the following scientific question are still open:

1. What are the insulation limits of classical PCB materials for embedded power semiconductors taking realistic semiconductor devices (silicon and silicon carbide) in consideration?
2. Can hybrid package concepts using ceramic substrates and silicone encapsulant provide better insulation?
3. How can high currents be handled – what conductor thicknesses are required?
4. Can generic design rules be established for high-voltage embedded power packages?

Approach

The topic will be addressed theoretically using state-of-the-art simulation tools and experimentally by investigation of test structures:

1. Definition of test vehicle, e.g. a 1.7kV SiC or 3.3kV Si Diode package
2. Theoretical analysis:
   - Electric field simulation
   - Loss simulation in different mission profiles
   - Thermal and thermo-mechanical simulation
   - Comparison of different insulator materials
3. Experimental analysis
   - Fabrication of test vehicles
   - High voltage insulation test (also with thermal and humidity stresses), PD - tests
   - Active load cycling until failure of package with different cycle frequencies
   - Investigation of failed devices: (X-Ray or SAM analysis, SEM images of cross-sections)
4. Optimization

- Optimization of the geometry (layout and layer stack)
- Optimization of the materials (insulation strength, thermal conductivity, CTE)
- Derivation of design rules

Funding

The “Bayerische Forschungsstiftung (Bavarian Research Foundation)” offers a scholarship program for international PhD students. The proposed research topic is linked to an existing research project, also funded by the Bavarian Research Foundation (hiDrive – highly integrated motor drive –), which focuses on the development of a motor drive with PCB embedded power semiconductors.

The scholarship comprises the following financial support for the student:

1. A monthly payment of 1500 € (free of tax)
2. Travel costs of up to 2500€ per year
3. Family care: additional 250€ per month, when married, and 160€ per month per child
4. Health care insurance support of 60€ per month

Funding is limited to 36 months.

Examination of the request takes 2-3 month. Potential project start 4-5 month after submission.

Supervision/schedule

This international research position is under the supervision of two institutions:

- University of Applied Science Kempten, Germany, which is the main hosting institution. This is where most of the work will be performed.
- Laboratoire Ampère, Lyon, France. This research laboratory (associated with the University of Lyon, the École Centrale de Lyon, INSA de Lyon and CNRS) offers a large range of high voltage testing equipment, and has a long experience in the design and test of high voltage silicon-carbide semiconductor devices. A part of the research work will be performed at Ampère, in accordance with the PhD candidate and his/her supervisors, either as a single long (several months) period, or as shorter trips.

Two researchers will supervise the research work, one from each hosting institution. The PhD candidate is expected to present his/her results in regular progress meetings (in person or remote).

Applicant profile

The applicant should have a master’s degree in electrical engineering, or in a related field (semiconductor manufacturing, materials science, micro engineering). Good experimental skills are required. The working language is English, although a good knowledge of German and/or French is also welcome.

Contact

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