DEPARTMENT OF ENERGY TECHNOLOGY
AALBORG UNIVERSITY

PhD Public Defence

Title: Packaging of Wide Bandgap Power Semiconductors using Simulation-based Design

Location: Pontoppidanstræde 111, auditorium

Time: Thursday 27 June at 13.00

PhD defendant: Asger Bjørn Jørgensen

Supervisor: Professor Stig Munk-Nielsen

Moderator: Associate Professor Christian Uhrenfeldt

Opponents: Associate Professor Pooya Davari, Dept. of Energy Technology, Aalborg University (Chairman)
Professor Mark Johnson, University of Nottingham, UK
Associate Professor Zhe Zhang, DTU, Denmark

All are welcome. The defence will be in English.

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Abstract:

Power electronic converters are used for the transformation of electric energy in applications such as wind turbines, pumps, solar arrays and many industrial processes. The main unit of any power electronic converter is the semiconductor die, which traditionally has been made from silicon. For past decades wide bandgap semiconductors, such as silicon carbide and gallium nitride, have matured. To utilize the benefits of these semiconductor materials they must be properly packaged and integrated with other parts of the power electronic converter.

This thesis presents a simulation framework for detailed modelling of electro-thermal behavior of 3D power module packaging and printed circuit board stackups used in integrated packaging. This enables rapid digital prototyping and accurate prediction of the performance prior to manufacturing and testing of the real device.

The thesis studies several aspects related to packaging of wide bandgap semiconductor power semiconductors and the experience gained from the studies is used to design and test the worlds first 10 kV SiC MOSFET power module driven in the MHz-range. Furthermore, a new power module structure is proposed for gallium nitride power devices, which is significantly easier to manufacture compared with other integrated structures. Although the new power module with gallium nitride devices is more expensive than conventional silicon power modules, its superior switching performance makes it a viable choice for future power electronics applications.