Chemnitz University of Technology
Chair Power Electronics and Electromagnetic Compatibility

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Research fields 2008

The education covers power devices, thermo-mechanical problems of power electronic systems, power circuits and electromagnetic compatibility. The focus of research is on power devices, especially their reliability. Main working fields:

- Reverse recovery of high power diodes, dynamic avalanche and ruggedness

At high stress in dynamic avalanche, current tubes or filaments occur. Of most importance is the nn^+-junction (at y=375µm in Fig. 1). Designs with improved ruggedness are deduced [1,2,3].

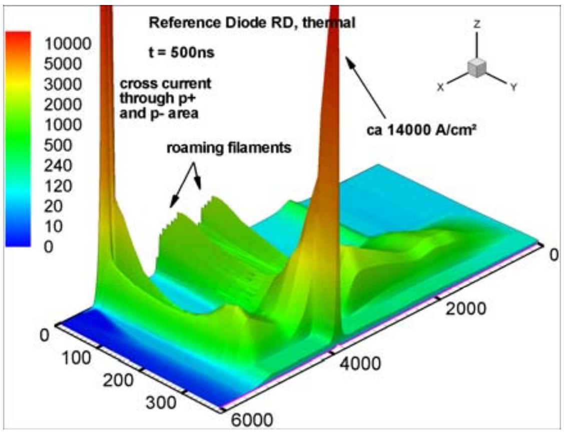

Fig. 1: Simulation of current filaments at strong dynamic avalanche. Example of 3.3kV power diode

- Surge current behaviour of power diodes in Si and SiC

Metallization thickness and interconnection pitch are of decisive influence. In the middle of the structure in Fig. 2 is a bond foot of 300µm width [4,5,6].

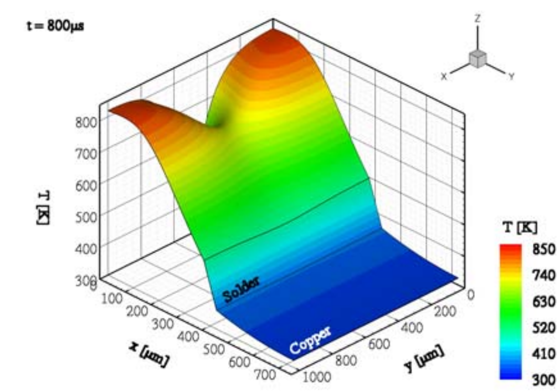

Fig. 2: Simulated temperature in a 3.3kV diode after a trapezoidal surge current pulse of 4.5kA/cm²

- Short circuit capability of high voltage IGBTs

Measurements, evaluation, analysis.

- Long term blocking stability of power devices

A hot reverse test station, DC 2500V, T_j up to 200°C has been built and is running.

- Diamond like carbon a-C:H

Deposition system with 32cm diameter process area available.

- Reliability of packaging technologies

Focus is on power cycling. Six self-build power cycling stations are running. New interconnection technologies for power cycling capability up to 200°C are investigated [7,8].

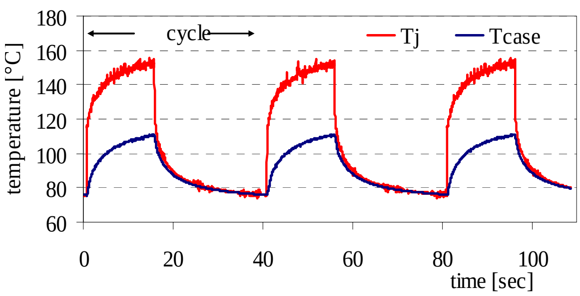

Fig. 3: Power cycling: Measured junction temperature T_j and case temperature T_{case}

- Simulation of thermal-mechanical stress in power devices

The analysis shows the local mechanical stresses and strains in the package. which result from the mismatch in the thermal expansion of the material layers (Fig. 4).

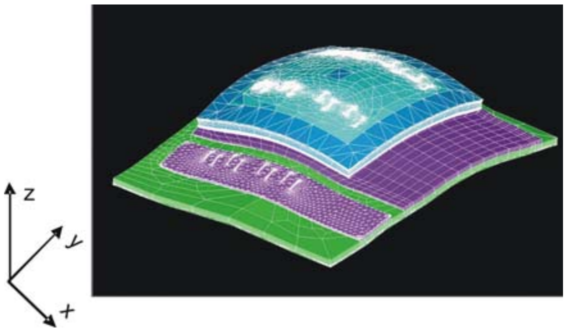

Fig. 4: Simulated mechanical deformation of a power device and substrate at power cycling. z-axis 1000x extended

- DC/DC-Converters for the integration of double-layer capacitors in automotive power-nets

Optimized converters for bidirectional power conversion.

Important research projects

SiC switching devices in matrix converters
Active and passive turn-on and turn-off characteristics, short circuit capability and behavior at paralleling have been investigated. Project finished in 2008.

Electric components for active gears - *EfA*
Joint project 2006-2010 for increased energy density of the electric components in the power train of a hybrid vehicle.

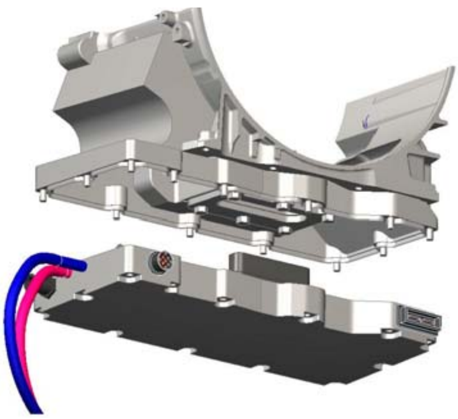

Fig. 6: Partial integration of the power electronic system in the automobile gear unit (EfA-project). Figure from ZF Friedrichshafen AG

Advanced Supercaps on base of nano-structured materials - *Nanocap*
Joint project finished in 2008. New materials for electrodes and electrolytes for a new generation of double-layer capacitors have been developed and their reliability was investigated.

Some important publications 2008

[1] R. Baburske, B. Heinze, J. Lutz, and F-J. Niedernostheide: "Charge-carrier Plasma Dynamics during the Reverse-recovery Period in p^+-n^--n^+ diodes, IEEE Trans El Dev Vol 55 No 8, pp 2164-2172 (2008)

[2] B. Heinze, J. Lutz, H.P. Felsl, H.-J. Schulze: "Ruggedness analysis of 3.3 kV high voltage diodes considering various buffer structures and edge terminations" Microelectronics Journal, Volume 39, Issue 6, Pages 868-877 (2008)

[3] H.P. Felsl, M. Pfaffenlehner, H. Schulze, J. Biermann, Th. Gutt, and H.-J. Schulze, M. Chen, J. Lutz: "The CIBH Diode – Great Improvement for Ruggedness and Softness of High Voltage Diodes", ISPSD 2008, Orlando, Florida, USA

[4] B. Heinze, J. Lutz, M. Neumeister, R. Rupp: „Surge Current Ruggedness of Silicon Carbide Schottky- and Merged-PiN-Schottky Diodes" ISPSD 2008, Orlando, Florida, USA

[5] M. Neumeister, B. Heinze, J. Lutz, R. Rupp, M. Holz: "Investigation of Surge Current Capability of SiC MPS Diodes" PCIM Europe 2008, Nuremberg, Germany

[6] B. Heinze, R. Baburske, J. Lutz, H.-J. Schulze: "Effects of Metallisation and Bondfeets in 3.3kV Free- Wheeling Diodes at Surge Current Conditions" Proceedings of the 9th ISPS, Prague, (2008)

[7] R. Bayerer, T. Licht, T. Herrmann, J. Lutz, M. Feller: "Model for power cycling lifetime of IGBT Modules – various factors influencing lifetime", Proceedings of the 5th International Conference on Integrated Power Electronic Systems, p 37-42 (2008)

[8] M. Feller, J. Lutz, R. Bayerer: „Power Cycling of IGBT- Modules with superimposed thermal cycles", PCIM Europe 2008, Nuremberg, Germany