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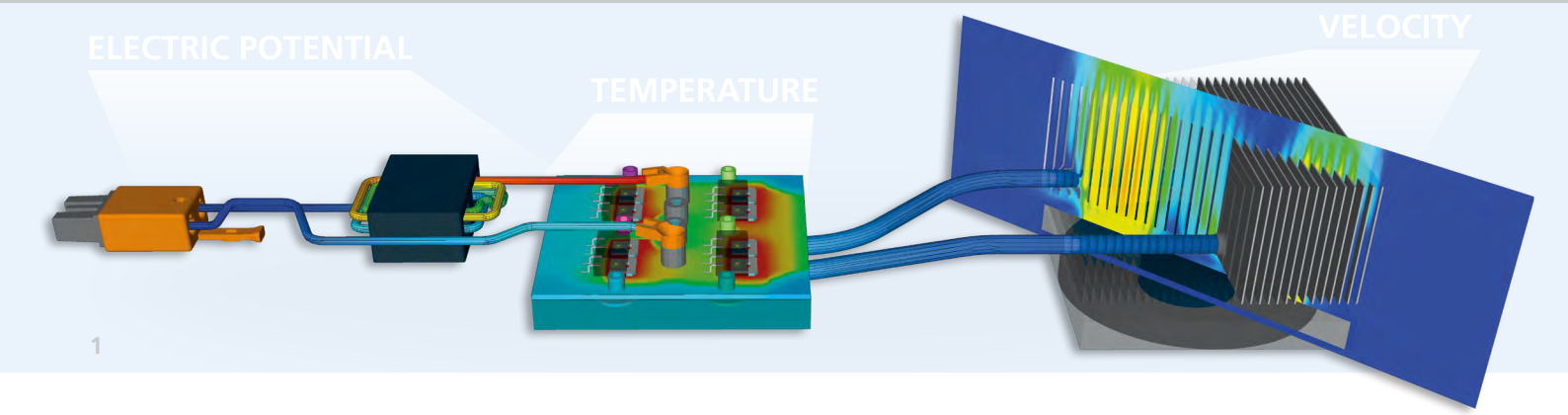
FRAUNHOFER INSTITUTE FOR INTEGRATED SYSTEMS AND DEVICE TECHNOLOGY



1 *Electronics simulation of Joule heating, component losses and forced convection*

SIMULATION FOR POWER ELECTRONICS

DEVICE, MODULE, AND SYSTEM SIMULATIONS

Supporting the development of power electronics, all simulations are closely linked to application and verified by measurements. Our measuring equipment is described in detail in extra information sheets.

Simulation subjects

- Electrical, thermal, and mechanical simulations on device, module, and system level
- Electronic cooling design, thermal management
- Coupled and multiphysics simulations
- Extraction of electric parasitics and circuit simulations
- Simulation – design – optimization – verification by measurement

Electrical, thermal, and mechanical simulation

- Electric current, potential and field strength distribution analysis
- Identification of critical areas of the insulation due to high field strengths
- Electromagnetic simulation
- Fundamental assessment of the temperature distribution
- Steady-state and transient temperature behavior
- Investigation of the temperature distribution of operating electronics
- Computation of the deformation due to temperature loads of the fabrication process or during operation
- Illustration of the internal stress of the attached materials in a stacked arrangement

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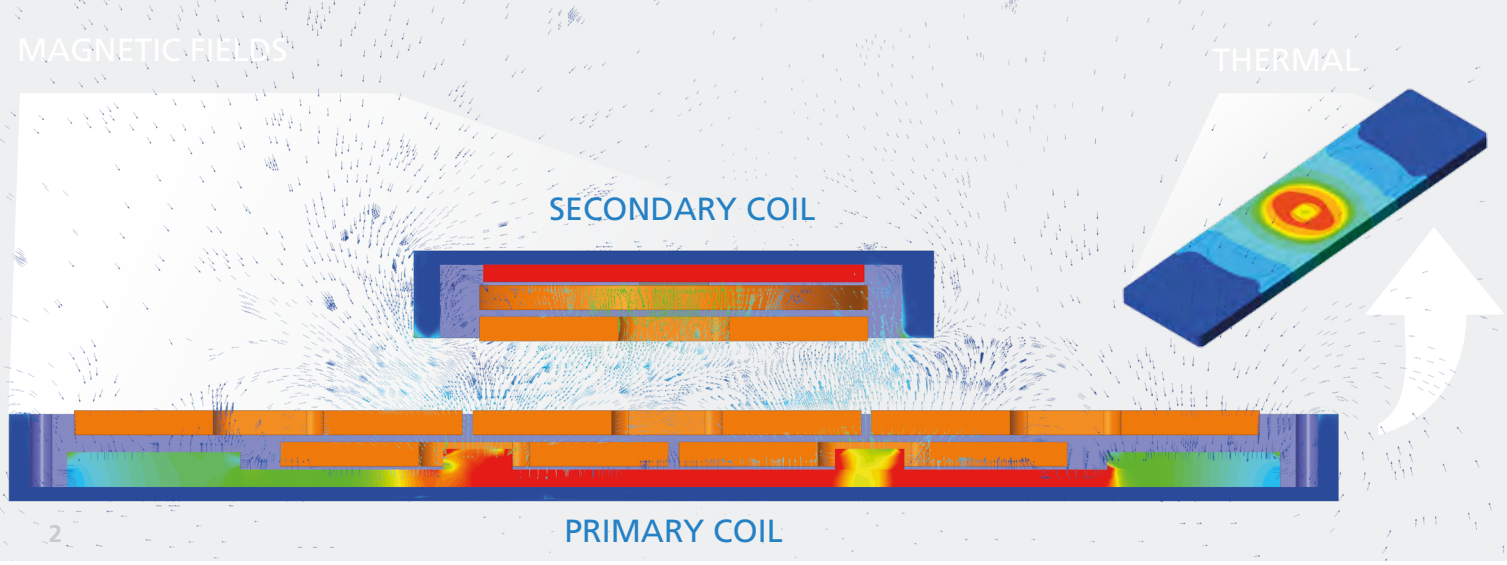

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Electronics cooling design

- Computational fluid dynamics (multi-fluid)
- Radiation and Joule heating
- Steady state and transient simulation
- Detailed chip, board, and system level within one simulation
- Complex geometries and 3D component assemblies

Multiphysics simulation

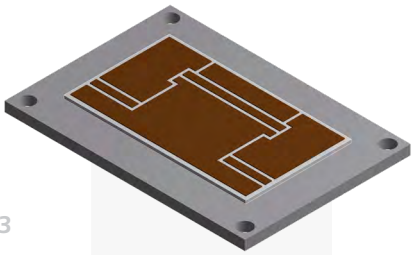
- Multiphysics coupling of simulation
- Coupled structures via electromagnetic fields
  - Coupling of coils – contactless energy transfer
  - Inductive heating of conductive components
- Coupling of simulation software – FEM calculations linked with circuit simulation

Electronic simulations

- Parasitic extraction of electronic setups – capacitance, conductance, inductance and resistance matrices
- Circuit simulation of electric circuits

Simulation – design – optimization - verification

- Power module design based on simulation
- Optimization and analysis of structures and arrangements via simulation
- Verification of test structures by various in-house measurement possibilities, for instance static and Lock-In-Thermography, indirect thermal impedance and resistance (R_{th}, Z_{th}/ different coolants, flow rates, temperatures), etc.
- Material characterization for realistic material properties as input for simulations (for example nanoindentation, tensile tests at different temperatures)



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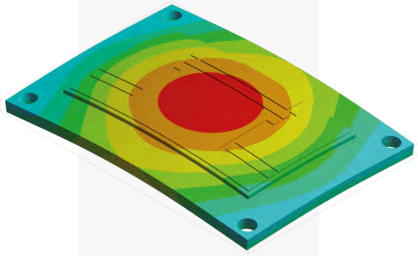
Ceramic substrate on baseplate



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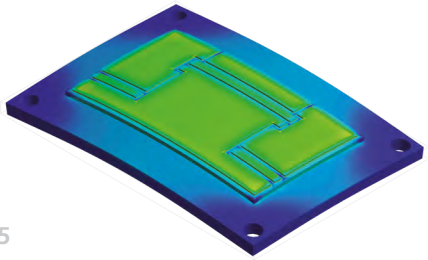
Deformation due to joining the temperature of substrate and baseplate



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Resulting stress distribution of the arrangement at room temperature

2 *Magnetic field distribution of an inductive power transfer simulation; power losses lead to a heating in the coil arrangement*

3 *Ceramic substrate on baseplate*

4 *Deformation due to joining the temperature of substrate and baseplate*

5 *Resulting stress distribution of the arrangement at room temperature*