Power Modules

Packaging & Prototyping

Reliability & Lifetime

Fraunhofer IISB

Fraunhofer Institute for Integrated Systems and Device Technology IISB

For Power Electronics Assemblies

Lifetime Prediction

Crack propagation in sintered die-attachment layer experiment © Fraunhofer IISB

Lifetime & reliability considerations during product development

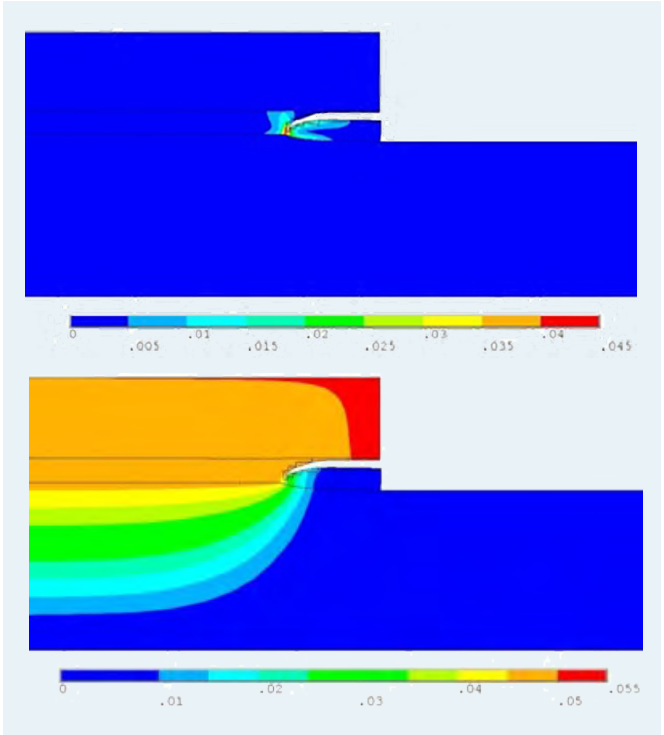
One essential goal of the design process of an electronic product is to create a robust and reliable design that meets the demands from field operation. Typical measurement values, the number of failures per operation time and their distribution are evaluated. Using accelerated aging tests together with numerical simulations, it is possible to get access to these quantities and to predict the lifetime of a product for different load cases.

Application and research

- Development of lifetime estimation strategies (experimental and theoretical)
- Statistical methods according to industrial standards and guidelines
- Numerical and analytical modeling of physical degradation mechanisms
- Objectives: electronic systems, subsystems, and components (e.g., converters, power modules, semiconductors, capacitors, inductors, etc.)

A typical lifetime prediction analysis involves the following steps (see backside)

We support our customers during each step to avoid over-engineering, increase power density, and enhance the competitiveness of your products.



top: Simulated deformation field, bottom: simulated stress field © Fraunhofer IISB

Example: lifetime analysis simulation chain

1 Mission profile
- Use cases, e.g. drive cycles
- Operating data, e.g. V and I vs. Time

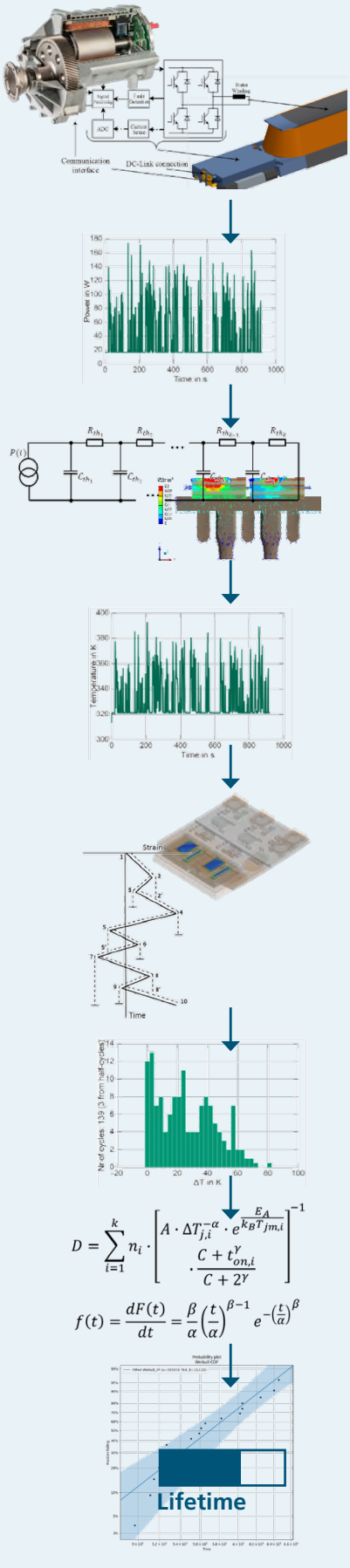
2 Power loss profile
- Electrical simulations
- Empirical mathematical relations

3 Temperature profile
- 3D-transient thermal Finite-Element-Analysis
- 1D-modeling by electro-thermal circuits

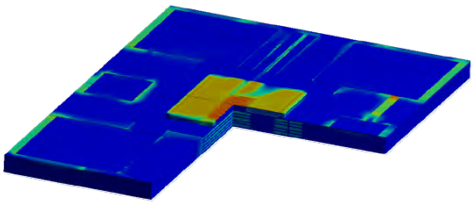
4 Load analysis
- Constant, variable, block, and random loads
- Extraction of hysteresis loops from load signal by use of counting algorithms

5 Lifetime model
- System response and damage variables
  - Accelerated ageing tests (e.g. power cycling, thermal cycling, shock tests, etc.)
  - Nonlinear transient Finite-Element-Analysis
- Modeling of damage evolution
  - Empirical, by observable variables, e.g. heating voltage, thermal resistance
  - Physical, by internal state variables, e.g. inelastic strain, plastic strain energy density, damage variables (CDM)

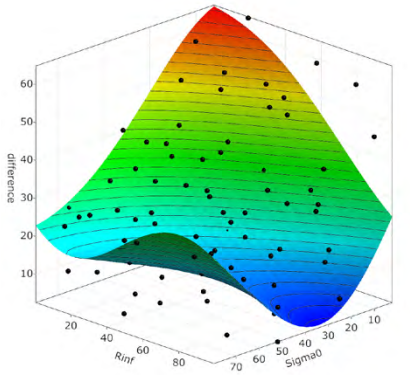
6 Prediction of lifetime
- Accumulation of damage per load increment
- Calculation of predicted lifetime



Lifetime analysis simulation chain © Fraunhofer IISB



Finite-Element-Analysis of GaN-on-PCB-Package © Fraunhofer IISB



Response surface from parameter sensitivity analysis © Fraunhofer IISB

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