Fraunhofer
IISB

Fraunhofer Institute for Integrated
Systems and Device Technology IISB

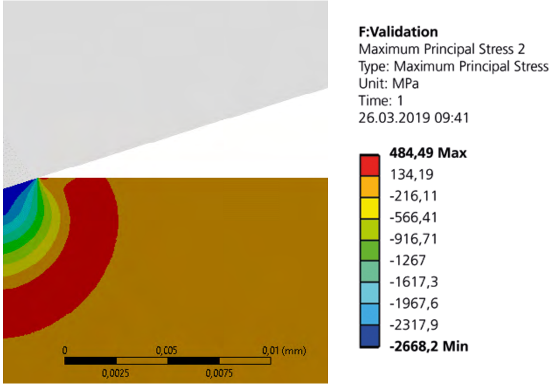
For Power Electronics Applications

Material Characterization and Modelling

Fracture surface of sintered die-attachment layer tested at 200° C, Center: FE-Simulation of principal stress field during a nanoindentation experiment © Fraunhofer IISB

Benefits in the field of power electronics

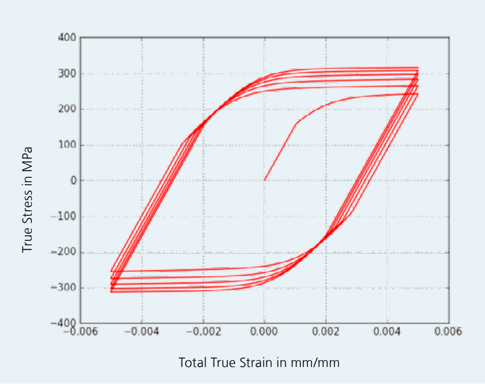
- Analyse thermal and mechanical material properties for the use in Finite-Element-Simulations (FEM)
- Obtain best material design and combinations for a specific application
- Find optimal manufacturing parameters for processing of solder- and sinter-interconnections, casting compounds, base plates, housings, terminals, windings, dielectrics, and many further materials and components
- Understand process-lifetime-reliability-interactions for a product
- Improve lifetime and reliability of your packaging concepts



FE-Simulation of principal stress field during a nanoindentation experiment © Fraunhofer IISB

Research areas and services at Fraunhofer IISB

- In-situ temperature-dependent characterization of mechanical properties of electronic packaging materials including creep, cyclic, and fracture behavior
- Nanoindentation method for local analysis of material behavior and direct probing of samples to take the complete process history into account
- Modelling of nonlinear mechanical material behavior and further special material effects that can be implemented in the finite-element-code
- Ageing of packaging materials during accelerated lifetime or field tests: Investigation of microstructure evolution and effective mechanical behavior, they can be seen as light weight insulation that is especially interesting for aerospace application



Hysteresis loop for combined nonlinear isotropic-kinematic viscoplastic hardening material © Fraunhofer IISB

Steps of Material Modelling

1 Mechanical characterization
- In-situ mechanical testing: tension, compression, cycling, 4-pt.-bending, fracture mechanics
- Nanoindentation and nanoscratch testing
- Nanomechanical topography analysis
- Testing temperature up to 500 °C

2 Thermal characterization
- Simultaneous thermal analysis (DSC+TGA)
- Thermomechanical analysis: CTE, thermal deformation

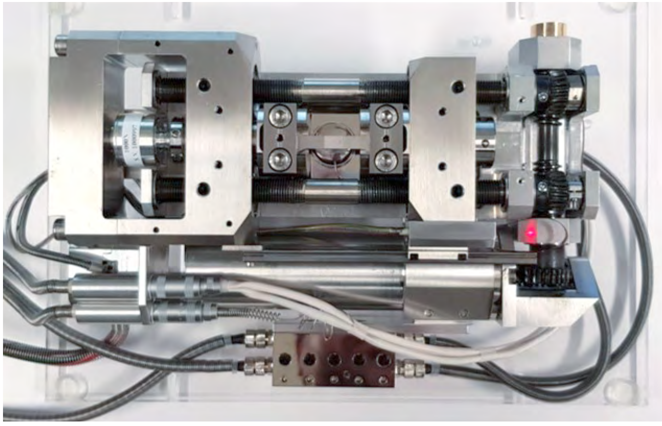
3 Optical characterization
- Optical (light) microscopy
- Dual beam Xe$^+$-FIB/SEM (tomography)

4 Structural/Chemical characterization
- Electron backscattering diffraction (EBSD)
- X-ray microanalysis (EDS)

5 Simulation methods
- Finite-Element-Method, Finite-Volume-Method
- Multiscale: Representative-Volume-Element analysis
- Inverse model parameter identification

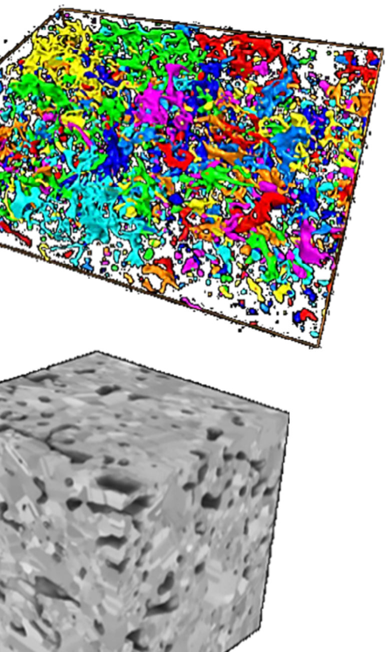
6 Specimen development and preparation
- All relevant electronic packaging technologies available
- Macroscopic to microscopic sample sizes
- Optimization of specimen design and manufacturing

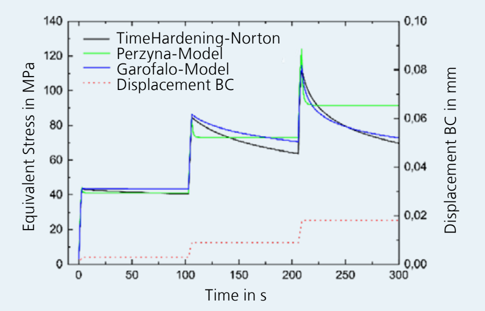
Xe+-Dual beam plasma FIB system at the IISB © Kurt Fuchs / Fraunhofer IISB



In-situ mechanical test module © Fraunhofer IISB

Left: 3d-Pore network reconstruction of sintered silver interconnection obtained by FIB-tomography. Right: Representative-volume-element for investigating microstructural impact on macroscopic behavior © Fraunhofer IISB





Different model predictions for a multiple-hardening-relaxation test at elevated temperature. © Fraunhofer IISB

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