MATERIAL CHARACTERIZATION
FOR POWER ELECTRONICS
PACKAGING MATERIALS

Why material characterization?

- Get thermal and mechanical properties for Finite Element Simulations (FEM)
- Reveal best material combination for specific application
- Find adequate parameters for processing of solder- and sintering-layers, casting compounds, base plates, housings, terminals, interconnections, windings, dielectrics
- Improve life time and reliability of packaging concepts
- Reduce development time and costs

Research and applications

- Temperature dependent characterization of mechanical properties including creep-, fatigue-, fracture- and failure-investigations
- Material property mapping by spatially resolved nanoindentation at small scales
  Application examples: Intermetallic phases, die-attaches, bond wires, phase boundaries and spatial property gradients
- Thermal analysis of materials: Specific heat of semiconductors, die-attaches, solder pastes (evaporation of fluxes, melting temperature, solidification behavior), sintering pastes (drying and sintering time, temperature, and atmosphere), substrates, TIMs
Assembly of test specimens

- Soldering: All kind of solders (lead-free, lead, gold, etc.)
- Silver-sintering: Representative specimens for tensile tests and nanoindentation
- Wire ultrasonic bonding and resistance welding
- Polishing, Etching, Micro machining

Tensile and compression testing

Global mechanical material parameters:
- Temperature dependent
- Elastic properties, tensile-, compressive-, yield-, creep- and fatigue strength
- Different strain rates for time-dependent material behavior
- Stress-strain curves for nonlinear FEM
- Special data for material models, e.g. Ramberg-Osgood, Anand, Garofalo

Nanoindentation

Local, global and gradients in mechanical material parameters:
- Temperature dependent
- Elastic modulus, hardness, creep parameters
- 3D-Mapping of material properties
- Quantitative scratch and wear testing
- According to test standard ISO 14577

Simultaneous thermal analysis STA

Thermal material parameters:
- Characteristic temperatures (sintering, melting, formation of intermetallics, decomposition, oxidation, glass transition)
- Temperature dependent specific heat capacity measurements
- Analyse of peak areas in dependence of mass change
- Kinetics of reactions, for instance oxidation and sintering
- Evaluation of mass change steps, for instance leakage of organics and debinding

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Uniaxial Testing</th>
<th>Nanoindentation</th>
<th>STA</th>
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</thead>
<tbody>
<tr>
<td>Rectangular cross section from sheets to bulk materials</td>
<td>Liquid or solid objects</td>
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<tr>
<td>Rectangular cross section from sheets to bulk materials</td>
<td>Thin layers, multi layers, bulk materials</td>
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<td>Liquid or solid objects</td>
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<tr>
<td>Temperature</td>
<td>RT to 300 °C</td>
<td>RT to 500 °C</td>
<td>RT to 1500 °C</td>
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<tr>
<td>Atmosphere</td>
<td>N₂, Ar, Air</td>
<td>N₂, Air, Ar</td>
<td>N₂, Air, Ar, O₂</td>
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</tbody>
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2 Micro scale thick silver-sintered dog bone immediately before hot tensile test
3 Mechanical behavior of silver-sintered dog bone in tensile test at different test temperatures and sintering pressures
4 Berkovich nanoindent on a silver-sintered bond line obtained by nanomechanical microscopy