Power Modules

Packaging & Prototyping

Reliability & Lifetime

Fraunhofer IISB

Fraunhofer Institute for Integrated Systems and Device Technology IISB

Environmental Testing, Corrosion and Failure Analysis

Dendrites on a ceramic circuit carrier
© Anja Grabinger / Fraunhofer IISB

Environmental testing

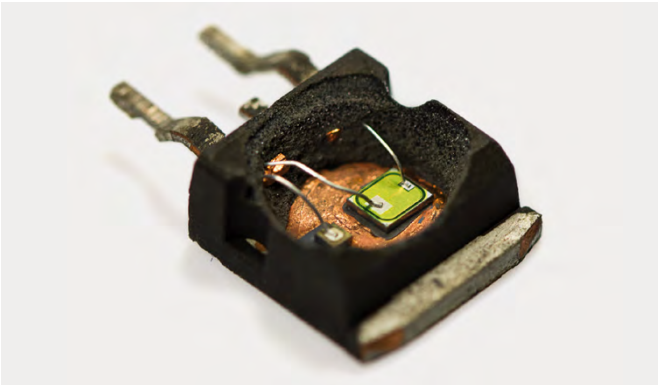
- Investigation of influences like temperature, humidity and (hazardous) gases on degradation and corrosion of electronic devices and materials
- Simulation of various fields of application with their different conditions (e.g. offshore PV, rail and automotive, aerospace)

Testing methods (performed at Fraunhofer IISB)

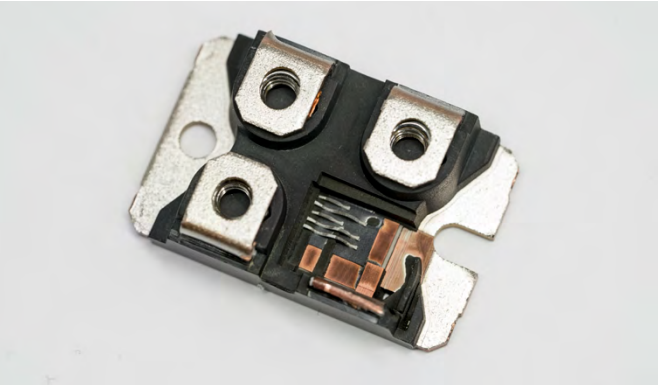
- Salt spray (e.g. DIN EN 60068-2-52) ordamp heat testing (e.g. DIN EN 60068-2-67), thermal shock, temperature cycling (e.g. DIN EN 60068-2-14)
- Corrosive gas (H2S, NO2, Cl2, SO2 and mixed gas) (e.g. DIN EN 60068-2-42)
- Highly accelerated stress test (HAST), pressure cooker test (PCT) (e.g. DIN EN 60068-2-67)
- Also available for (reverse) biased devices

The focus is on Electrochemical migration of power electronics

- Steadily increasing demands in terms of higher packing densities
- Demand for applications of power electronic modules under extreme environmental conditions is rising
- Assemblies that are exposed to changing environmental influences e.g. in automotive and energy
- Electrochemical migration (ECM) that leads to dendrite formation is one important form of corrosion in power electronics



(1) Removal of mold compound by etching © Fraunhofer IISB



(1) Removal of mold compound by laser © Fraunhofer IISB

Mechanisms behind ECM

- Potential and humidity between metallic structures is present
- Metal ions dissolve
- Positive metal ions migrate from the anode to the cathode
- Ions are captured at the cathode
- Dendrites grow from the cathode to the anode

ECM occurs immediately in electronic packages if the following is given

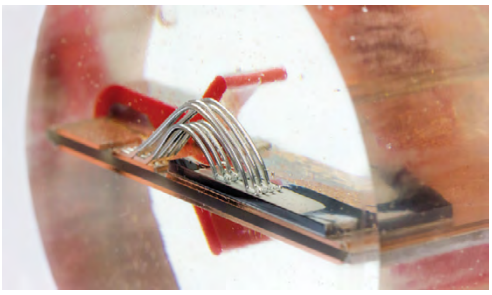
- Gaps exist (due to delaminated insulating potting material)
- Metals and metal combinations tend to corrode and form dendrites
- Humidity is present
- A sufficient voltage load is given (several volts)

Measures against corrosion

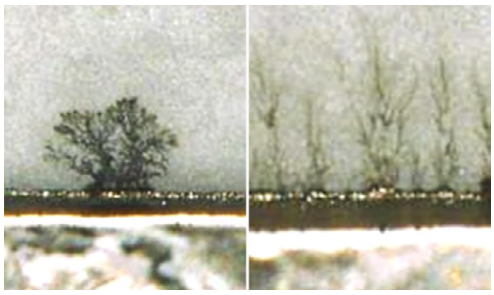
- Cleaning and adhesion promotion
- Chemical corrosion inhibition
- Protective coatings: Potting and parylene
- Coating material
  - Processes
  - Characterization

Failure analysis

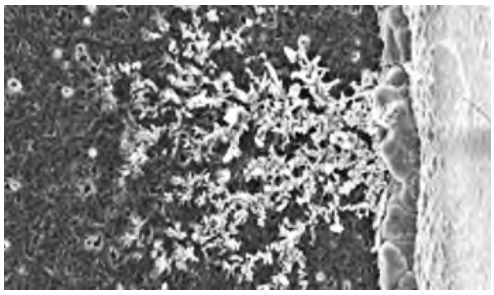
- Partial discharge measurement
- Optical microscopy for dendrite localization and shape analysis
- Laser interferometry (for analysis of coating quality and coating thickness)
- Cross-sectioning by sawing, grinding, polishing, as in figure 2
- Cross-sectioning by femto-laser cutting
- Comparative tracking index (CTI)
- Scratch test (Cross-cutting test)
- Decapsulation of mold compounds as well as silicone gels, e.g. as in figure 1
- Scanning electron microscopy (SEM) and elemental analysis with energydispersive X-ray spectroscopy (EDX), distribution and quantity, as in figures 4 and 5
- Focused ion beam (FIB), high speed cutting by plasma
- Thermogravimetric analysis (TGA) and differential scanning calorimetry (DSC)
- Fourier-transform infrared spectroscopy (FTIR)
- Radiography / Co



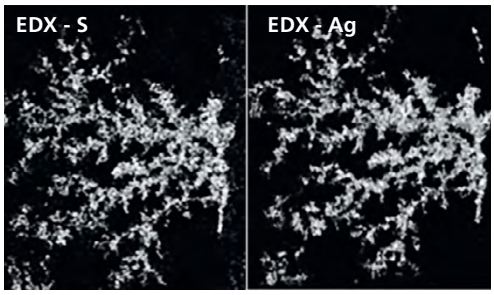
(2) Cross section of IGBT power module © Fraunhofer IISB



(3) Dendrite formation and electrical treeing © Fraunhofer IISB



(4) SEM picture of dendrite on an IGBT module © Fraunhofer IISB



(5) EDX analysis of dendrite, element maps of sulfur and silver © Fraunhofer IISB

Contact

Dr. Victoria Zimmermann
Testing and Reliability
Tel.: +49 9131 761 638
victoria.zimmermann@
iisb.fraunhofer.de

Fraunhofer IISB
Schottkystr. 10
91058 Erlangen
Germany
www.iisb.fraunhofer.de

vCard Victoria Zimmermann