



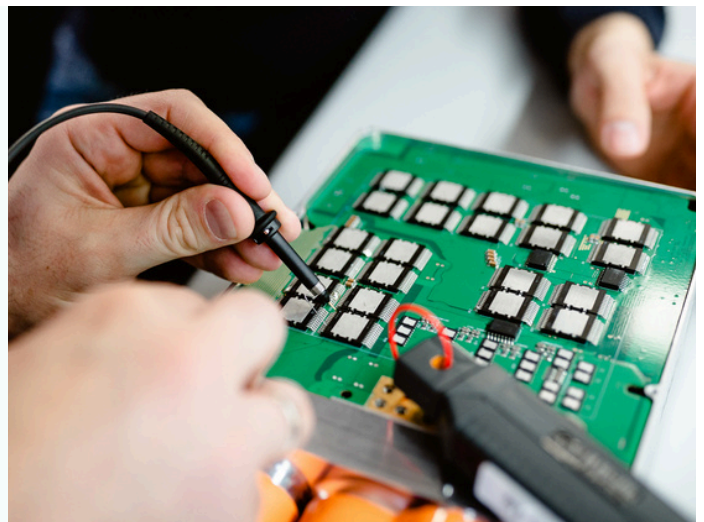
# Characterization

## Service Portfolio

**Characterization is the key for achieving high power density converters: addressing challenges related to high-frequency, high-temperature, and high-power operation with state-of-the-art power devices and passive components.**

Power Electronics provides services around the following topics using its beyond state-of-the-art facilities for:

- Static parameter characterization of power devices
- Dynamic parameter characterization of power devices
- Characterization of passive components

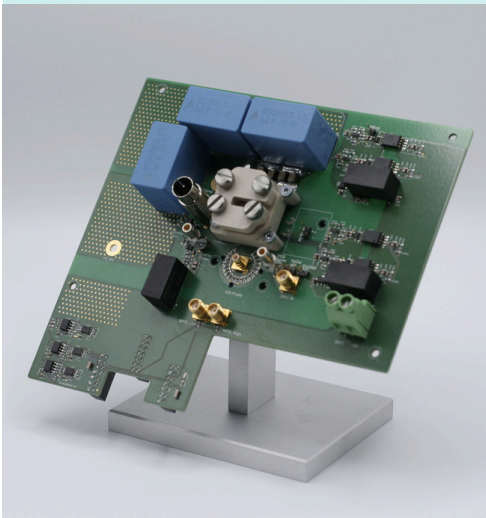


## Static Parameter Characterization of Power Devices using Curve-Tracer

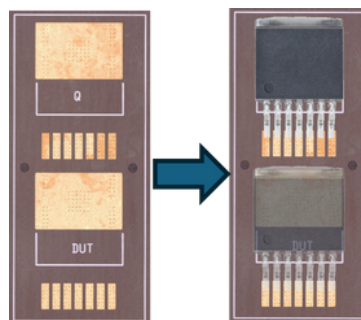


- Datasheet parameters for power devices – SiC/GaN, Discretes/Modules
  - IV- characteristics: Transfer ( $I_d$ - $V_{gs}$ ), Output ( $I_d$ - $V_{ds}$ ,  $R_{ds}$ - $V_{ds}$ ), Drain leakage currents, and Breakdown voltage ( $BV_{ds}$ )
  - CV-characteristics: Device capacitances ( $C_{iss}$ ,  $C_{oss}$ ,  $C_{rss}$ )
- Temperature aided measurements from  $-40^\circ$  to  $200^\circ$  C
- Device specific interface boards
- Easy setup of test routines (with and without temperature control)

## Dynamic Parameter Characterization of Power Devices using Double-Pulse Tester

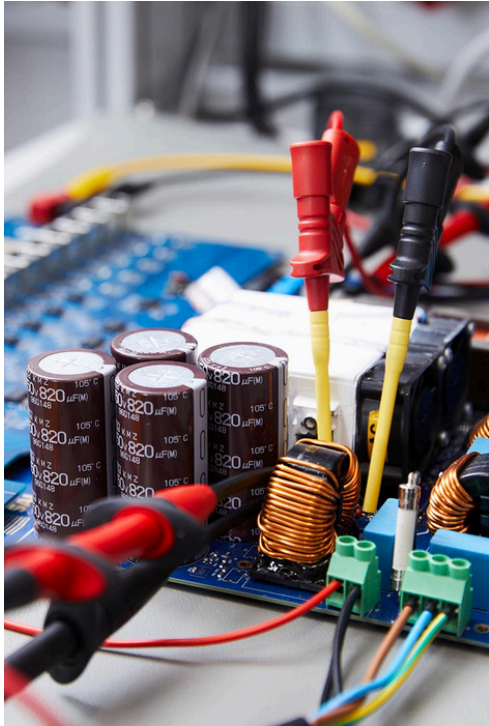


- Standard hard-switched, and reverse-recovery tests: Large datasets across wide range of operation voltage, current and temperatures
- Easy replacement of DUTs of same package
- Low Inductance, and solderless contact membrane
- Dynamic  $R_{ds}$ , on measurement
- Device specific interface boards
- Training on the mechanical socket and membrane designs
- Device model generation in Keysight ADS, SPICE, PLECS



Example lowest impedance contact membranes for exchangeable DUT





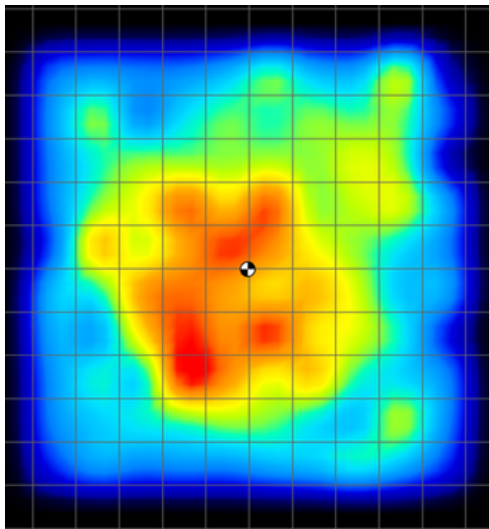
## Characterization of Passives

### Capacitors and Magnetics

- Detailed characterization of magnetic components, including inductors, transformers, and filters.
- Small- and Large-signal behavior under wide-range of frequency, DC and AC bias, temperatures, and operation specific conditions
- Hysteresis behaviour and dissipation losses
- Broadband impedance (ESR, ESL, HF parasitics)
- Interactive and informative curves for you to choose best configuration
- Testing in different operation specific conditions possible

### Material Characterization

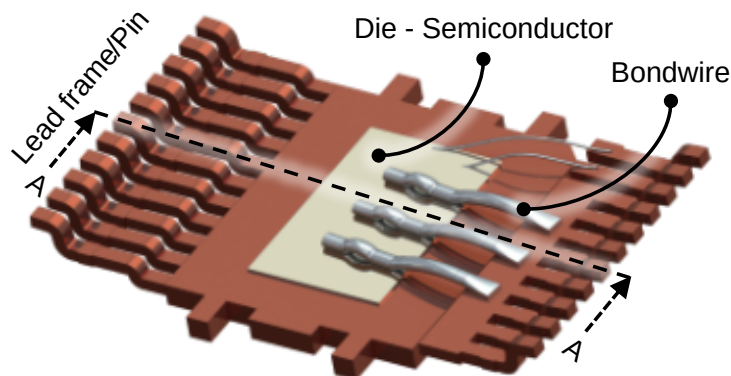
- Extraction of electromagnetic properties like permeability, permittivity and conductivity of material samples
- Measurement of broadband electric impedance (20Hz – 3GHz)
- Artificial aging, thermal stress, vibration



## Mechanical and Thermal Characterization

- Thermal and mechanical package analysis
- Thermal Interface Characterization and Cycling Test Bench
- Mechanical Stress Evaluation and pressure dependent TIM characterization
- Novel Tj Evaluation methodologies and in-situ Rth evaluation capabilities
- Profilometer measurements and tolerance analysis of components and system assemblies
- Rth extraction and thermal network modelling
- Material characteristics and thermal properties modeling
- 3D reconstruction and modeling (for FEA)

External components of a discrete power package





## Key equipment and infrastructure

- B1505A Keysight Curve Tracer
- PD1500A Double-Pulse Tester
- MPI Thermostream
- TIM Test Bench
- Mechanical Characterization
- Device for Material Parameters  $\mu_r/\epsilon_r$
- Keysight Autobalanced Bridge
- Microscope
- Profilometer
- Standard LCR Meters and BODE 100



## ABOUT SAL

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## CONTACT

**DI Dr. Christian Mentin**

Head of Research Unit

System-Level Integration Technologies

[christian.mentin@silicon-austria.com](mailto:christian.mentin@silicon-austria.com)





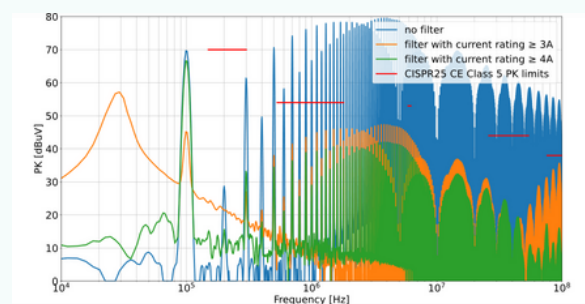
# Electromagnetic Compatibility (EMC)

## *Service Portfolio*

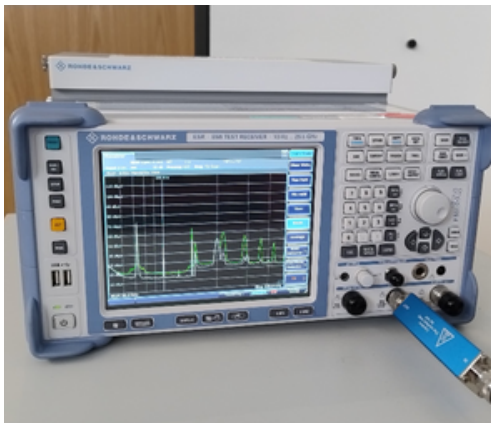
**Electromagnetic Compatibility (EMC) is crucial to ensure that electronic devices do not disturb other devices by Electromagnetic Interference (EMI). Additionally, electronic devices should be able to withstand interferences from the outside as well as from the inside.**

We offer many services that are needed to fulfill the necessary EMC standards for your product, be it in measurement or in modelling & simulation. Our measurement services are pre-compliance.

- Conducted Emission Measurements
- Radiated Emission Measurements
- Bulk Current Injection Tests
- Vector Network Analysis with De-Embedding
- Impedance Analysis with De-Embedding
- Simulation of EMC for electronic circuits
- Model creation of your components and electronic circuits considering EMC



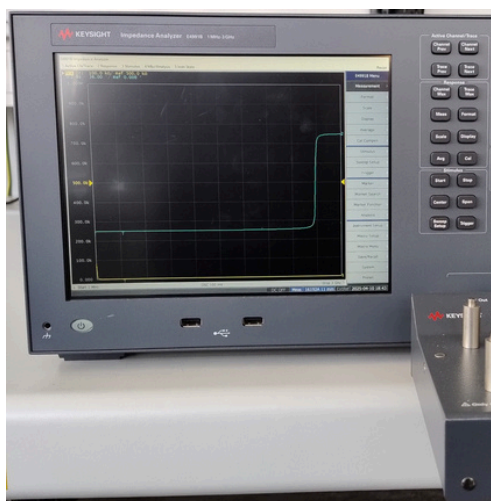
# Electromagnetic Compatibility (EMC)



## Conducted and Radiated Emission Measurement

We offer to measure Electromagnetic Interference (EMI) of your power electronic Device Under Test (DUT).

- Conducted EMI in-house
- Radiated EMI together with our partners
- Signal Integrity
- Power Integrity



## Impedance and Vector Network Analysis

Precise Modeling and Simulation requires well defined and established measurement procedures including component biasing and de-embedding of fixtures.

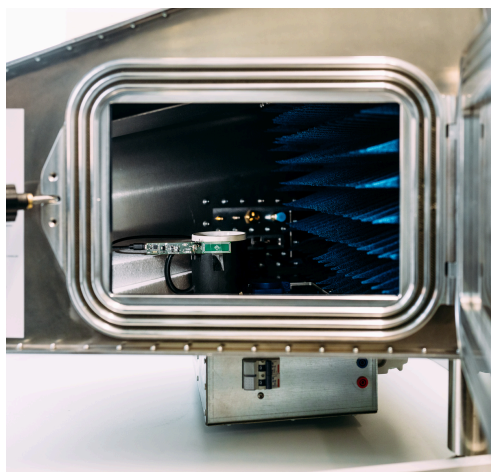
- High precision Impedance Analysis 20 Hz ... 120 MHz (Autobalancing Bridge)
- High precision Impedance Analysis 1 MHz ... 3 GHz (RF-IV Analyzer)
- 2-port Vector Network Analyzer (VNA) 9 kHz ... 8.5 GHz



## Bulk Current Injection Tests

Bulk Current Injection (BCI) is a conducted immunity test often applied for automotive products. Common test standards include IEC 61000-4-6 and ISO 11452-4. We can offer a pre-compliant measurement setup with the necessary Line Impedance Stabilization networks, signal generation, amplification and coupling devices.

- Frequency range: 9kHz ... 400 MHz
- Power up to 100W



## Radiated EMI and GTEM Measurements

Quick radiated tests without the need of an anechoic chamber can be done in the Gigahertz Transversal Electromagnetic (GTEM) Cell. The GTEM Cell can be used for radiated emission tests as well as for immunity tests, including signal generators and power amplifiers.

- Measure radiated Electromagnetic Interference of a DUT
- Measure radiated Immunity of DUTs
- Measure influence of high field strengths on DUTs with the cutout close to the GTEM cell septum

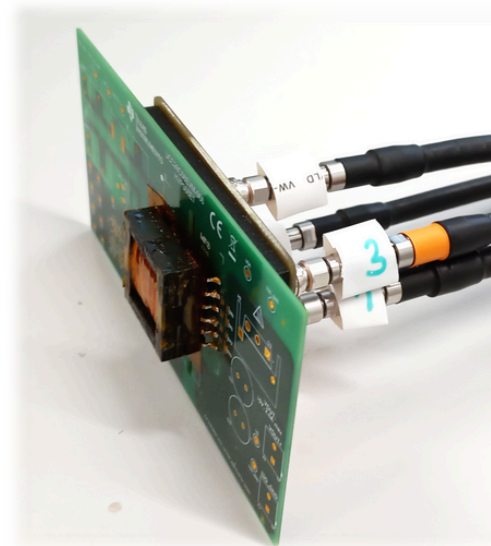




## Simulation of Electromagnetic Interference (EMI)

Simulation of Electromagnetic Interference (EMI) and Immunity is the future key driver for predictable Time To Market of new products. By employing these simulations companies can predict the EMC behavior of their products without having physical prototypes at hand. In this sense, the electronic design can be tweaked easily until it fulfills regulations. We offer all necessary tools for modelling and simulation of components, sub-systems and systems.

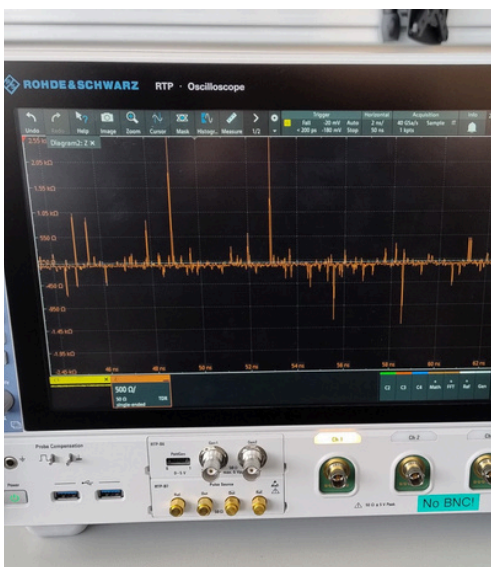
- Simulate EMI of power electronic circuits
- Create framework for: filter optimization, emission reduction, optimizing Bill of Material (BOM), simulate design variants and exchanged components



## Model creation of passive components and material characterization for EMC

For proper emission and immunity simulations in Electromagnetic Compatibility, precise component models are necessary. Biasing of components can significantly change the nominal values and the parasitic behavior of the components.

- Impedance measurement of components
- Vector Signal Analysis
- Creating Fixtures for proper measurement incl. biasing
- De-Embedding of the fixtures to have component characteristics only



## Time domain measurements and reflectometry

Fast time domain measurements can be crucial for debugging electronic systems and transmission quality. Time Domain Reflectometry (TDR) is an important procedure to characterize and localize discontinuities in electrical systems like printed circuit boards, connectors, or any other electrical path.

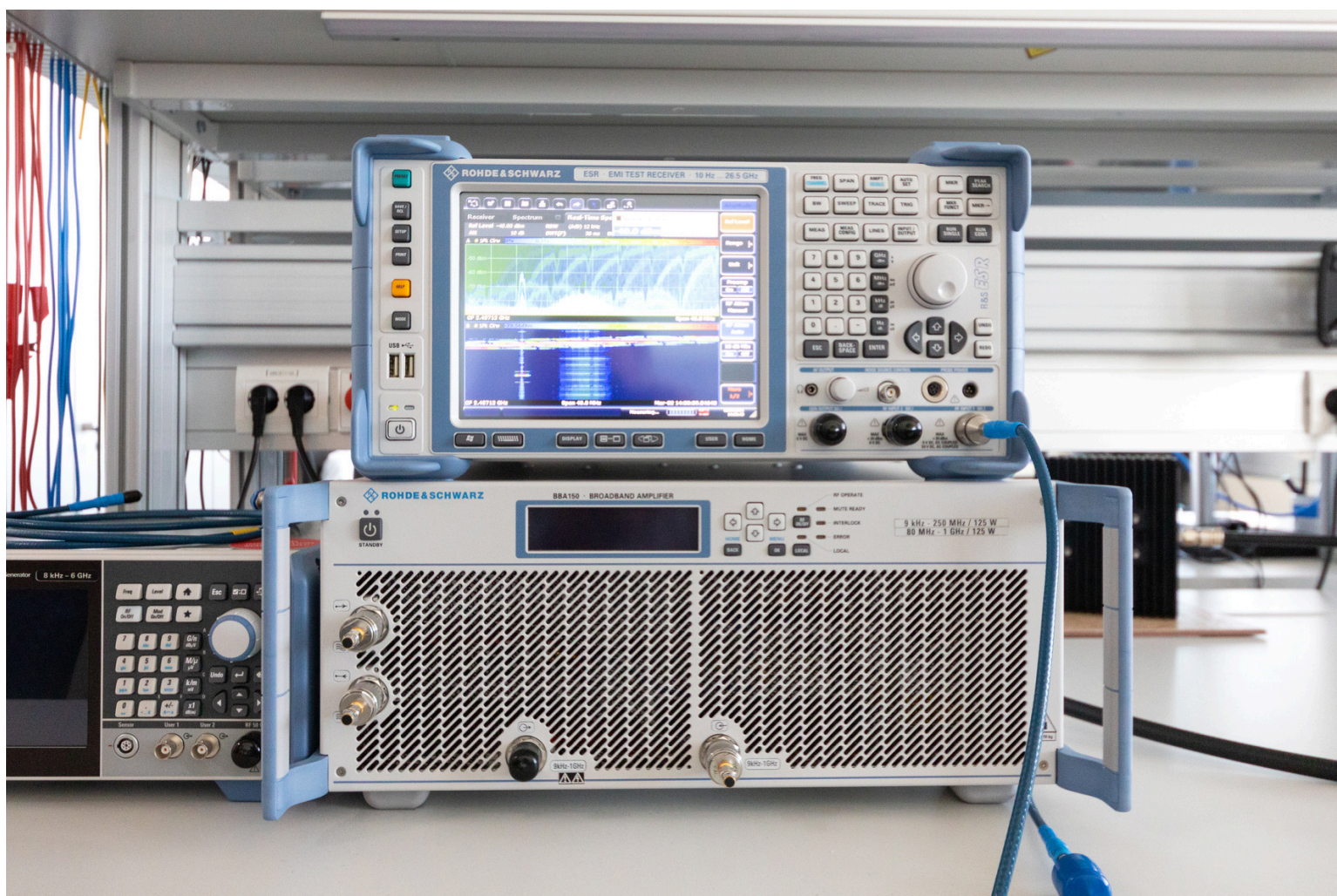
- Fast data acquisition
- Measure transmission data quality and signal integrity
- Discover discontinuities in impedance controlled cabling and measurement systems by TDR
- 16 GHz bandwidth, 40 Gsamples/s sampling rate, 16 bit resolution





## Key equipment and infrastructure

- Vector Network Analyzer
- Impedance Analyzer (20 Hz-120 MHz) incl. fixtures
- Impedance Analyzer up to 3 GHz incl. fixtures
- Time Domain Reflectometry up to 16 GHz
- GTEM Cell & TEM Cell
- Keysight Pathwave ADS
- Ansys HFSS, Q3D and Maxwell
- EMI Receiver (26.5 GHz)
- Bulk Current Injection Test Setup
- Vector Signal Generator and Broadband Amplifier



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## CONTACT

**DI Dr. Bernhard Auinger**

Head of Research Unit

Coexistence & Electromagnetic Compatibility

[bernhard.auinger@silicon-austria.com](mailto:bernhard.auinger@silicon-austria.com)





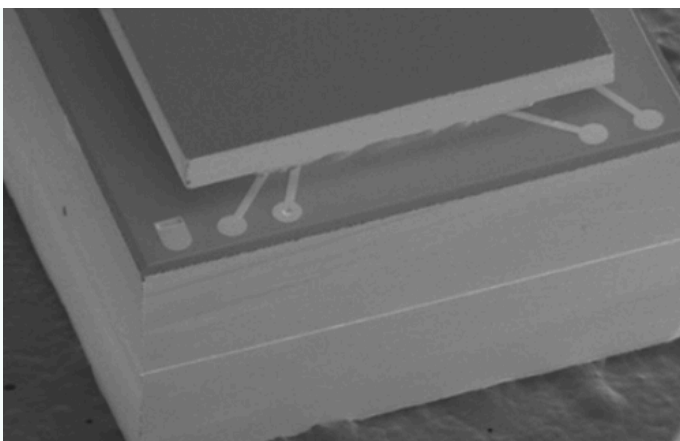
# Heterogeneous Integration Technologies

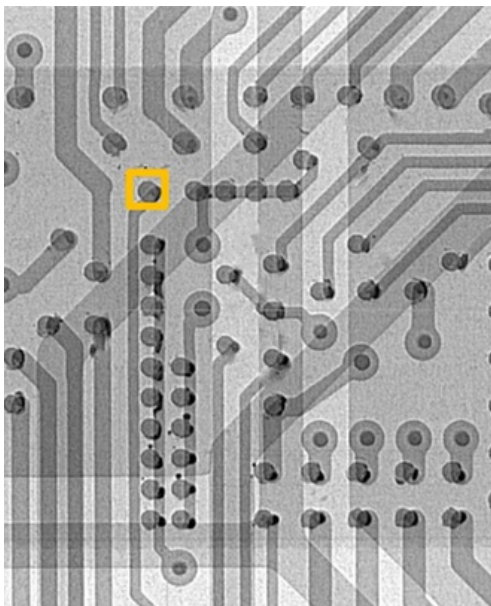
## *Service Portfolio*

**Heterogeneous Integration refers to the integration of separately manufactured components into a higher-level assembly that provides enhanced functionality and improved operating characteristics.**

The research unit provides services around the following topics using its state-of-the-art facilities for packaging, analysis and characterization:

- Packaging (Discrete, module and system)
- Interconnects
- Micro assembly technologies
- Wafer bonding and debonding
- Backend processing
- Molding and embedding
- Failure analysis and characterization
- Chip-to-package and Multiphysics simulation
- Photonic assembly



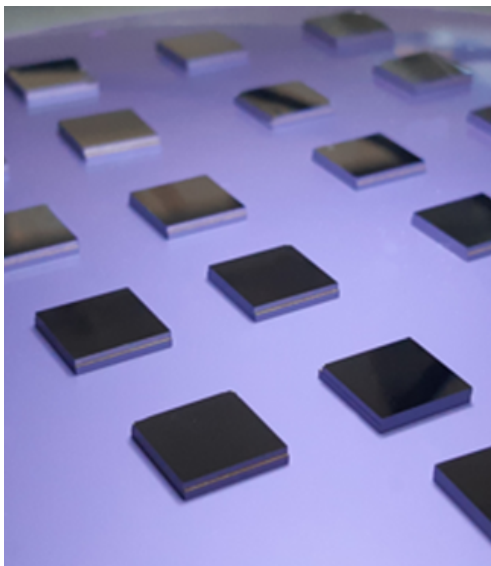


© SAL – Flip Chip bonded chip

## Interconnects

Reliable interconnect solutions are essential for high-performance electronic packaging. SAL's advanced interconnect technologies ensure strong electrical and mechanical connections for various semiconductor applications including:

- Wire, Ribbon, Clip bonding
- Die-attach (Solders, ACP/NCP, ACF/NCF)
- Encapsulation (Globtop, Molding)
- Parylene coating (C, AF4)
- Underfill and over-molding
- Sinterconnects<sup>®</sup>
- Sintering (Pressure-less & Pressure-assisted Ag, Cu, TLP)

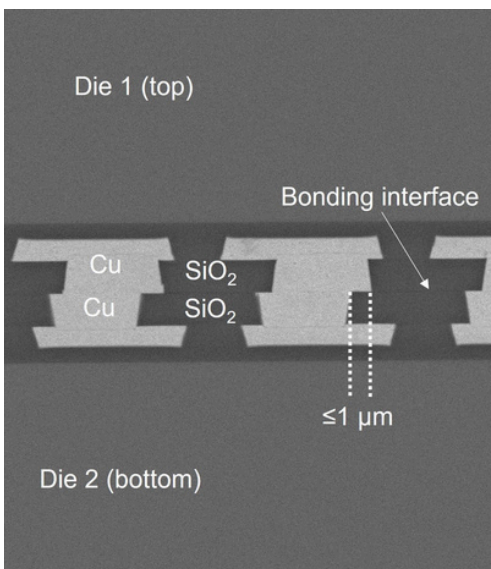


© SAL – 3D stacking

## Micro assembly technologies

Our state-of-the-art micro assembly technologies enable high-density, compact, and reliable packaging solutions for modern electronic applications. We specialize in a range of assembly methods to optimize performance, miniaturization, and integration including:

- Flip Chip
- Chip on Board (CoB)
- System in Package (SiP) and System in Module (SiM)
- Quad Flat No-lead package (QFN)
- Lead frame
- Flexible and stretchable electronics



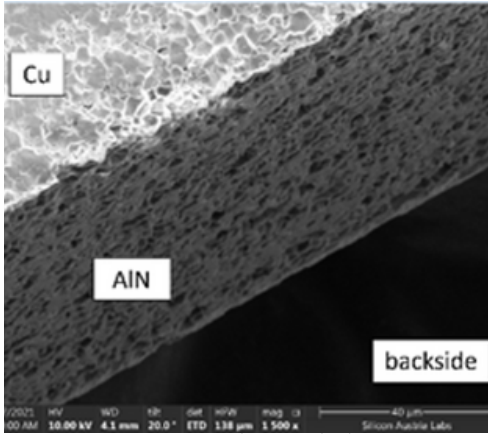
© SAL – Hybrid bonding

## Wafer bonding and debonding

SAL's wafer bonding and debonding solutions provide high-precision, reliable techniques for semiconductor and MEMS applications. These processes ensure strong adhesion, thermal stability, and seamless integration of wafers for advanced device fabrication:

- Anodic
- Thermocompression
- Eutectic
- Glass frit
- Adhesive (Temporary and permanent)
- Direct bonding



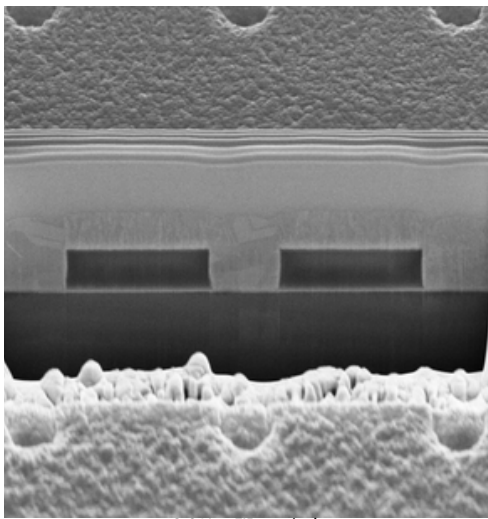


© SAL – Back Side metallization

## Backend processing

Our backend processing services ensure high-performance semiconductor packaging with precision and reliability including:

- Backside metallization
- Bumping
- Passivation
- Dicing
- Testing and characterization

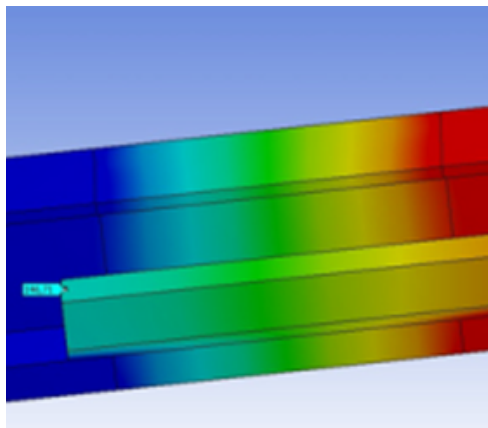


© SAL – FIB analysis

## Failure analysis and characterization

We offer failure analysis and characterization services to ensure product reliability, identify defects, and enhance process optimization. Our techniques provide in-depth insights into material integrity, structural defects, and failure mechanisms including:

- SAM and SEM
- Focused Ion Beam
- Shear and leakage tests
- Metallography and cross-sectional analysis
- Electrical measurements and wafer probing

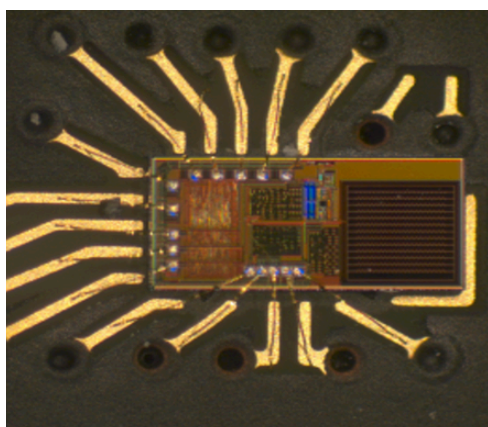


© SAL – Temperature distribution on chip inside a sensor package

## Chip-to-Package and Multiphysics simulations

SAL's advanced simulation capabilities enable optimized electronic packaging by analyzing electromagnetic, thermal, and mechanical behaviors at multiple scales:

- Electromagnetic and thermo-mechanical simulations
- 3D FEM and CFD simulations
- Multidomain simulations
- Reduced order models and system simulations



© SAL – Particle sensor

## Photonic assembly

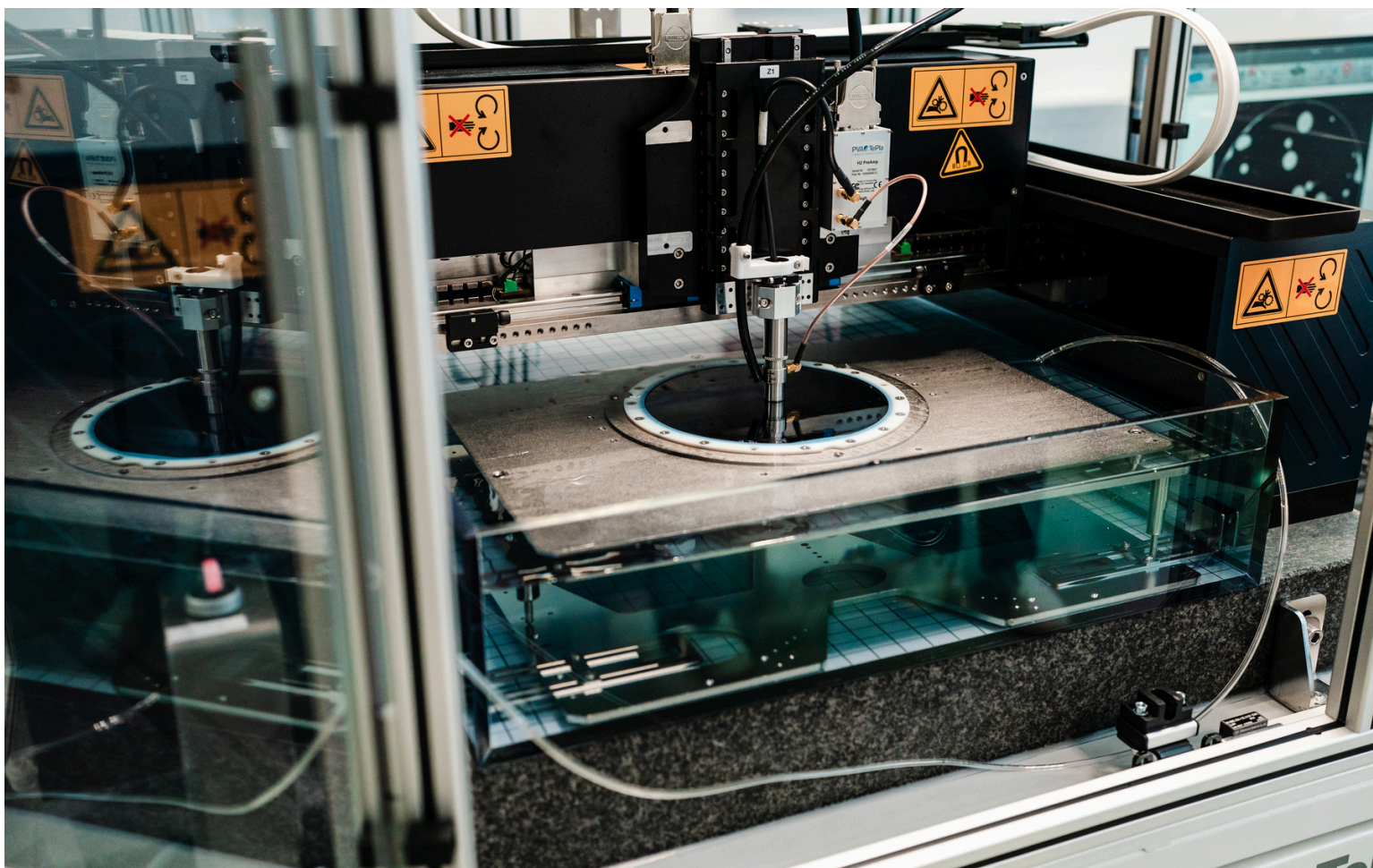
Our photonic assembly solutions provide precise integration of optical components for high-performance photonic and optoelectronic devices. We specialize in advanced micro- and nano-scale assembly techniques to meet the demands of modern optical systems:

- 3D photonic micro-assembly
- Meso/micro-optical assembly
- Two Photon Printing of optical elements



## Key equipment and infrastructure

- Wafer Bonder
- Bond Aligner
- Automatic Die Bonder
- Manual/Semi-Automatic Die Bonder
- CMP
- Thermocompression Wafer Molding
- Cleanroom ISO8 (400 m<sup>2</sup>)
- SAM
- Nano Indenter
- Shear Tester
- Two-Photon Polymerization
- Photonic Assembly
- Micro-Assembly Station
- Cleanroom ISO5 (1300 m<sup>2</sup>)



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## CONTACT

**Dr. Ali Roshanghias**

Head of Research Unit

Heterogeneous Integration Technologies

[ali.roshanghias@silicon-austria.com](mailto:ali.roshanghias@silicon-austria.com)





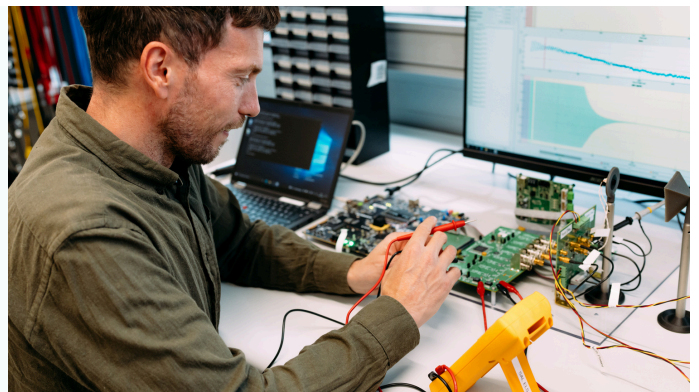
# Measurement & Testing

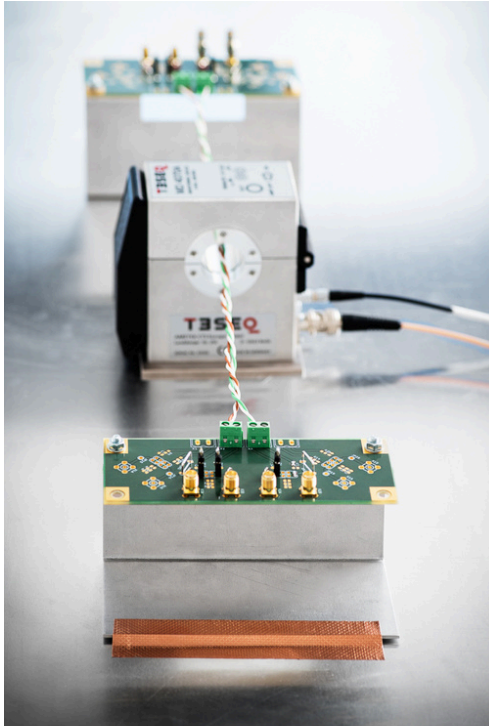
## *Service Portfolio*

**Accurate measurement and testing solutions to optimize power electronics for both peak performance and reliability.**

Silicon Austria Labs provides expert testing and measurement services for power electronic components and systems, ensuring efficiency, reliability and compliance with relevant standards around the following topics:

- Efficiency measurements
- Power factor/THD measurements
- Power Hardware in the Loop testing
- Thermal and calorimetric measurements
- Magnetic component testing and optimization





## Efficiency, Power factor and THD measurements

**Optimize your systems with precise Efficiency, Power Factor, and THD measurements.**

Our services include:

- **Efficiency:** Identify inefficiencies in inverters, converters, and power supplies, ensuring compliance with industry standards and improving overall system reliability.
- **Power factor measurement:** We analyze the power factor of your system to determine how effectively it utilizes electrical power. Our precise measurements help identify reactive power issues, improve grid compatibility, and ensure compliance with regulations, reducing energy costs and enhancing operational efficiency.
- **Total Harmonic Distortion:** We evaluate the harmonic distortion in your power electronics to ensure clean and stable power delivery, compliant with IEC and IEEE standard.



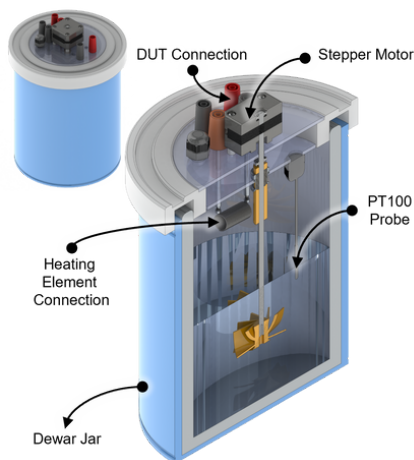
## Power Hardware in the Loop (PHIL) testing

**Emulate real-world conditions and validate your power systems and their control with accurate PHIL testing.**

Our services include:

- **Real-Time Performance Testing:** Evaluate inverters, converters, and motor drives under real-world operating conditions. Emulate dynamic loads, grid disturbances, and faults.
- **Power System Emulation & Grid Compliance Testing:** Emulate AC/DC grids, renewable energy sources (solar, wind), and microgrids. Tests compliant with IEC and IEEE standards and grid codes for distributed energy resources.
- **Fault and Protection Testing:** Inject grid faults, voltage sags, frequency variations, and test system response. Verify protection algorithms, islanding detection, and fault ride-through performance.
- **Controller and Algorithm Validation:** Test MPPT (Maximum Power Point Tracking) for PV inverters. Validate adaptive control, real-time optimization, and machine learning algorithms for power electronics.





## Thermal and calorimetric measurements

**Optimize heat management and efficiency with precise thermal and calorimetric testing.**

We provide advanced thermal and calorimetric measurements to help you evaluate heat dissipation, energy losses, and thermal stability in power electronics and electrical components to improve the reliability and longevity of your components.

Our services include:

- **Power Loss & Efficiency Measurement:** Accurate calorimetric testing to quantify energy losses in power electronics.
- **Hot Spot Detection & Failure Analysis:** Identification of overheating risks and weak points in electronic components.
- **Active & Passive Cooling System Evaluation:** Performance validation of heat sinks, fans, and liquid cooling systems.
- **Steady-State & Transient Thermal Analysis:** Dynamic testing to assess thermal response under varying load conditions.
- **Advanced Simulation & Modeling:** Finite element analysis (FEA) for thermal simulations and optimization.

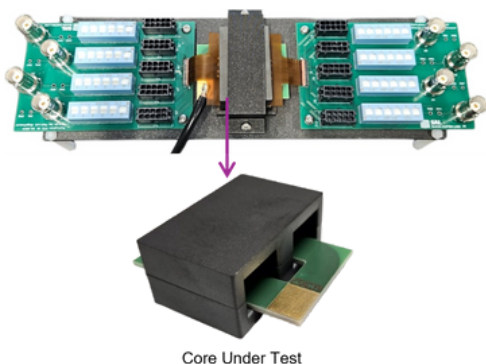
## Magnetic Component Testing & Optimization

**Optimize your inductors, transformers, and magnetic materials with precise testing, finite element simulations and analysis.**

We provide comprehensive characterization services to ensure your magnetic components meet the highest performance and efficiency standards.

Our services include:

- **Core Loss Analysis:** Evaluation of energy losses under real operating conditions to optimize efficiency.
- **Optimization of magnetic components:** Tailored solutions for reducing AC losses, improving flux distribution, and enhancing manufacturability.
- **Power Loss & Efficiency:** Accurate assessment of transformer and inductor performance.
- **Thermal Performance:** Infrared (IR) imaging to analyze heat dissipation and thermal stability.
- **Finite Element Simulations:** Using 2D/3D electromagnetic, thermal, and mechanical simulations to predict performance, losses, and field distribution.





## Key equipment and infrastructure

- 8 Channel Oscilloscopes
- Power Analyzers
- Power Hardware in the Loop setup
- High power and high frequency application capability
- Rapid Control Prototyping System
- AC/DC Power Supplies
- Thermal Imaging System
- High current, high frequency current and optically isolated voltage probes



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## CONTACT

### Dr. Johann Krenn

Senior Scientist & Team Lead

Architectures & Topologies

[johann.krenn@silicon-austria.com](mailto:johann.krenn@silicon-austria.com)





# Prototyping

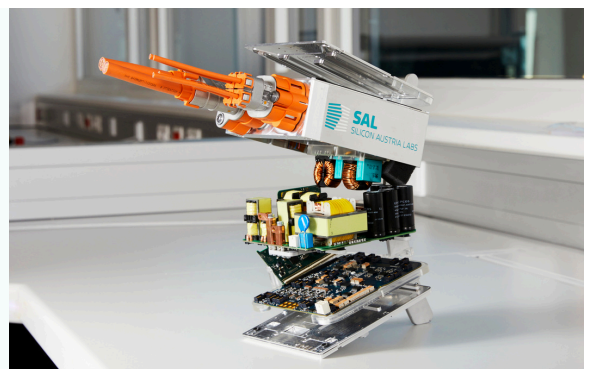
## Modeling & Simulation – Design – Hardware

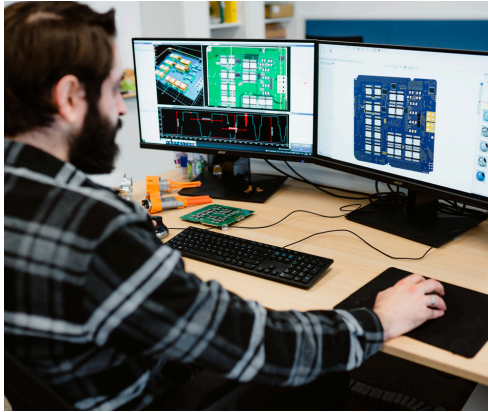
### *Service Portfolio*

**Modeling and simulation are essential for rapid system prototyping, allowing the demonstration of the latest technologies in application prototypes without the need for lengthy iterative design cycles. State-of-the-art laboratory equipment for in-house hardware and software rapid prototyping ensures a swift development process and facilitates early-stage testing within real-world application environments.**

The Division Power Electronics provides services around the following topics using its state-of-the-art facilities for:

- Detailed modelling of active and passive components
- Multi-domain and coupled simulations for power electronic systems
- High density and optimal system design and integration
- Rapid prototyping workflows and code generation for different control platforms

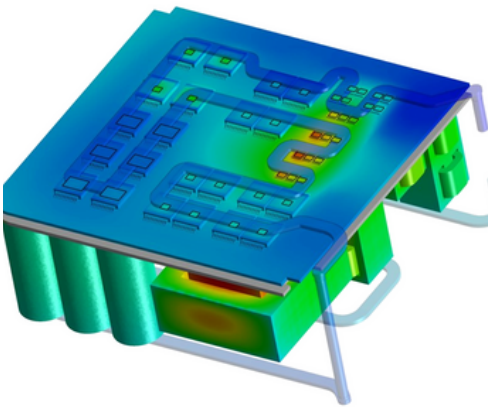




## Components and System Modelling

### Components Analysis and Modelling

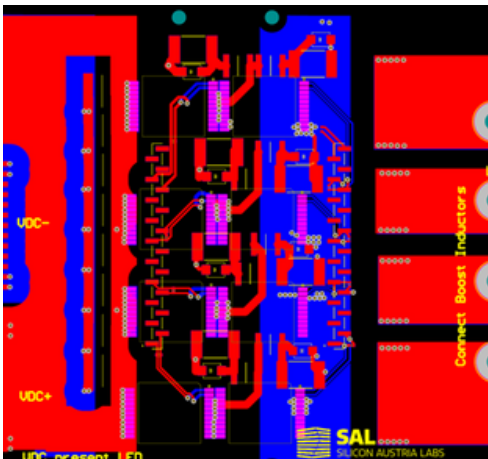
- Mechanical geometrical analysis and modelling
- Material parameter modelling
- Preparation of simulation ready 3D models
- Simplification of models for transient system simulations



## Cooling System Simulation and Optimization

### Thermal System Analysis

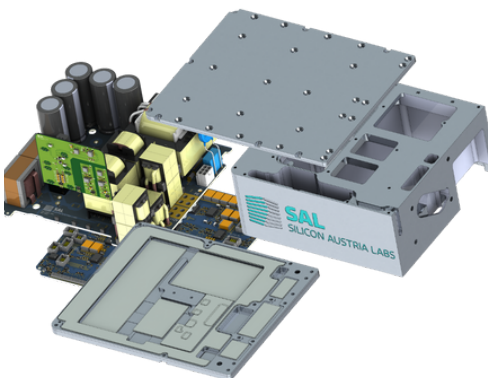
- Cooling system optimization with FEA and CFD analysis
- Generation of reduced order models for more advanced transient simulations
- 3D system modeling with high fidelity components
- Thermal and mechanical package analysis (e.g. thermal cycling analysis incl. mission profile of the system)



## Electrical System Design & Topology Optimization

### Electrical System Design including:

- Topology optimization (pareto front analysis)
- Optimal device technology and components selection
- Electrical simulations with state-of-the-art software (PLECS, Spice...)
- Schematic design
- Layout optimization using newest PCB technologies e.g. thick copper, copper inlays
- Magnetic component design and optimization

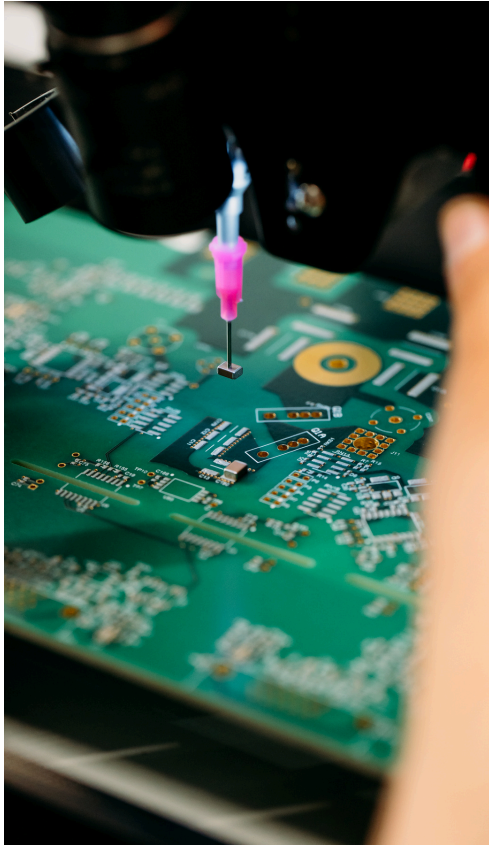


## Mechanical System Design & Simulation

Mechanical System Design is carried out in a ECAD/MCAD Co-design procedure to improve the mechanical integration procedure.

- Simulation backed mechanical design for high density integration and cooling system integration
- System Simulation and thermal cross-talk analysis of sub-systems and components
- Connectors interface and high current busbar design

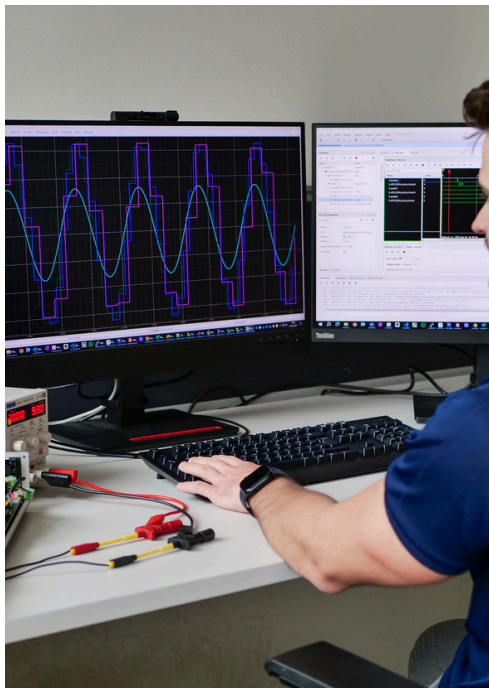




## Hardware Prototyping

SAL offers in-house capabilities for system rapid and high-quality Prototyping.

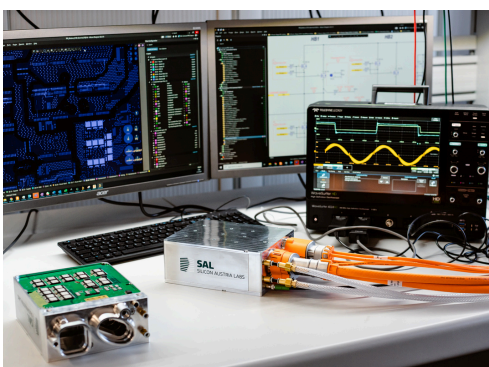
- In-house PCB manual and semi-automatic assembly and vapor phase reflow
- Inspection and electrical commissioning of prototype assemblies
- Mechanical prototyping capabilities for
- CNC machining of components (Metals, Alloys, Composites and Plastic)
- Dry and wet CNC Machining processes
- FDM and SLA 3D Printing with options for thermally conductive materials or high temperature resistant materials such as PEEK
- Laser Cutting and Engraving
- Cutting and processing of Ferrite Materials
- System assembly and commissioning for fast prototype development cycles
- Mechanical parts fast turn-over and re-design cycles
- Custom cold plate machining and cooling performance evaluation
- Vacuum potting and selective coating equipment for passive components and PCB assemblies (available 2026)



## Rapid Control Prototyping, Control Deployment & HiL testing

Development of custom solutions for Rapid Control Prototyping from concept phase to deployment:

- Initial laboratory testing of novel control concepts using state-of-the-art rapid control prototyping platforms (on-click control model deployment)
- Implementing and automating workflows for control model code generation for different MCU platforms
- Supporting model development for C and HDL code generation
- Building custom firmware for SoC devices with dual C and HDL Code deployment, including data exchange logic
- Implementing firmware components such as ADCs, DACs and fast communication interfaces
- Testing of control model implementations on any platform using available HiL environments



## Hardware commissioning and testing

System assembly and commissioning for fast prototype development cycles

- Efficiency and thermal measurements on a system prototype
- High power testing possibilities
- Transient behavior analysis and thermal cycling capabilities
- Conducted EMI analysis



## Key equipment and infrastructure

- Profilometer and microscope
- Mechanical measurement tools
- Mechanical machining infrastructure
- Imperix rapid control prototyping
- 3D printers
- Hioki and Yokogawa power analyzer
- Water cooling for prototyping setups
- Multi-domain simulations including CFD
- Solidworks, Altium Designer
- Typhoon & PLECS RT Box HiL
- Vapor phase
- Regatron/ITECH power supplies
- Thermostream



## ABOUT SAL

Silicon Austria Labs (SAL) is a top European research center for Electronics and Software Based Systems (ESBS). The application-oriented center offers cooperative research & services at three locations – Graz, Linz and Villach – in the pioneering research areas of Sensor Systems, Microsystems, Intelligent Wireless Systems, Power Electronics and Embedded Systems. | [www.silicon-austria-labs.com](http://www.silicon-austria-labs.com)

## CONTACT

**DI Dr. Christian Mentin**

Head of Research Unit

System-Level Integration Technologies

[christian.mentin@silicon-austria.com](mailto:christian.mentin@silicon-austria.com)