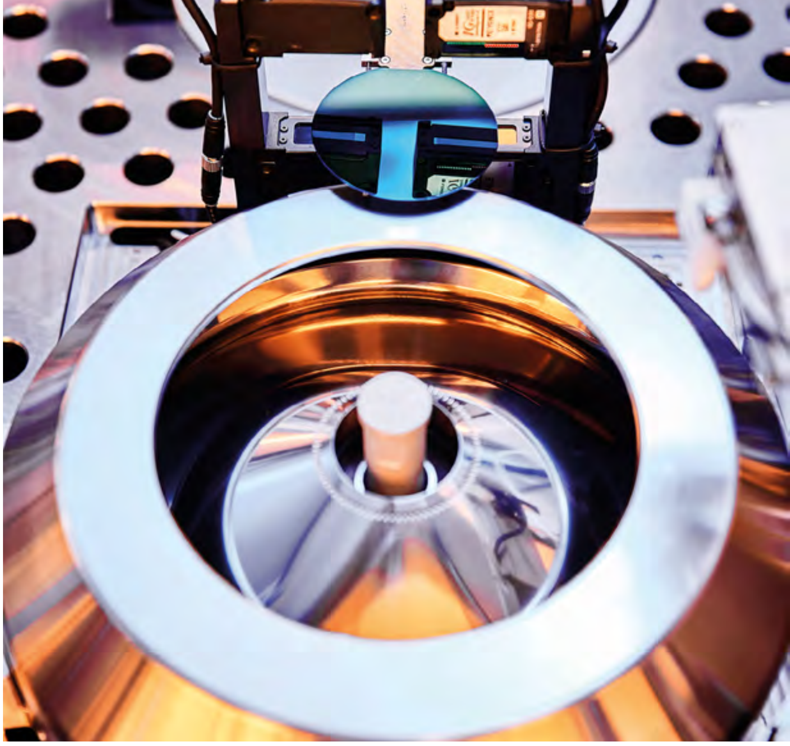


Leibniz
Ferdinand
Braun
Institut

Advanced III-V Materials & Processes
Services up to Prototyping

Your partner across the entire III-V compound semiconductor value chain

FBH combines comprehensive expertise in materials, process technology, mounting, characterization, and assembly to cover the full value chain – from simulation to research prototypes and small-series production. This comprehensive approach enables sophisticated diode lasers, UV LEDs, PICs, MMICs, and power transistors, as well as complex, application-specific modules and systems.

We provide advanced technological know-how and infrastructure to support your development projects at every stage. Our services include customer-specific epitaxial wafers, dedicated process steps, development and fabrication of devices, application-specific modules, mounting and micro-optical integration, comprehensive device analysis, characterization and testing, as well as industry-ready prototyping solutions. As a member of Research Fab Microelectronics Germany (FMD), we will also offer our indium phosphide MMIC and heterogeneous integration processes to external customers within the APECS pilot line.

Through our in-house Prototype Engineering Lab, we develop highly integrated, plug-and-play systems that enable direct performance evaluation in your application environment – accelerating technology transfer, reducing development risk, and shortening time to market.

Alongside end-to-end collaboration, we also offer tailored individual services to meet your specific requirements.

Modeling, simulation & design

We use advanced modeling and simulation to design photonic, electronic, and quantum devices, circuits, and systems. By optimizing and validating designs before manufacturing, assembly, integration, and testing, we shorten development cycles, reduce development risk, and accelerate time to market.

Diode lasers & amplifiers

Numerical simulations of

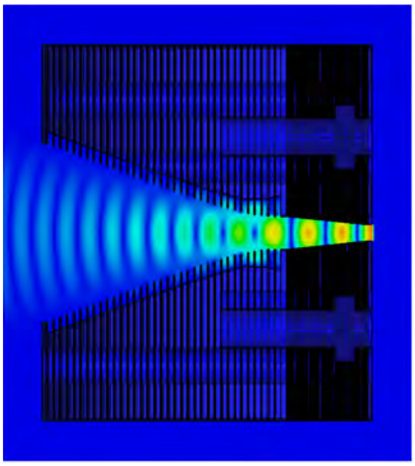
- Epitaxial layer structures
- Bragg gratings
- Cavity geometries

Photonic circuits, modules & systems

- Advanced virtual prototyping approaches that combine mechanical, thermal, electrical, electronic, as well as optical and photonic modeling
- Methods include: tolerance analysis, vibration load analysis, finite element method, ray tracing, finite-difference time-domain, and further analytical approaches

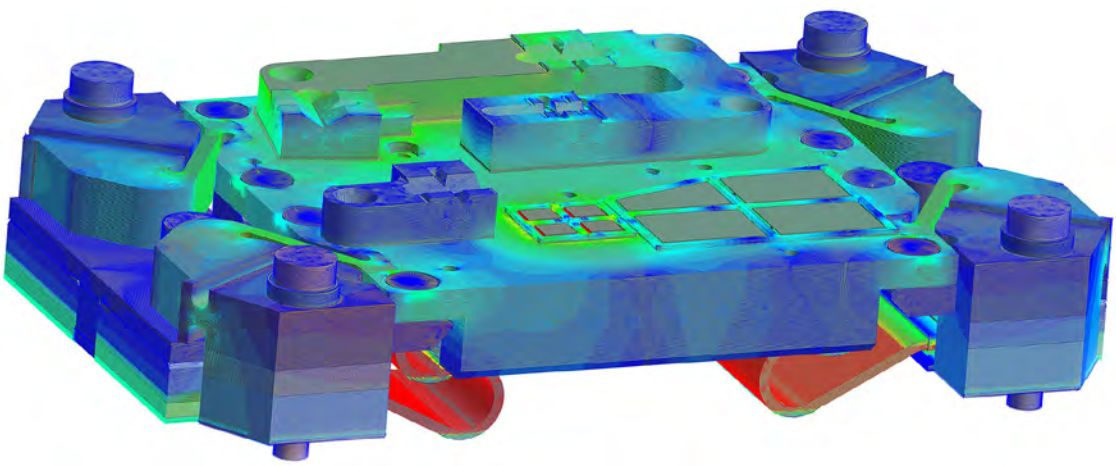
Electronic devices & circuits

- Modeling of electromagnetic fields (DC to THz) using various methods, such as finite integration theory, finite element method, and (semi)analytical methods
- MMIC design and device modeling using FBH-developed large-signal models for various circuits in the entire microwave frequency range



Simulated electrical field distribution of a horn antenna for the W-band.

We also offer tailored modeling and simulation services aligned with customer-specific requirements.



Heat flux distribution obtained from a steady-state thermal simulation of a spaceborne laser system.

Epitaxy

We develop and grow high-quality semiconductor layers with precisely defined crystalline, electrical, and optical properties on single-crystalline substrates, supporting both internal R&D activities and external customers.

- Nitrides: AlGaInN heterostructures for UV LEDs, violet-blue laser diodes, and GaN/AlN-based transistors
- Arsenides: AlGaAs and AlGaInP heterostructures for GaAs-based edge- and surface-emitting laser diodes, semiconductor saturable absorber mirrors (SESAMs) for pulsed laser systems and photocathodes

As an experienced epi-wafer foundry, we realize customized arsenide- and nitride-based layer structures with excellent material quality tailored to customer specifications.

In our epitaxy lab, we grow ultrathin semiconductor layers with precisely defined crystalline properties.

Process technology

We transform epitaxial wafers into a wide range of electronic and optoelectronic devices based on GaAs, InP, GaN, AlGaN, AlN, Ga_2O_3, GeO_2, SiC, and diamond. Our flexible process line meets industry standards and supports tailored wafer processing, from lithography, deposition, and etching to chip dicing.

We also develop advanced nanofabrication technologies, including the generation of color centers in diamond and their integration in photonic nanostructures for the implementation of active and passive quantum optical components and devices.

Front-end processing

Our cleanroom facilities (up to ISO class 5) handle 2" - 100 mm wafers and wafer parts as well as few mm^2 small pieces using automated and manual batch processing. We are currently expanding the line to process up to 150 mm and 200 mm wafers.

Key modules include:

- Photolithography and electron beam lithography
- Wet and plasma etching
- Deposition of thin metallic and dielectric layers
- Ion implantation of various elements with acceleration energies 15 - 400 keV including simulation of implantation profiles
- Thermal processing
- DC measurements

Back-end processing

We bridge front-end fabrication with chip packaging to deliver fully functional devices.

Modules include:

- Laser micro-processing
- Aligned wafer-to-wafer bonding
- Wafer backside thinning
- Backside processing of RF devices
- DC device characterization
- Wafer dicing (sawing, diamond scribing, laser scribing, and breaking)
- Precision dicing for laser facets (scribe and cleave)
- Laser facet passivation and coating

Our services for external partners include customized process development, application-specific modules, end-to-end device fabrication, and small-series manufacturing. We offer industry-grade GaN-HEMT and InP-HBT processes. GaN foundry services are available on 100 mm GaN-on-SiC substrates with 150 nm and 250 nm gate lengths. The GaN-HEMT technology includes transistors, Schottky diodes, passive components, and process design kits (PDKs) for Keysight ADS. Our InP-HBT technology features a standard triple-mesa topology with cut-off frequencies exceeding 500 GHz for millimeter-wave integrated circuits (MMIC), supported by a dedicated PDK for multi-project wafer (MPW) runs.

Automated tools for wet chemical and electroplating processes to ensure superior reproducibility.

Precision wafer thinning for advanced semiconductor devices.

Heterogeneous integration, mounting & assembly

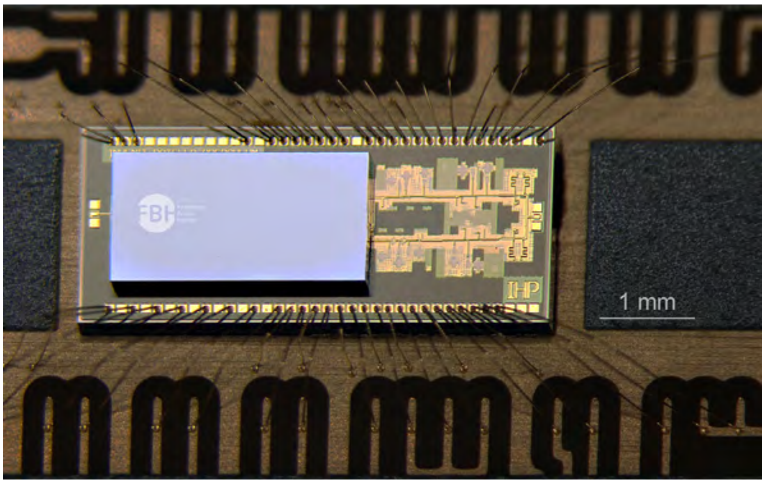
We mount and package devices with a strong focus on heterogeneous integration, combining different material systems and technologies as required. Integrated on heat sinks and into packages with reliable electrical interconnects, the devices are ready for full characterization and performance evaluation. Partners can receive chips on submounts (CoS) or fully assembled modules in standard or customized housings, ready for immediate use.

Capabilities include:

- Solder bonding (AuSn, PbSn, SnAgCu), including in-house preform fabrication
- Wire and ribbon bonding (Au wire, Ø 17.5 µm & 25 µm, deep access up to 14 mm)
- High-precision adhesive bonding with automated dispensing systems
- Chip separation by scribe and break (laser chips, InP MMICs)
- Heterogeneous integration via the APECS pilot line
  - InP-on-BiCMOS/CMOS: FBH's propriety microbump process integrates highly efficient InP-MMIC chiplets with complex CMOS and BiCMOS circuits (PDK available)
  - GaAs-based laser and amplifier coupons/chiplets: integration via micro-transfer printing (MTP)

We offer chip picking and sorting services from dicing frames, tailored assembly solutions, application-specific modules, and complete device packaging for prototypes and small-series production. This gives partners fast access to functional, ready-to-use components.

APECS



InP power amplifier chiplet heterogeneously integrated on a BiCMOS transceiver chip. The assembly is embedded in a PCB and connected to DC supplies via wire bonding.

Our mounting and assembly cleanroom laboratory – transforming microchips into fully functional and robust devices.

Advanced hybrid micro-integration techniques

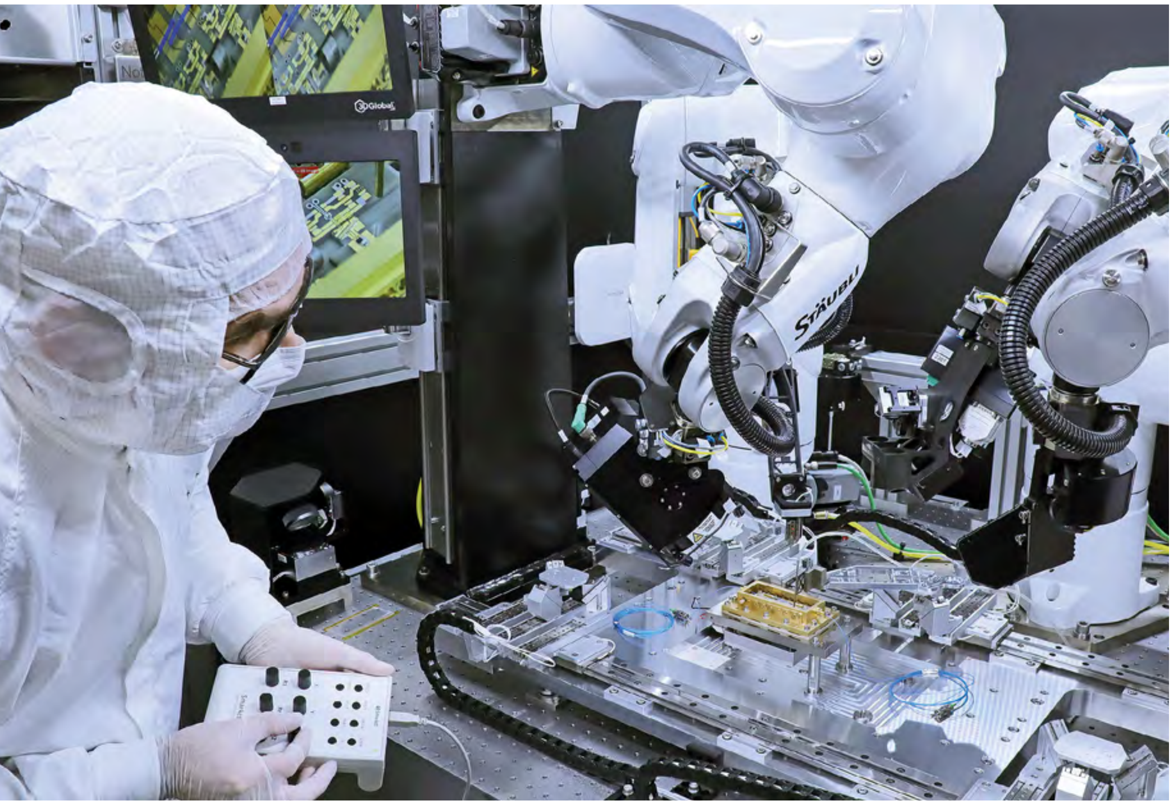
FBH's hybrid micro-integration technology enables the assembly of complex, compact, and robust photonic modules. Our modules operate reliably even in harsh environments such as space, withstanding vibration, shock, and rapid temperature changes. We validate component and process stability throughout all development stages.

High integration density and high precision ensure excellent electro-optical, thermal, and mechanical performance within a minimal footprint. Our industry-compatible assembly stations combine robotic handling with advanced industry 5.0 control architectures to support flexible low-volume production.

Capabilities include:

- Assembly of optical benches based on thermally conductive, expansion-matched alloys
- Micrometer-precision bonding for active laser elements
- Nanometer-precision alignment of passive micro-optics
- Optimization and integration of nonlinear optical (NLO) crystals for 320 - 600 nm and mid-infrared applications, including thermal management, waveguide design, and damage mechanisms
- Beam combining (spectral, polarization, and coherent)
- Packaging with fiber pig-tails (SMF, LMF, PM)
- Hermetical sealing of thermo-electrically cooled packages

We offer hybrid micro-integration solutions for the design, assembly, and packaging of complex, high-performance photonic modules, tailored to customer-specific requirements and application environments.



Advanced robotic system for ultra-precise micro-integration of photonic modules for space applications.

Additive manufacturing (3D printing)

We develop and manufacture complex and precise metal and ceramic components using advanced additive manufacturing technologies. Our capabilities enable high design freedom, functional integration, and efficient production for prototypes, customized parts, and small series.

Metal additive manufacturing enables light-weight, high-strength structures with integrated functions such as internal cooling channels. This technology reduces material consumption and shortens development time.

Technical ceramics as well as advanced micro- and nanostructuring extend our portfolio for demanding applications. Ceramics offer high mechanical stability, favorable thermal properties, and ultra-high vacuum compatibility. Micro- and nanostructuring enable precise functional features for electronic, photonic, and sensing systems.

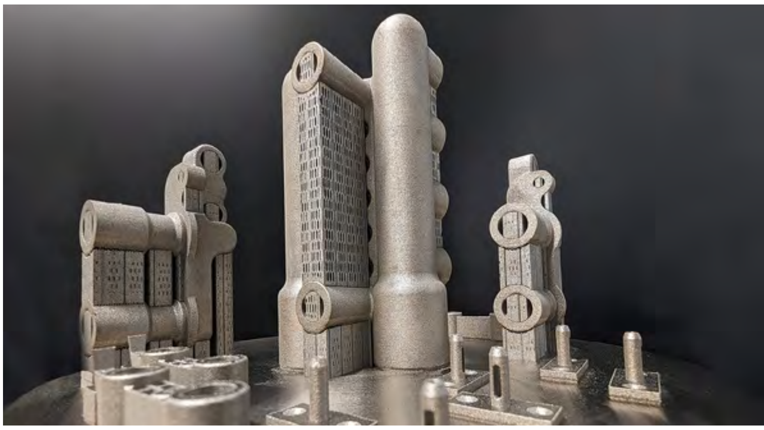
Metals

- Laser-based metal additive manufacturing
- Accuracy of approximately ±50 µm with fine feature resolution
- Build volume up to Ø 200 × 200 mm^3
- Materials: stainless steel, aluminum, titanium, and copper-chromium-zirconium

Ceramics

- Lithography-based ceramic manufacturing (LCM)
- 40 µm pixel pitch and down to 10 µm layer height with 102 x 64 x 320 mm^3 build volume
- Materials: oxide and nitride ceramics, including Al_2O_3, ZrO_2, and AlN

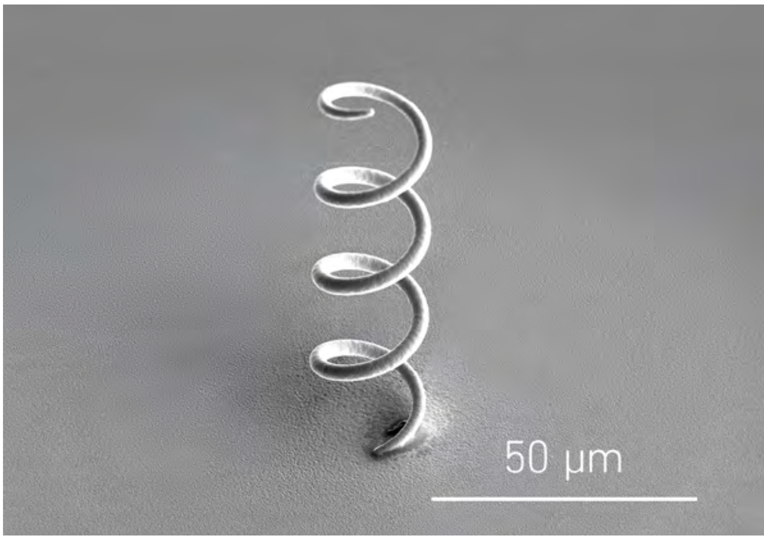
Optical frequency reference for portable quantum sensors based on an additively manufactured ceramic micro-optics platform with a system volume of just 6 mL



Test structures fabricated using FBH's 3D metal printer.

Micro- & nanostructures

- Copper microstructures based on localized electro-chemical deposition with voxel sizes in the single-digit micrometer range
- Gold and carbon nanostructures fabricated by direct electron beam writing with feature sizes down to wire diameters of about 30 nm



Copper microstructure fabricated by localized electrochemical deposition.

We offer end-to-end solutions in advanced additive manufacturing for complex metal and ceramic components as well as high-precision micro- and nanostructures. Our expertise enables rapid proto-typing, customized solutions, and small-series production for demanding applications in photonics, electronics, sensing, and quantum technologies.

Analytics & characterization

At FBH, we provide comprehensive in-house material and device characterization to support technology development and industrial applications. Our analytical methods enable heterostructure development, process and assembly optimization, device performance evaluation, and failure analysis.

Material analytics

- X-ray diffraction measurements
- X-ray fluorescence analysis
- Energy dispersive X-ray spectroscopy
- Photoluminescence and electroluminescence spectroscopy
- Capacitance-voltage and Hall effect measurements
- Secondary electron microscopy of bulk materials and devices
- Transmission electron microscopy
- Cathodoluminescence imaging and spectroscopy
- Sample preparation (cross section and plan-view; chemical, mechanical, FIB)

Electronic device and circuit characterization & metrology

- On-wafer small-signal S-parameter measurements from 1 MHz to 1100 GHz
- Single-sweep on-wafer S-parameter measurements from 70 kHz to 220 GHz
- Pulsed S-parameter measurements up to 50 GHz
- Spectral characterization up to 750 GHz (1100 GHz)
- Power characterization and active/passive load-pull measurements up to 50 GHz
- On-wafer high-voltage DC characterization up to 3000 V
- On-wafer power-electronic switching transients up to 50 A/1200 V
- Non-linear network and intermodulation analysis
- Noise characterization up to 160 GHz
- Phase-noise measurements 1 MHz - 50 GHz
- Time domain small-signal and large-signal on-wafer test measurements from 1 GHz to 72 GHz, including AWG signal generation
- Wideband MIMO characterization with DPD, IQ signal bandwidth exceeding 1 GHz, and 5 GHz analysis bandwidth up to 50 GHz
- Automated device characterization and modeling
- Metrology for mm-wave calibration routines based on electromagnetic simulation and measurements

Wideband vector-corrected measurement system for 5G-MIMO and space applications.

Laser and LED characterization & metrology

Device characterization on wafer & bar level

- Electro-optical and spectral characterization of lasers and LEDs
- AI-assisted optical device inspection of laser diodes

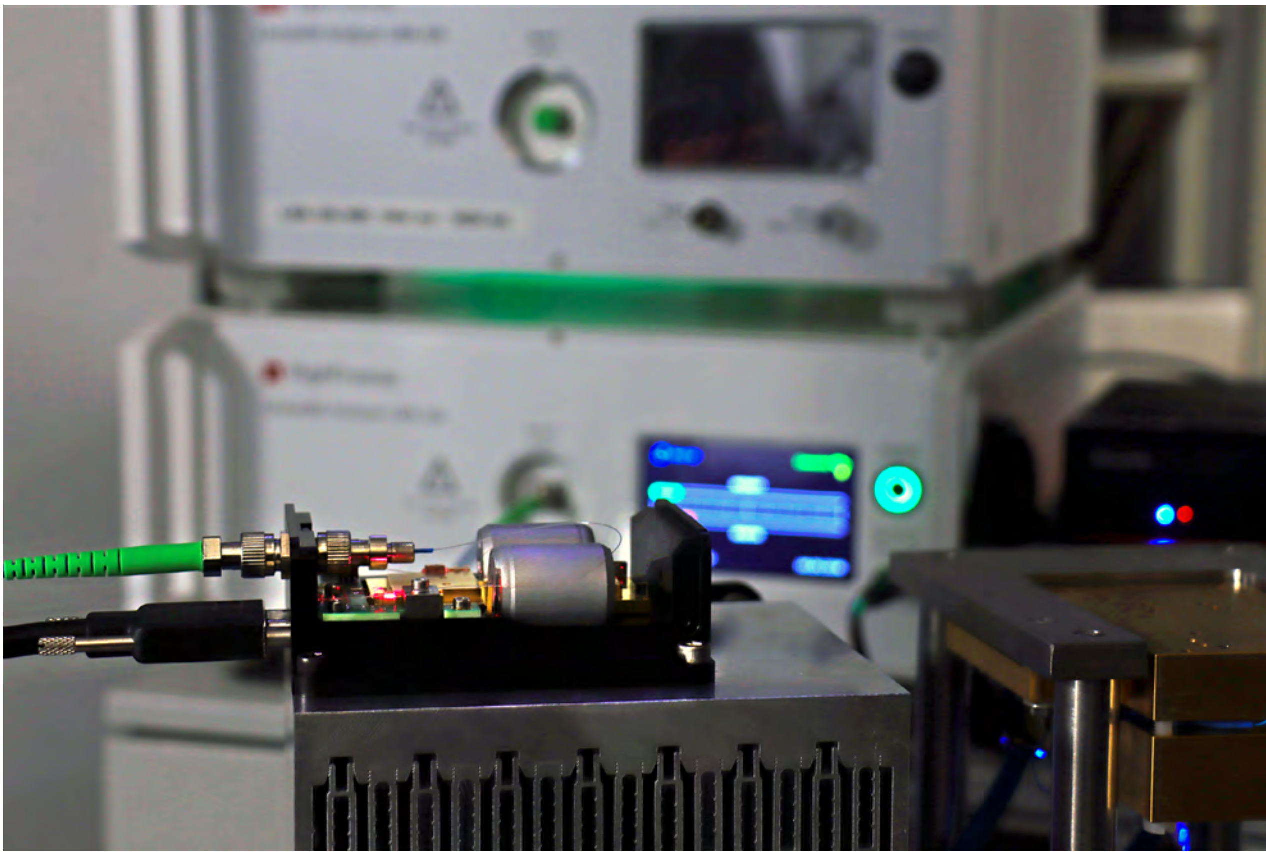
Device characterization for mounted laser diodes & LEDs

- Electro-optical and spectral characterization in CW, QCW, and pulse drive mode
- Laser beam quality measurements according to ISO11641-2
- Hemispherical far-field as well as polarization-resolved near- and far-field measurements
- Pulse characterization (ps to ns), including spatially and temporally resolved measurements using a streak camera

Laser device & module characterization

- High and ultra-high resolution (kHz) optical spectra
- High and ultra-high resolution (kHz), high dynamic range (50+ dB) side-mode suppression ratio
- Coherent beam profile, polarization extinction ratio
- Short-term phase instability: phase and frequency noise spectra (Hz to GHz), jitter
- Linear and non-linear vector network dynamic response of lasers and modulators to modulation of injection currents, heaters/thermoelectric coolers and other actuators (Hz to GHz)
- Optical metrology infrastructure used for short- and long-term frequency instability measurements: optical frequency references (rubidium, cesium, strontium), high-finesse optical cavities, optical frequency combs, wavemeters, and counters

We offer advanced material, photonic, and electronic device characterization services, enabling end-to-end insight from fundamental material properties to device and module performance. Our capabilities support research, process optimization, model verification, and failure analysis for industrial and scientific applications.



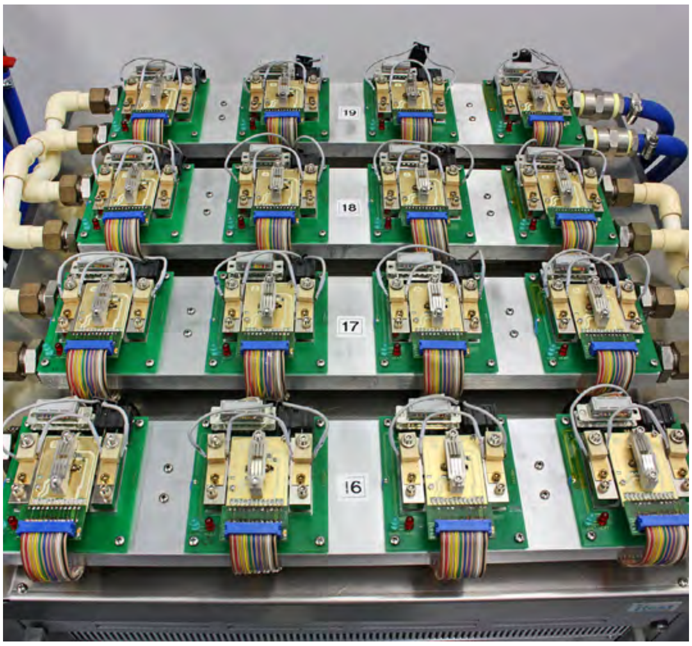
Comprehensive laser characterization to determine spectral properties.

Reliability investigation & qualification

Reliability is crucial for optoelectronic and electronic devices used in demanding applications. In our reliability labs, we investigate degradation behavior and qualify the lifetime of UV LEDs, laser diodes, photonic modules, and RF transistors using advanced measurement infrastructure.

Services include:

- Reliability testing of laser diodes, stacks (380 - 1200 nm, CW and QCW operation), modules, and UV LEDs (220 - 450 nm).
- Testing under ISO 5 cleanroom conditions for demanding applications, including space missions
- Device qualification according to standards such as “Telcordia GR-468-CORE” and “ECSS-Q-ST-60C”
- Environmental stress testing (vibration, shock, and thermal cycling)
- Standard on-wafer reliability tests for RF transistors, i.e., HTRB, IDQ, and SST (base plate temperature up to 150 °C)
- Temperature-accelerated lifetime DC tests of up to 64 packaged microwave devices (base plate temperature up to 250 °C)
- Root cause analysis of device failure



Lifetime test system for high-power transistors with controlled dissipation power and 64 device slots equipped with stabilization circuits.

ISO 5 cleanroom laboratory for reliability testing of diode lasers for space missions.

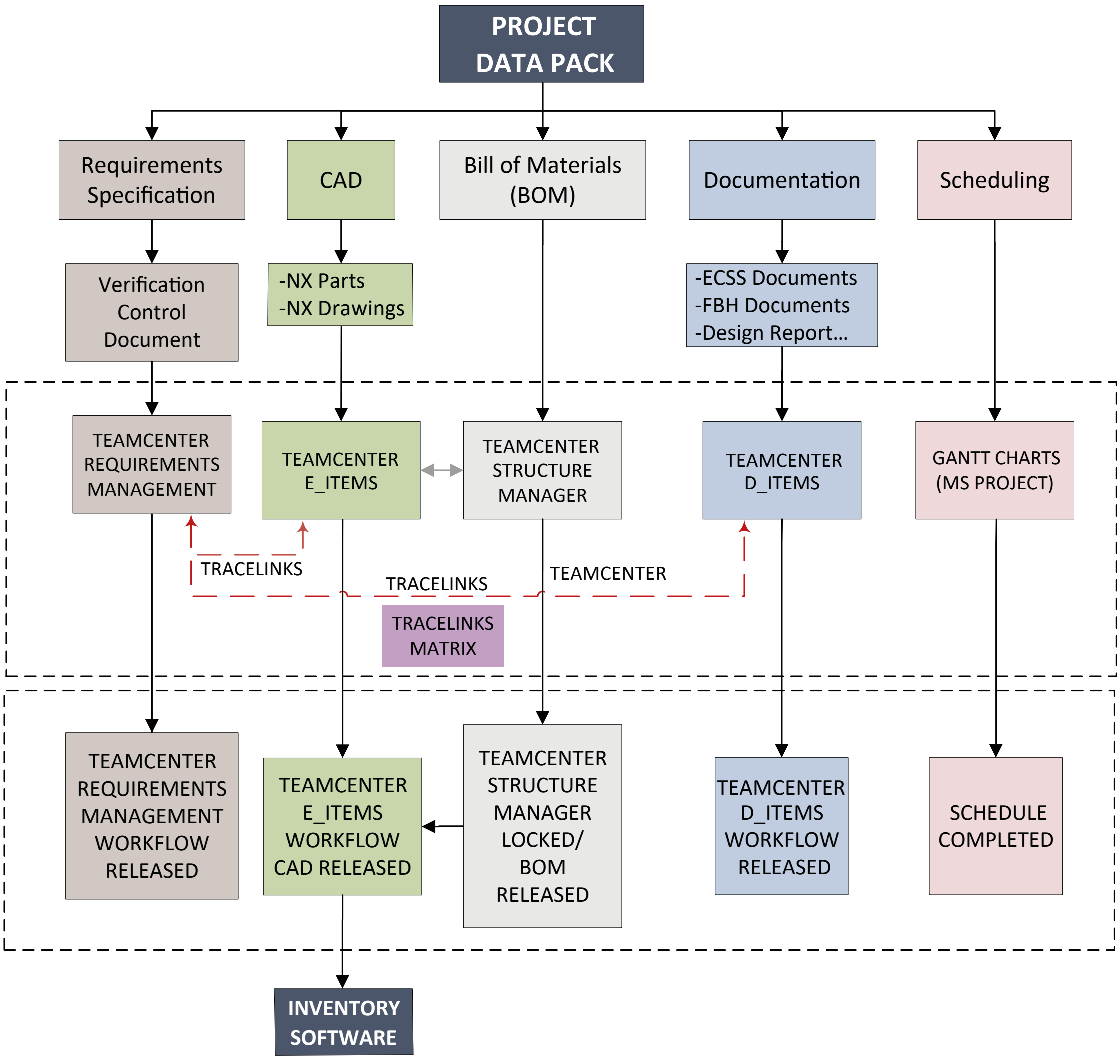
Product assurance for space projects

FBH's product assurance team supports projects throughout the complete development cycle and facilitates smooth and timely delivery of reliable space hardware.

We manage projects according to several standards, including ECSS, ESCC, and NASA. Our team of experts oversees project and supply chain management, qualification, as well as manufacturing, assembly, integration, and testing (MAIT).

Services for third-party components and payloads include:

- Product lifecycle management (PLM)
- Support for mission definition studies and hardware development projects
- Product assurance (PA) plan requirements break down
- Support documentation activities to ensure compliance with ECSS/PA plan
- Monitoring of MAIT processes and related MAIT-hardware and -environment for compliance with ECSS/PA plan
- Qualification according on ECSS and ESCC standards



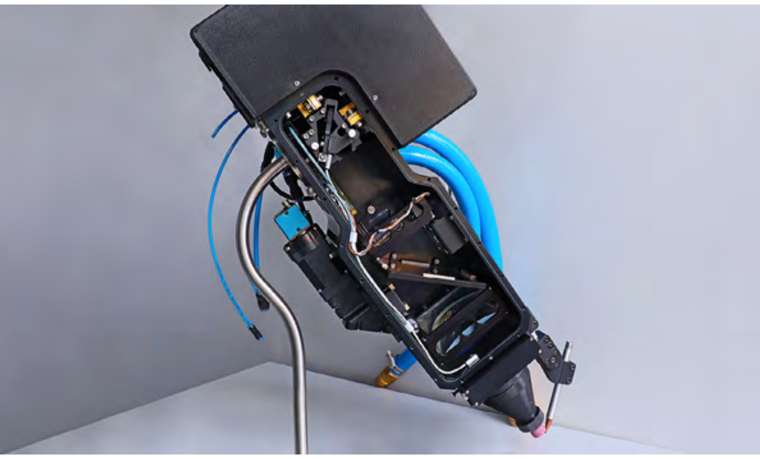
Product lifecycle management process for space-related projects at FBH.

Prototyping & system validation

We support partners from concept to functional demonstrator, translating advanced research into portable, standalone devices. By miniaturizing complex laboratory setups into user-friendly systems, we deliver application-ready hardware. Our expertise includes customized optical sensing solutions tailored to analytical methods like Raman spectroscopy.

Services cover the full development process, including:

- Mechanical design, electronic engineering, and simulations
- Customized software development with user-friendly GUIs
- Extensive functional testing
- Precision component manufacturing in our fine mechanics workshop, including metal and polymer 3D printing, wire EDM, and 5-axis CNC milling



Direct-diode laser system for additive manufacturing – with integrated kW-class laser stack modules.

System validation in practice: Raman spectroscopy

Our novel diode lasers, customized laboratory setups, and field-deployable sensor systems enable system validation under real-world conditions.

Services include the analysis of solid and liquid samples using target-specific approaches based on:

- Confocal Raman microscopy
- Raman and resonance Raman spectroscopy
- Shifted excitation Raman difference spectroscopy (SERDS)
- On-site Raman and SERDS investigations

To support system validation in your experimental setups, we also provide turnkey dual-wavelength diode laser systems optimized for SERDS.

Diode laser turn-key system with integrated dual-wavelength laser used for Raman spectroscopy and SERDS investigations.

Ferdinand-Braun-Institut (FBH)

is an application-oriented research institute in the fields of high-frequency electronics, photonics, and quantum physics. R&D includes power-electronic as well as high-frequency devices and circuits for communications, power electronics, and sensor technology. Moreover, FBH develops light sources from the near-infrared to the UV spectral range: high-power diode lasers, UV light sources, and hybrid laser systems. Applications range from medical technology, materials processing and sensors to optical communications in space and integrated quantum technology. In close cooperation with industry, its research results lead to cutting-edge products.

How to work with us

- Joint research projects
- Industrial contracts
- Small-series production
- Prototypes
- Consulting
- Technology services
- Technology transfer

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