FBH competencies in photonics & quantum technologies

Our developments are driven by a deep understanding of physics, advanced design expertise, and end-to-end semiconductor manufacturing – from epitaxy and wafer processing through packaging and hybrid micro-integration to system integration.

We create cutting-edge modules and systems engineered for, e.g., medical, LiDAR, metrology, laser pumping, space, and quantum applications.

- Full-cycle development: requirements engineering, design, realization, characterization, and reliability testing (including space qualification)
- Additive manufacturing of ceramics, metals, and polymers
- Flexible coupling options: free-space or fiber (MMF, FMF, SMF, PM-SMF)
- Seamless integration of micro-optics, modulation, thermal management, and tailored control and readout electronics
- System integration into turn-key devices suited to specific applications
- Standards-compliant documentation

High-precision micro-assembly of photonic modules for space applications.

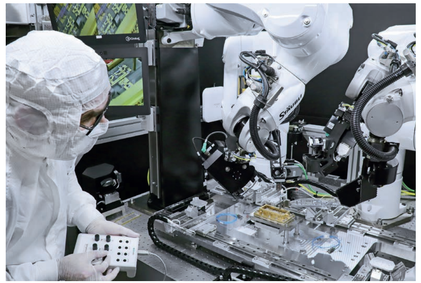
Our modules deliver outstanding electro-optical, thermal, and mechanical performance through advanced assembly and integration techniques.

These include:

- Optical benches made from thermally conductive, expansion-matched alloys
- Micrometer bonding precision for active laser elements
- Nanometer alignment precision of passive micro-optics
- Hermetically sealed, thermo-electrically cooled packages
- Proven robustness under vibration, shock, and thermal stress

Hybrid micro-integration technology

We design and manufacture custom micro-integrated modules for photonics and quantum-technology applications – up to small series production – using state-of-the-art infrastructure and based on of precision engineering expertise.



Robotic setup for ultra-precise micro-integration of photonic modules for space applications.

→ **Find out more about our technologies and expertise.**

The 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-scale series
- → Prototypes
- → Consulting
- → Technology services
- → Technology transfer

Feel free to contact us

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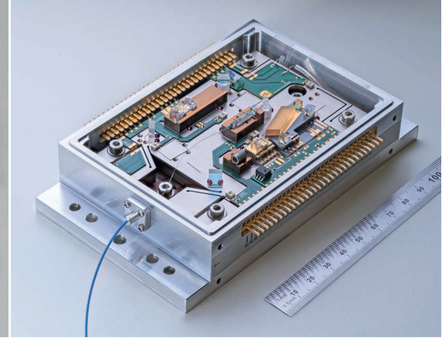
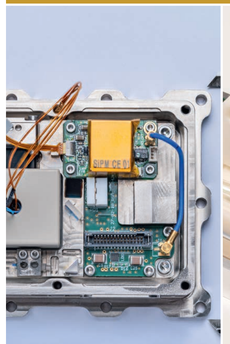
Website

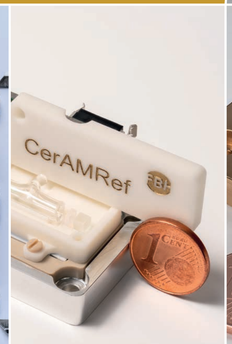
LinkedIn

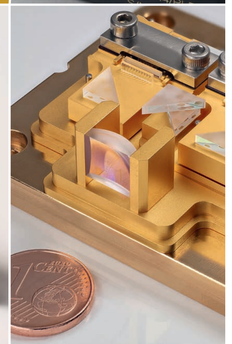


Leibniz Ferdinand Braun Institut

Advanced Photonic & Quantum Modules





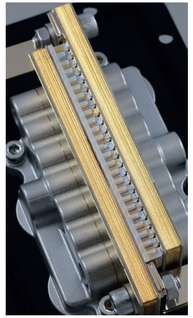


Comprehensive capabilities in modules & systems

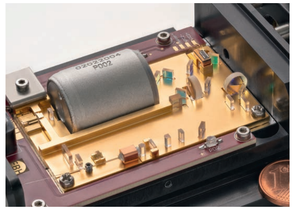
We offer a wide range of modules and systems that are highly complex yet miniaturized, incorporating tailored FBH laser diodes, light-emitting diodes (LEDs), amplifiers, vapor cells, electronics, and further (electro-)optical components. Their tailored functionalities make them suited for a multitude of applications, thus ensuring low-barrier system integration and operation in challenging environments. Our complete inhouse technology chain ensures that all modules and systems can be flexibly adapted to customer requirements – up to small series production:

- GaAs- and GaN-based single emitters, laser bars, amplifiers, multiple wavelength emitters, monolithically or hybrid-integrated gratings for stabilization…
- Wide wavelength range from inhouse developed devices: 220 nm to 1200 nm
- Frequency mixing to realize customized wavelengths, e.g., emission in the mid-infrared, yellow, and deep-UV spectral range
- Output powers from the milliwatt (mW) to the kilowatt range (kW)
- Frequency noise down to hertz (Hz) range linewidths
- Continuous wave to ultrashort (pico-second) pulsed emission, optionally integrated with high-current FBH drivers
- Vapor-cell-based atomic devices for frequency metrology and sensing
- Plug & play modules with/without fiber coupling for simple system integration at customer's site and support with validation in the respective application
- Integration of third-party lasers possible
- Comprehensive characterization and reliability testing
- Transfer of know-how and technology to industry for further product development

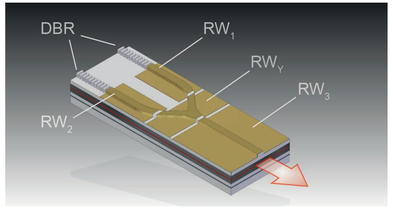
Overview
of what we offer



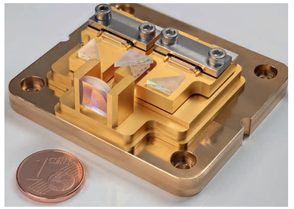
High-power diode laser stack module designed for integration into a direct-diode laser system used for additive manufacturing.



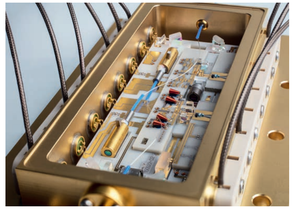
Quantum light module for generating entangled photons, with built-in laser source and quantum interferometer.



Dual-wavelength laser chip for Shifted Excitation Raman Spectroscopy (SERDS).



Extremely low-noise pump laser module used for optical data transmission in space.



Remarkably robust – micro-integrated, frequency-stabilized diode laser module used for precision experiments in space.

Optical frequency reference module with integrated gas cell for spectroscopy applications.

We offer a wide range of modules and systems that are highly complex yet miniaturized.

High power

- Pumps for high-energy pulsed lasers
  - Several kW pulse power
  - Very high repetition rate/duty cycle
- Diode modules for direct material processing
  - Output power up to the kW range (CW)
  - Application-adapted: interfaces, wavelength, working distance, spot size/shape, grating stabilization
- High brightness, compact fiber laser pumps
  - Hundreds of watts of power from ≤ 400 µm output fibers
  - Compact, lightweight module design possible
- Ultra-high brightness modules, via advanced beam combining
  - Integrated polarization, wavelength and coherent beam combining schemes for brightness scaling
  - Diffraction-limited emission possible
- Plug & play system integration possible

Customized wavelengths

- Single diode lasers directly emitting in the wavelength ranges: 610 – 1200 nm (GaAs) and: 390 – 460 nm (GaN)
- UV LEDs emitting in the range 220 – 340 nm
- Frequency conversion for wavelengths that are otherwise difficult to realize using GaAs or GaN, e.g., laser emission in the RGB(Y), mid-infrared, and deep-UV spectral ranges
- Single chips with multi-wavelength emission

Entangled photon pairs

- Miniaturized modules for the generation of entangled photon pairs
- Broadband wavelength ranges in the mid-IR and integrated nonlinear interferometers

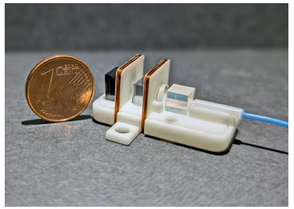
Grating-based frequency stabilization

- Monolithically integrated gratings: DFB/DBR-based modules enabling moderate linewidths
- Hybrid integration with external gratings: Extended and external cavity diode lasers enabling narrow and ultra-narrow linewidths down to the Hz level
- Additional amplification stage possible to boost the output power
- Ultra-low relative intensity noise < 0.001
- Lifetime reliability > 10 years
- Space-grade demonstrated

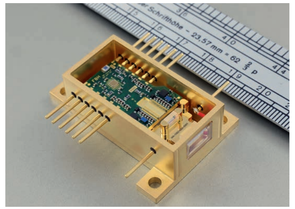
Optical frequency references

- With or without integrated laser
- Integration with detection and control electronics possible
- Absolute optical references based on atomic transitions, including integrated vapor cells and various spectroscopy schemes
- Tunable optical frequency references based on volume Bragg gratings, implementation at all wavelengths of interest

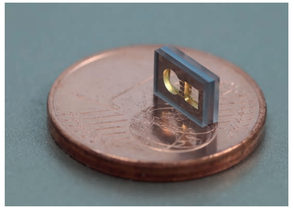
Our developments are driven by a deep understanding of physics, advanced design expertise, and end-to-end semiconductor manufacturing.



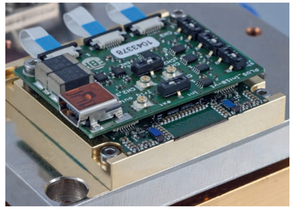
Wafer-level spectroscopy cell-based optically pumped magnetometer (OPM) sensor head with a volume of just 7 ml.



Time-of-flight Light Detection and Ranging (LiDAR) laser module for space applications.



Wafer-level vapor cell.



Laser module with integrated driver for automotive LiDAR applications.

Optically pumped magnetometers

- Customized designs from single-axis to multi-axis measurements
- Magnetic sensing platform capable of spatially resolving biomagnetic signals

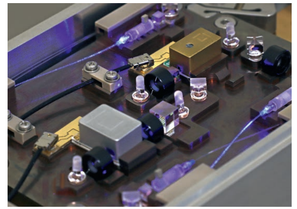
Wafer-level spectroscopy cells

- Microfabrication of alkali vapor cells with customized designs including functionalization (optical coatings, heating structures)
- Micro-integration of wafer-level spectroscopy cells into robust spectroscopy devices, such as frequency references and magnetometers

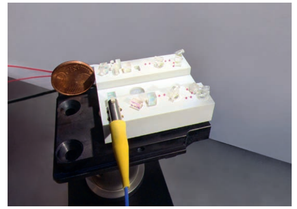
Pulsed laser sources

Picosecond to nanosecond pulse lasers – up to kA peak current, up to kW output power

- From single emitter lasers to laser bars, optionally:
  - Wavelength and temperature stabilized by Bragg grating (DBR, DFB lasers)
  - Power scaling using epitaxial stacks of active regions and tunnel junctions
- Ready-to-use laser modules
  - Integration into driver board
  - Hybrid integration with micro-optics in butterfly housing
  - Free-space output
  - Inhouse-developed electronic and mechanical interfaces



Miniaturized modulators and optical elements integrated into a light control unit operating at 461 nm.



Compact, micro-integrated crossed beam optical dipole trap with a volume of less than 25 ml.

Light-control units

Fiber-coupled modules for overlapping, switching, and manipulating light (shift and modulate phase/frequency) as link between laser module(s) and experimental setup(s), for example:

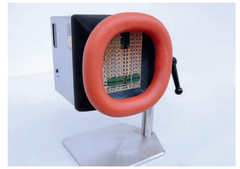
- Fiber-length stabilization modules for optical clocks/ frequency references (integrated Acousto-Optic Modulators (AOMs) as well as photodiodes & electronics for beat detection)
- Amplitude stabilization and phase modulation, enabling spectroscopy (integrated AOM and Electro-Optic Modulator (EOM))
- Providing and combing multiple wavelengths in a single fiber (integrated DBR-lasers)

System integration & demonstration

- Implementation of functionalities, micro-integration
- Verification in respective applications, pilot investigations, and services
- Modules and turnkey-ready systems for easy integration at partner's/customer's site

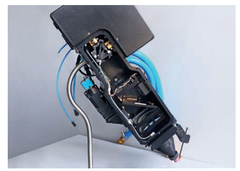
Application examples

Spectrometer-free portable Raman spectroscopy measurement system with integrated dual-wavelength diode laser.



Far-UVC LED irradiation system for medical tests on human skin.

Fully autonomous, frequency-stabilized laser source for quantum sensors and atomic clocks.



Direct-diode laser system for additive manufacturing.