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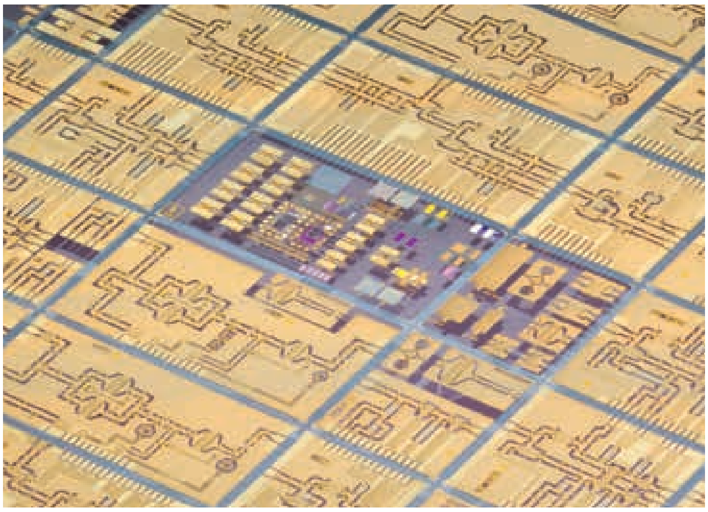
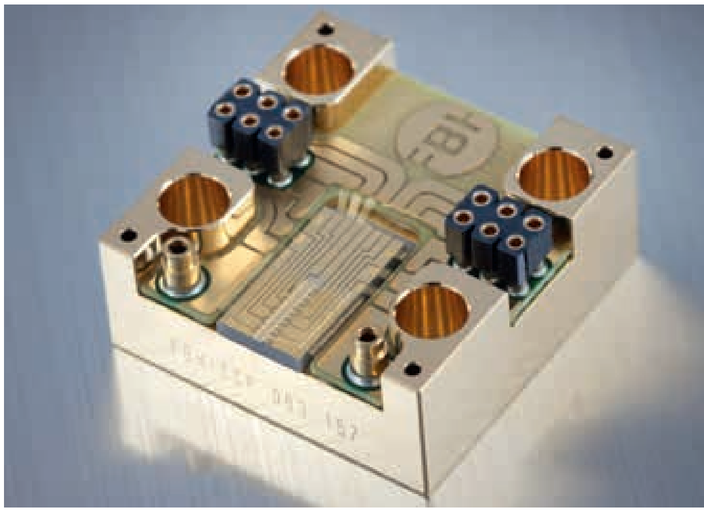




III-V Materials & Processes

Complete Process Chain from Substrate to Mounted Devices

The FBH bundles its know-how and resources in materials, process technology, and mounting and assembly. This III-V technology research area forms the basis for device development including diode lasers, UV LEDs, MMICs, and power transistors.

Epitaxy

Epitaxial layer growth is the starting point for realizing FBH's advanced optoelectronic and electronic devices. On a single crystalline substrate, semiconductor layer structures with well-defined crystalline, electrical, and optical properties are grown for both FBH and external customers.

- **nitrides:** AlGa(In)N heterostructures as basis for the respective devices including UV LEDs, violet laser diodes, GaN and AlN transistors.

- **arsenides:** AlGaAs and AlGaInP heterostructures for GaAs-based laser diodes; also: Bragg mirrors and saturable absorber mirrors (SAM) for pulsed laser systems.

Process Technology

Epitaxial semiconductor wafers are processed into a large variety of electrical and electro-optical devices based on GaAs, InP, SiC, GaN, Ga_2O_3, and AlN. Tailored wafer processing is carried out in a highly flexible process line compatible with industry standards. All technology steps, from lithography, deposition and etching to chip dicing, are available and continuously improved.

Front-end processing: comprises all process modules to fabricate components at wafer level using full 2" to 4" wafers as well as wafer parts. Automated and manual processing of wafers in batches of different sizes and retail operations are carried out in FBH's cleanroom of up to ISO class 5. Process modules in operation are

- photolithography and electron beam lithography
- wet and plasma etching techniques
- various deposition methods for thin metallic and dielectric layers
- ion implantation of a large variety of elements with acceleration energies from 15 keV to 400 keV
- thermal processing techniques
- DC measurements

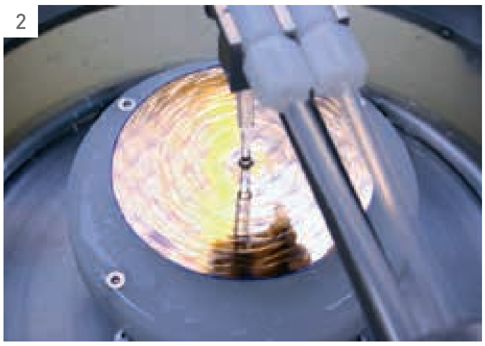
Back-end processing: links front-end processing of full wafers to packaging of single chips, thus obtaining the desired device functionality. Established process modules comprise

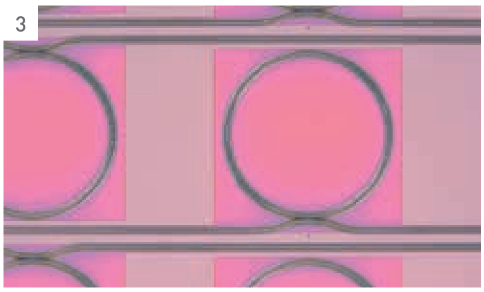
- laser micro processing
- aligned wafer-to-wafer bonding
- wafer back-side thinning
- back-side processing of RF devices
- DC device characterization
- wafer dicing: sawing, diamond as well as laser scribing and breaking

design

epitaxy

front-end processing





1 epitaxy reactor
2 wafer coating
3 optical micro resonators
4 wafer back-end processing
5 laser chip packaged on c-mount
6 UV LED on AlN submount
7 PL spectra of materials used for FBH's LEDs & laser diodes

Services

Mounting & Assembly

Devices are mounted on heat sinks or into packages and electrically contacted for full characterization and performance evaluation. For its partners, FBH offers laser chips on submounts (CoS) as well as mounting and assembly into housings and packages both standardized and customized. Relevant process skills include

- scribe and break dicing (e.g. laser bars into chips)
- solder bonding (AuSn, PbSn, SnAgCu etc), in house tailoring of preforms
- wire and ribbon bonding (e.g. Au wire, 17.5 µm and 25 µm diameter)
- adhesive bonding (dispens robot for high precision and repeatability dispensing)

Material Analytics

Analysis techniques support the development of epitaxial growth processes by characterization of heterostructures, development of processing and mounting steps as well as investigation of root causes for device failure. In-house methods comprise

- X-ray diffraction
- photoluminescence
- electroluminescence
- carrier-density profiling
- Hall effect measurements
- electron microscopy
- cathodoluminescence
- sample preparation (cross section and plan-view)

FBH makes its technological infrastructure and know-how available to external partners. It offers customer-specific epitaxial wafers as well as process modules, mounting services and analysis of epitaxial wafers, processed or failed devices.

As an epi-wafer foundry, FBH realizes **epitaxial structures with excellent properties** according to customer's requirements

- GaAs-based layer structures for laser diodes, waveguides, transistors, detectors, Bragg mirrors, and SAMs
- GaN-based layer structures for transistors and laser diodes, AlGaN UV emitters, GaN and AlN template layers

FBH offers **customized wafer process steps and modules** as well as complete device manufacturing up to small-scale series fabrication. It also develops and tests custom-specific process modules, which can be transferred to external partners. InP HBTs for THz frequencies form the basis for FBH's THz systems. Monolithically integrated with Si BiCMOS circuits, this technology is also made available to external customers in cooperation with the Leibniz institute IHP.

Capabilities in **characterization of semiconductor layers and devices** offered to customers include analysis of crystalline, optical, and electrical properties of layer structures by X-ray diffraction, photoluminescence and cathodoluminescence, electron microscopy and Hall effect measurements. To analyze the root causes of device failures, FBH makes the relevant layers accessible for analysis by mechanical and chemical sample preparation.

all steps supported by material analytics

back-end processing

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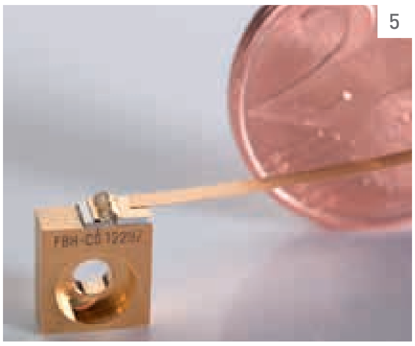
mounting & assembly



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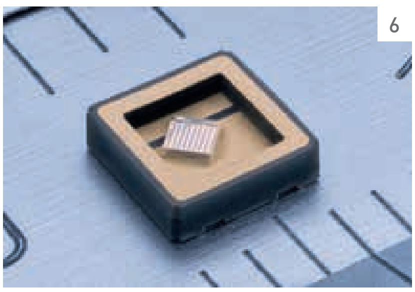

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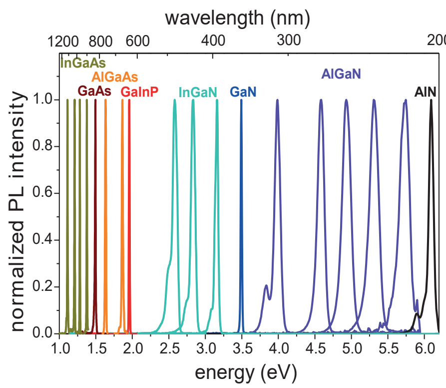

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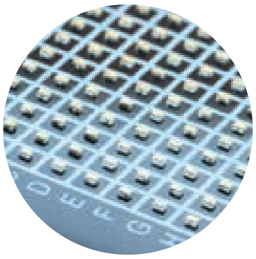
device characterization


translating ideas into innovation

The Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik (FBH) is an application-oriented research institute in the fields of high-frequency electronics, photonics and quantum physics. It researches and realizes electronic and optical components, modules and systems based on compound semiconductors. These devices are key enablers that address the needs of today's society in fields like communications, energy, health, and mobility.

Specifically, FBH develops light sources from the infrared to the ultra-violet spectral range: high-power diode lasers with excellent beam quality, UV light sources, and hybrid laser modules. Applications range from medical technology, high-precision metrology and sensors to optical communications in space and integrated quantum technology. In the field of microwaves, FBH develops high-efficiency multi-functional power amplifiers and millimeter wave frontends targeting energy-efficient mobile communications, industrial sensing and imaging as well as car safety systems. In addition, the institute fabricates laser drivers and compact atmospheric microwave plasma sources operating with energy-efficient low-voltage drivers for use in a variety of applications.

The FBH is a center of competence for III-V compound semiconductors covering the full range of capabilities, from design through fabrication to device characterization. Within Research Fab Microelectronics Germany (Forschungsfabrik Mikroelektronik Deutschland – FMD), FBH joins forces with 12 other German research institutes, thus offering the complete micro and nanoelectronics value chain as a one-stop shop.

In close cooperation and strategic partnerships with industry, FBH's research results lead to cutting-edge products. The institute also successfully turns innovative product ideas into spin-off companies. With its Prototype Engineering Lab, the institute strengthens its cooperation with customers in industry by turning excellent research results into market-oriented products, processes and services. The institute thereby offers its international customer base complete solutions and know-how–from design to ready-to-use modules and prototypes.

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