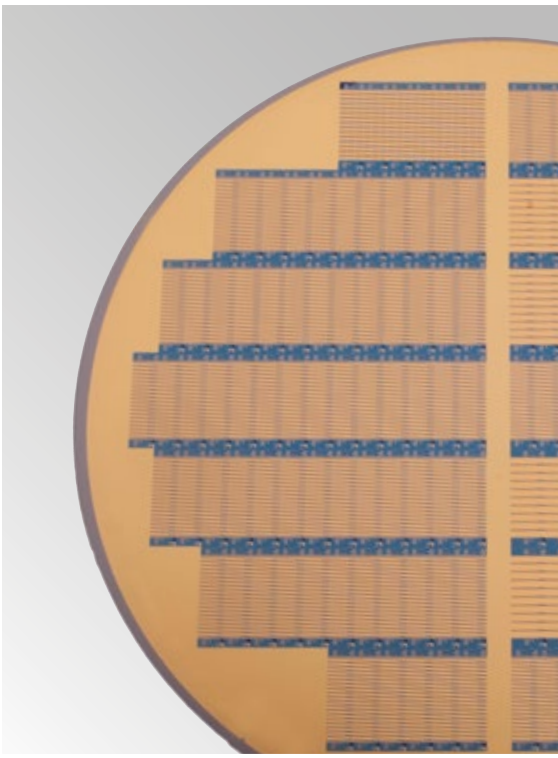
Leibniz
Ferdinand
Braun
Institut



Laser Diodes

Leading Technology in Semiconductor Lasers

The FBH is a center of competence for compound semiconductors comprising the full value chain – from device design to epitaxy, process and mounting technology. As a one-stop agency, the institute offers complete solutions and know-how starting with the key components, the laser chips, through to sophisticated ready-to-use modules.

FBH's laser diodes are highly brilliant light sources which are preferred for use in material processing, measurement, medical diagnostic, and sensing applications, as well as for use as pump sources for ultra-high peak power solid-state laser systems.

High-power diode laser with outstanding brightness, efficiency, and reliability are the main objectives of FBH's optoelectronic research. The institute achieves cutting-edge results through continuously improving technology and by innovation in design. Recent examples include very efficient high-power 1 ms pulsed sources for pumping solid-state laser systems. Developments comprise modules that combine many single emitters to deliver 6 kW fibered power with 20 % duty cycle at pulse widths from 100 µs to 100 ms (for pumping disk lasers) and laser bars that deliver over 1.5 kW (for pumping large area solid-state amplifiers).

Products & Services

Research & Development

The FBH conducts research on diode lasers targeting the highest possible brightness as well as maximum conversion efficiency. Building on this technology, the institute develops tailor-made devices according to the highly specific requirements of its customers in research and industry, such as

- highly reliable and highly efficient power laser diodes for material processing and medical applications
- laser diodes for highest output power in the kW range, as pump modules for large-scale solid-state laser research facilities for studies into laser-induced fusion
- multi-emitter chips with tailored properties for sensing and high-precision measurement systems

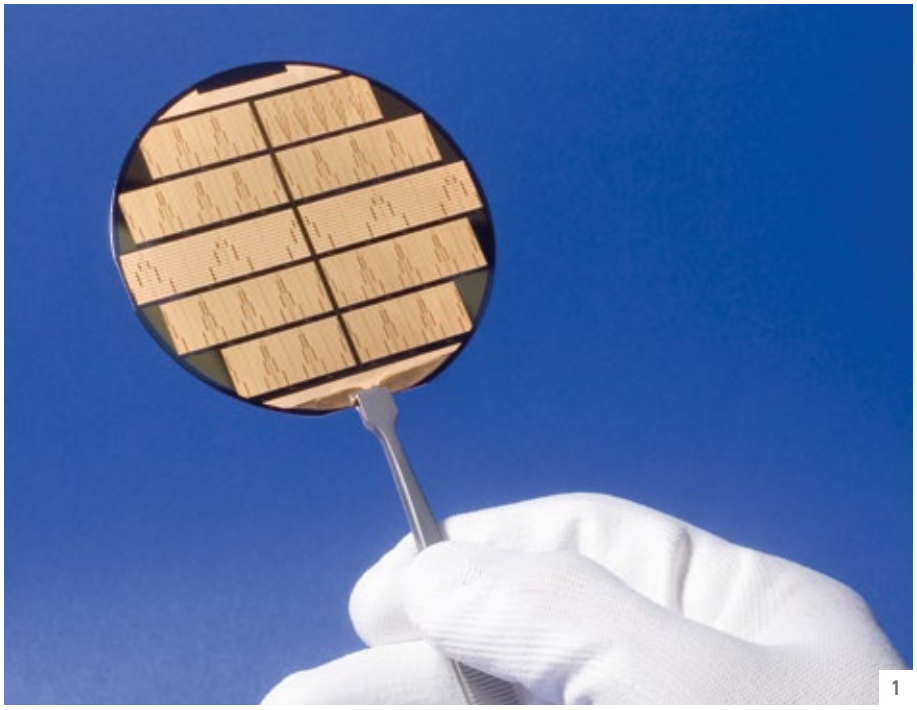
The FBH has long-term experience of commercial delivery and collaboration on development projects with industrial partners and uses an integrated management system (ISO 9001, 14001 and 45001).

Diode Lasers for the Highest Demands

The FBH offers a wide variety of cutting-edge devices to meet specific requirements in various applications. These are based on FBH's long-term research program and leverage its unique know-how in diode laser technology.The wavelength range covered extends from 630 to 1180 nm.

High power and efficiency

- **broad area (BA) lasers**
  - with up to 20 W reliable operation from devices with 100 µm stripe width in the wavelength range of 750 to 1100 nm, up to 1.5 W in the range of 640 to 690 nm
  - with high lateral brightness, delivering over 7 W within a beam parameter product of 1.5 mm-mrad



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1 processed 3" laser diode wafer
2 1 kW QCW diode laser bar
3 red-emitting laser bar
4 sensor chip containing 24 single mode emitters
5 SEM image of an apodized grating for efficient, high yield monolithic wavelength stabilization
6 High duty cycle pump modules for advanced solid-state lasers, 10 years plus of development, from 1 kW @ 10 Hz to 6 kW @ 100 – 1000 Hz

- **laser bars**
  - with > 1500 W QCW output power (1 ms, 10 Hz) using passively cooled mounts at 25° C (> 2 kW at -70° C) and conversion efficiency above 70 % at 8xx to 9xx nm
  - with > 350 W QCW output power (0.6 ms, 10 Hz) in the range of 630 to 690 nm
  - multi-wavelength arrays of high-power DFB lasers for spectral beam combination

- **laser stacks**
  with 6 kW QCW output power (1 ms, 200 Hz; 100 µs, 1 kHz), coupled into 1.9 mm core fiber, as complete application-ready modules

High brightness

- **ridge waveguide (RW) lasers**
  > 1 W with > 60% efficiency in fundamental mode at 9xx nm and peak power > 4 W

- **narrow linewidth tapered lasers**
  with integrated Bragg reflector, > 5 W in a nearly diffraction-limited beam from 800 to 1060 nm, spectral width below 50 pm

- **distributed feedback (DFB) and distributed Bragg reflector (DBR) RW lasers**
  up to 500 mW output power in fundamental mode, from 785 to 1080 nm, spectral width down to 100 kHz

- **mode-locked lasers**
  pulse width < 10 ps, repetition rates 4 GHz (monolithic cavity) and below 1 GHz (external cavity).

- **tilted RW amplifiers**
  1 W from 780 to 1070 nm

Customized chips

- **RW DBR laser arrays**
  up to 24 individually addressable emitters with independently adjustable wavelengths and small spectral widths

- **gain switched RW lasers**
  pulse widths from several 100 ps to several ns, > 5 W peak power in fundamental mode

- **single-emitter dual-wavelength RW DBR lasers**
  up to 200 mW, wavelength spacing > 0.3 nm

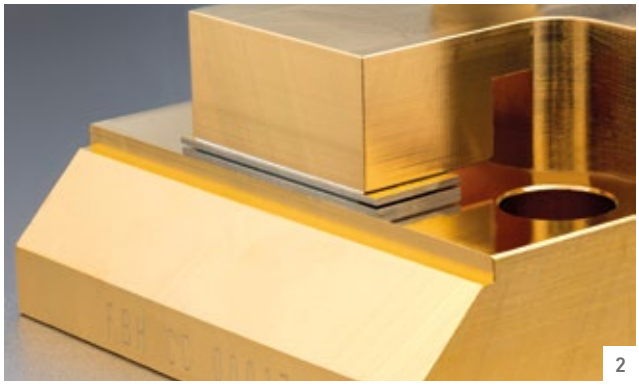
Technology

AlInGaAsP-based layer structures for highly sophisticated optoelectronic devices are grown on 2",3", and 4" wafers in multiwafer MOVPE reactors. Single and multiple GaInP, GaAsP, InGaAsP, AlInGaAs and InGaAs quantum wells are grown as active regions for use in semiconductor lasers at wavelengths between 630 and 1180 nm.

The FBH runs a highly flexible and industry-compatible full wafer process line for compound semiconductor devices. It includes an i-line wafer stepper as well as holographic and e-beam exposure for sub-micron periodic structures.

High-performance automated die bonding and assembly tools are used for mounting laser chips on submounts and for assembly of laser modules. Micro-optic components are fixed in place using an adhesive technology which is qualified for space applications and enables stable attachment with sub-micron precision.

The performance of these high-brightness high-power laser diodes is comprehensively characterized in FBH's test laboratories by using state-of-the-art measurement equipment.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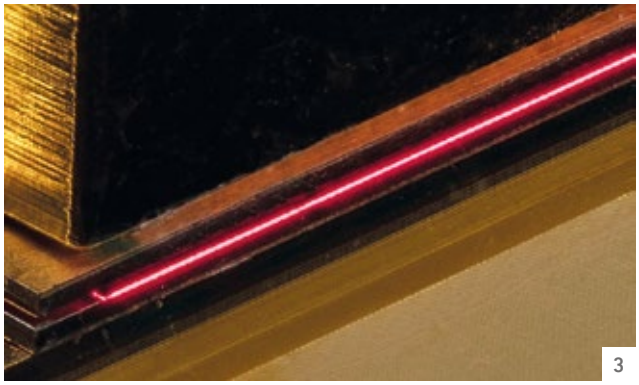
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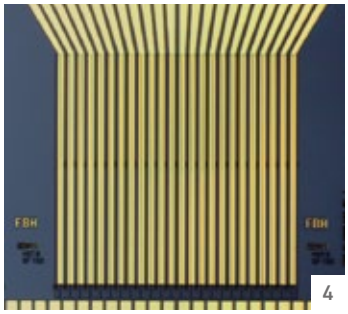
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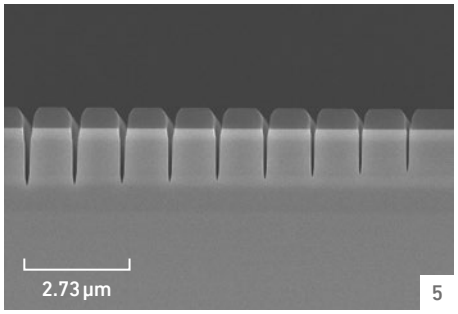

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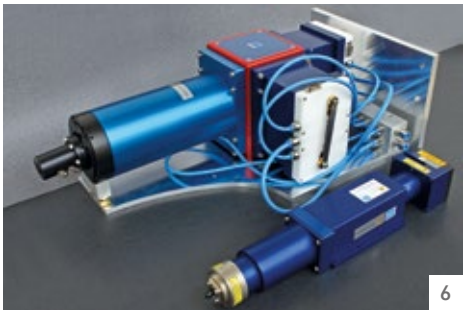
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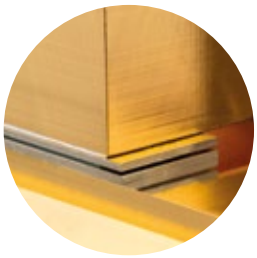
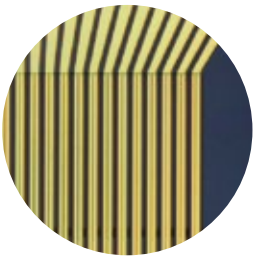


translating ideas into innovation

The Ferdinand-Braun-Institut, Leibniz-Institut fuer Hoechstfrequenztechnik (FBH) researches 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 visible 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. 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 an internationally recognized center of competence for III-V compound semiconductors. It operates industry-compatible and flexible cleanroom laboratories with vapor phase epitaxy units and a III-V semiconductor process line. The work relies on comprehensive materials and process analysis equipment, a state-of-the-art device measurement environment, and excellent tools for simulation and CAD.

In close cooperation 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 offers its international customer base complete solutions and know-how as a one-stop agency - from design to ready-to-use modules and prototypes. Overall, working in strategic partnerships with industry, FBH ensures Germany's technological excellence in microwave and optoelectronic research.

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