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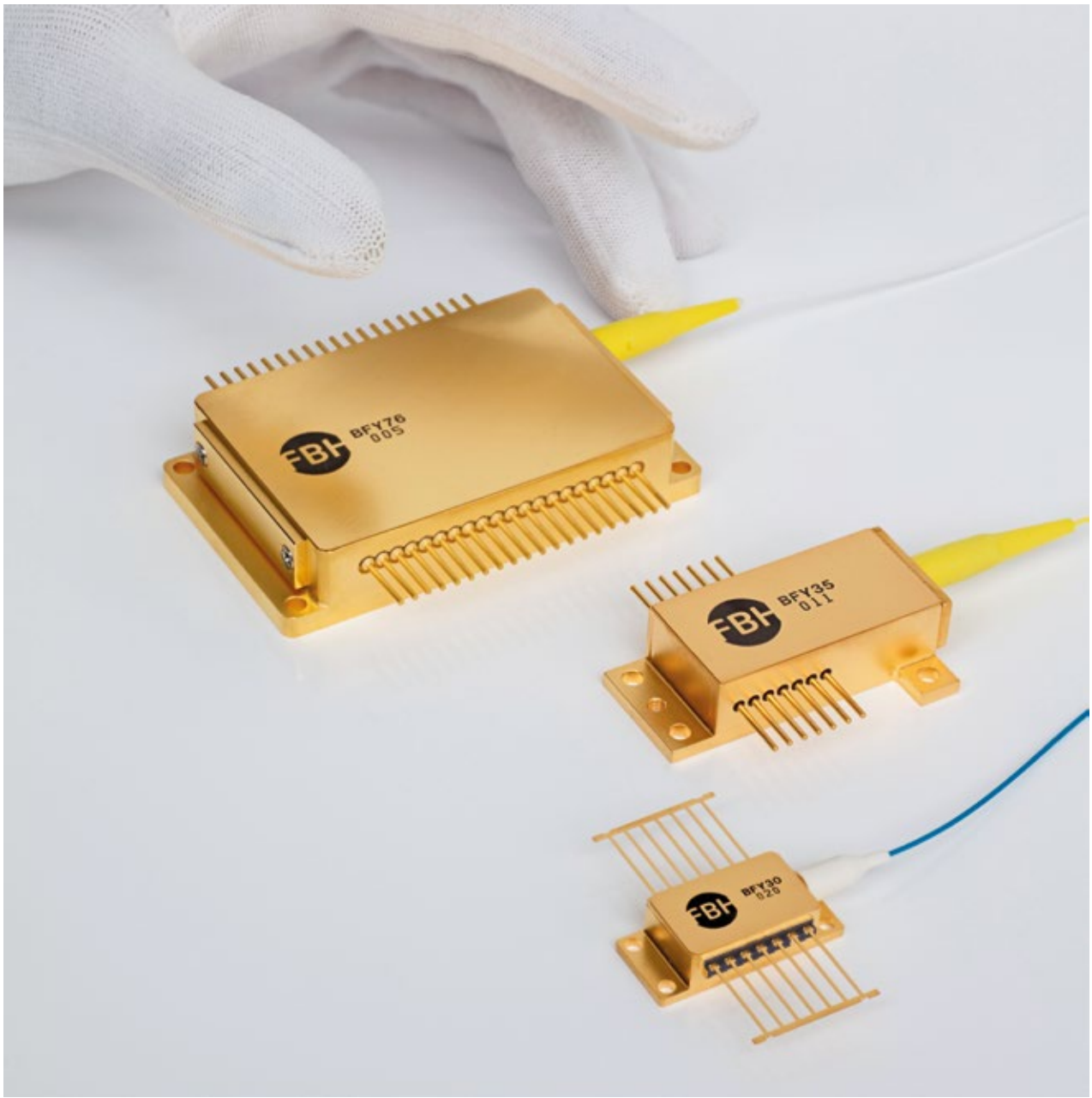
Institut



Diode lasers for medical diagnostics & treatment

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 prototypes and ready-to-use modules.

FBH's laser diodes and systems are highly brilliant light sources which are preferred for use in materials processing, measurement technology, sensing, as well as medical diagnostics and treatment. They are also used as pump sources for ultra-high peak power solid-state laser systems.

Products & Services

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 diode lasers and laser modules according to the highly specific requirements of its customers in research and industry. 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 medical diagnostics & treatment

The FBH offers a wide variety of cutting-edge diode laser modules that are tailored to meet the specific requirements of the targeted applications. Light sources emitting at specific wavelengths with excellent beam quality, delivering the desired output power in pulsed or continuous mode operation, can be designed and realized. All necessary optical and electronical components are integrated with highest precision into the compact master-oscillator power-amplifier modules, allowing customers an easy application.

Laser sources for diagnostics

The FBH provides light sources according to the needs of modern **confocal imaging** instruments. By precisely adjusting the grating periodicity any desired wavelength or wavelength set can be selected, thus exciting even exotic dyes (e.g. in the NIR).

For time-resolved fluorescence spectroscopy or in situ measurements of living cells by means of **STED microscopy**, the FBH offers short-pulse lasers in the yellow-green spectral range from 532 nm to 590 nm. They deliver intensive laser pulses with pulse lengths around 100 ps and pulse peak powers of several watts.

Raman spectroscopy as label-free technology offers the chance to distinguish between different molecules and thus also between healthy tissue and pathological changes. The FBH uses **shifted excitation Raman difference spectroscopy** (SERDS) to extract Raman signals efficiently and rapidly from disturbing backgrounds such as fluorescence. For this purpose, narrow-linewidth dual-wavelength diode lasers with a small spectral distance were developed and successfully tested with in-house manufactured compact Raman systems. Also, SHG-based devices in the visible spectral range were developed for resonance Raman spectroscopy.

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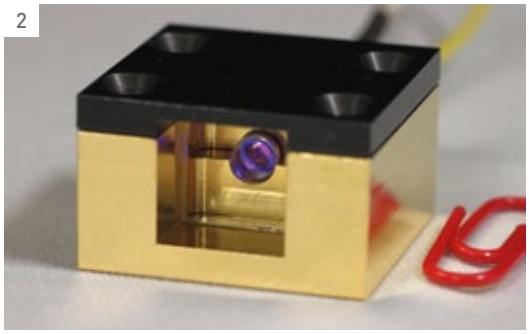

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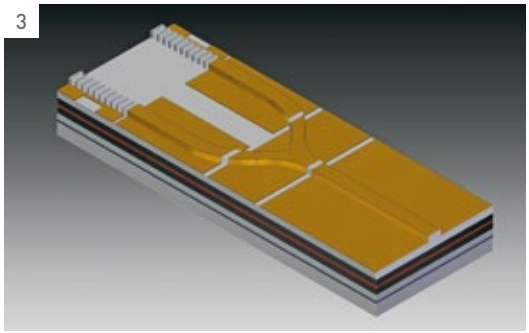


1 Turnkey laser system for dual-wavelength light sources, suited for shifted excitation Raman difference spectroscopy

2 External wavelength-stabilized 445 nm GaN diode laser for laser sensor applications

3 Scheme of a dual-wavelength diode laser for shifted excitation Raman difference spectroscopy

The FBH develops RW DBR laser arrays with up to 24 individually addressable emitters with independently adjustable wavelengths and small spectral widths for **precise surface detection** including digital holography.

Microscopy

To reach wavelength ranges that are not directly accessible with laser diodes (e.g., yellow & orange), frequency doubling of highly brilliant diode lasers has been successfully realized with hybrid-integrated modules in the wavelength range 530 – 590 nm. The light can be guided via polarization-maintaining fiber directly to the place of application.

low-power (confocal)
– very compact size: 34 x 47 x 12 mm³
– output power: up to 100 mW (CW)

high-power (super resolution)
– compact package: 76 x 44 x 15 mm³
– output power: up to 2 W (CW)
– operational modes: CW with direct modulation capability

pulsed (fluorescence & STED)
– compact package: 76 x 44 x 15 mm³
– pulse characteristics: 100 ps FWHM, up to 80 MHz repetition rate
– pulse peak power: > 2 W

Raman spectroscopy

monolithic dual-wavelength diode lasers
(VIS & NIR spectral range), suitable for SERDS
– wavelengths: 671 nm ≤ λ ≤ 1064 nm
– output power: up to 200 mW
– fast switching with frequencies into the kHz range

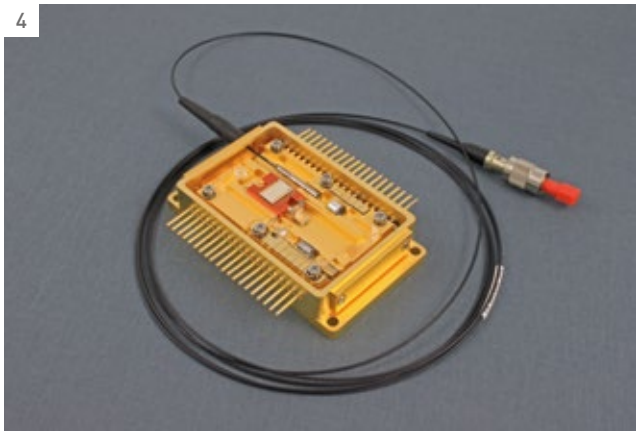
SHG light sources (UV to visible spectral range), suited to replace gas & solid-state lasers
– wavelengths: 488 nm ≤ λ ≤ 532 nm (GaAs-based)
– down to 220 nm (GaN-based)
– output power: up to 20 mW

wavelength-stabilized laser sources for imaging, providing high output power to excite larger spots for Raman imaging
– wavelengths: VIS to NIR
– output power: up to several watts

Laser sources for medical treatment

For photocoagulation in ophthalmology the preferred target wavelength is 577 nm with output powers in the watt range and an excellent beam quality. The spectral width is < 7 pm, limited by the resolution. The SHG-based sources can be modulated in the microsecond range.

FBH has also developed diode lasers for photodynamic therapy – especially in the red spectral range with



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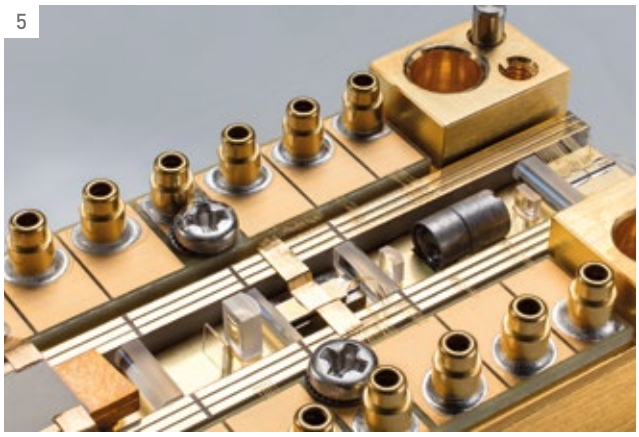

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4 Pulsed laser module emitting at 590 nm with polarization-maintaining fiber, suited e.g. for spectroscopy and microscopy
5 Hybrid-integrated master-oscillator power-amplifier diode laser module, emitting light in the yellow-green spectral range

watt-range output powers – that address the specific wavelengths defined by the used photosensitizer.

coagulation in ophthalmology – compact laser sources as replacement for dye & copper bromide lasers
– wavelengths: yellow-green spectral range
– output power: > 2 W with very high beam quality
– operational modes: CW with direct modulation capability

photodynamic therapy & hair removal
– typical wavelengths: red to NIR, depending on the used dyes, adjustable (wavelength & output power) to the specific needs of the therapy

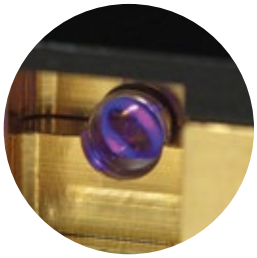
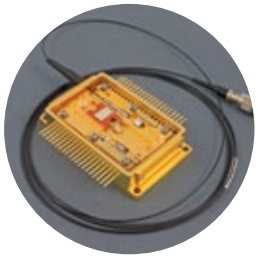
dentistry – for periodontal disease treatments
– wavelengths: NIR
– high output power: up to 10 W

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, and InGaAs quantum wells are grown as active regions for use in semiconductor lasers at wavelengths between 630 nm and 1150 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. Cutting-edge laser chips for optoelectronic devices are developed and fabricated in the ISO 5 cleanroom environment.

Laser chips are mounted on submounts and laser modules in high-performance assembly and packaging facilities. The performance of these high-brightness high-power laser diodes and bars is comprehensively characterized in FBH's test laboratories by using state-of-the-art measurement equipment.


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.

contact

Ferdinand-Braun-Institut
Leibniz-Institut für Höchstfrequenztechnik
Gustav-Kirchhoff-Straße 4
12489 Berlin, Germany
www.fbh-berlin.de

laser modules
Dr. Katrin Paschke
Phone +49 30 6392 3955
Email katrin.paschke@fbh-berlin.de

laser sensors & spectroscopy
Dr. Martin Maiwald
Phone +49 30 6392 2651
Email martin.maiwald@fbh-berlin.de

Part of
Forschungsfabrik Mikroelektronik Deutschland