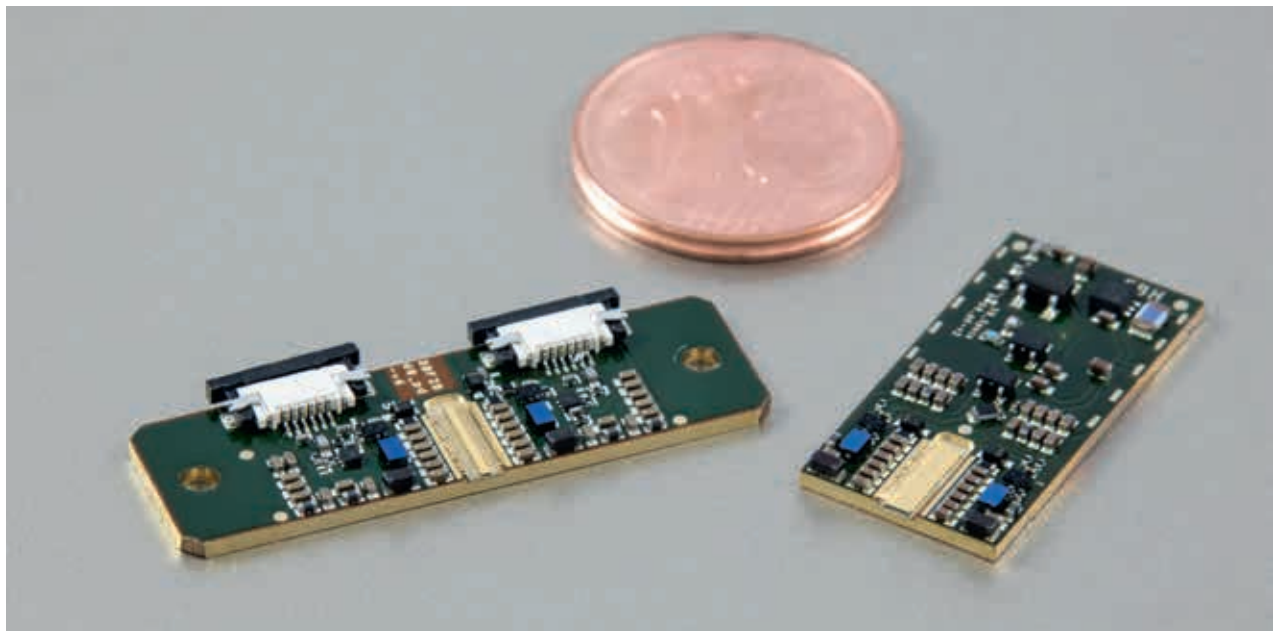
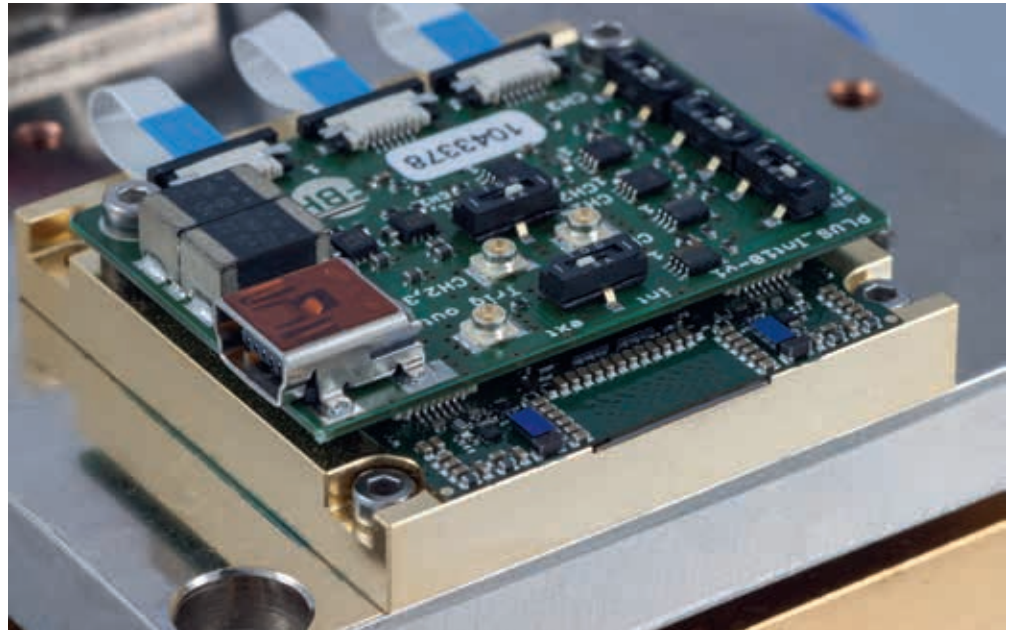
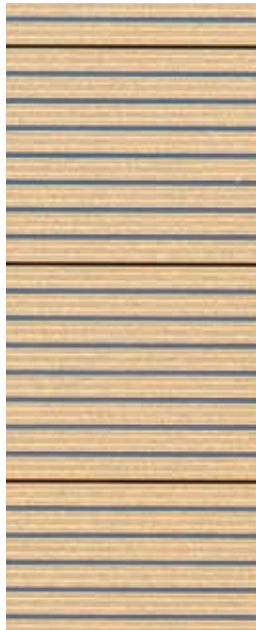




Leibniz
Ferdinand
Braun
Institut



High-Power Pulse Laser Sources for LiDAR Applications

Leading Technology in Semiconductor Laser Modules

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 and the complete electronic circuits, through to sophisticated prototypes and ready-to-use modules.

FBH's laser diode modules are highly brilliant light sources which are preferred for use in materials processing, measurement, medical diagnostics, and sensing applications as well as for use in LiDAR applications.

Products & Services

Research & Development

The FBH develops novel, compact laser beam sources delivering highly precise pulses in the pico- and nanosecond range. These sources use a tailored design for pulse generation from the diode laser technology as well as optimized RF components from microwave electronics as electronic driver. Both are core competencies of the FBH. The laser sources and systems can be flexibly adapted to the respective application, thus leading to customized solutions for different LiDAR applications, e.g., for autonomous driving, 3D object detection, and laser scanning (air-/spaceborne).

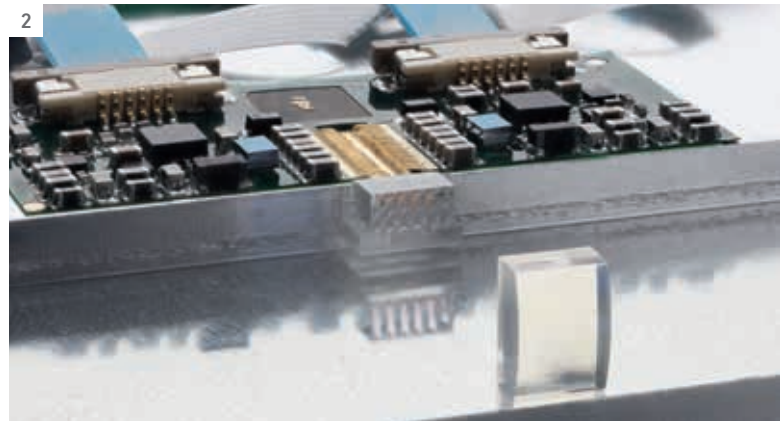
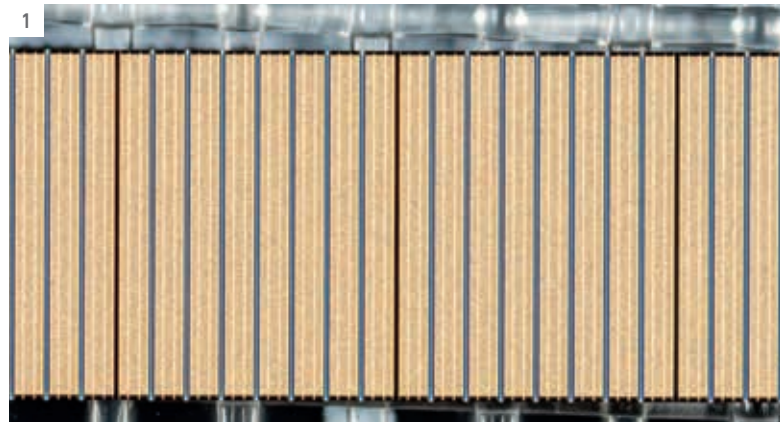
The FBH has long-term experience of commercial delivery and collaboration on development projects with industrial partners and uses an integrated management system (based on ISO 9001, 14001, and 45001).

Light sources for pulse applications

For customized applications, a broad variety of FBH laser diodes can be combined with fast switching laser drivers and offered as complete pulsed laser sources. The FBH laser diode portfolio comprises high-power and highly brilliant diodes with single or multi-mode operation as single emitters or laser bars – offered also with on-chip wavelength stabilization. Special distributed Bragg reflector (DBR) and distributed feedback (DFB) broad area (BA) as well as weakly tapered ridge-waveguide (TRW) laser diodes are available for LiDAR applications.

Customized laser drivers for nanosecond short pulse generation

The maximum range of a LiDAR system depends on the available optical pulse power, the range resolution is determined by the pulse width. Typical scenarios demand power levels exceeding 100W at pulse widths from 2 ns to 10 ns. To generate such short and powerful laser pulses, pulse drivers with a peak current of 100A or more, high efficiency, and high repetition rates are needed.

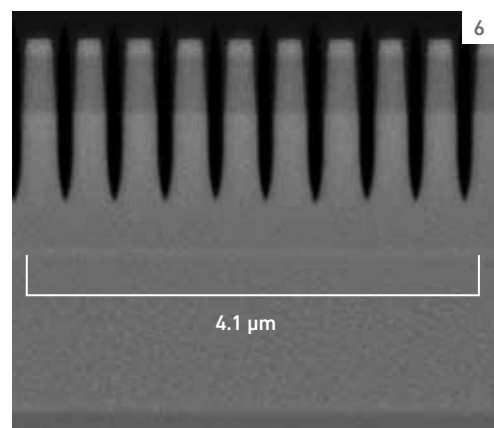
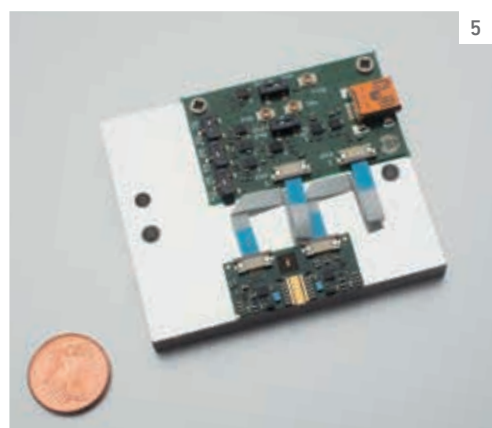
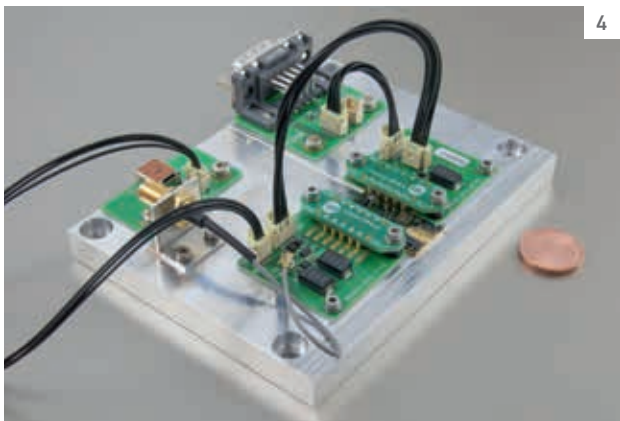
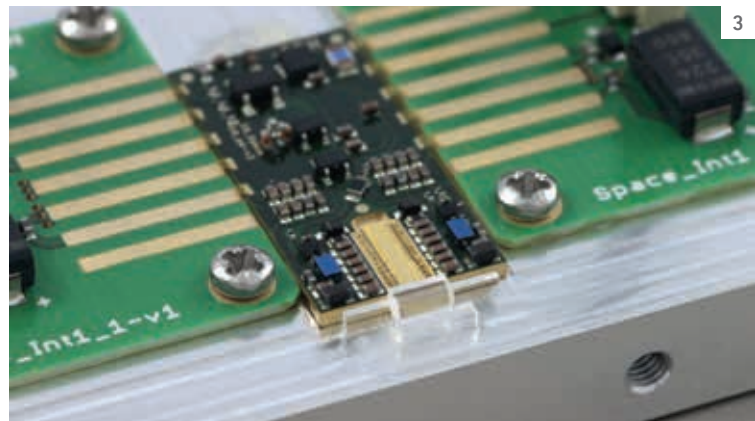


- 1 DBR laser bar with 48 emitters for pulse powers up to 2.1 W. For lower power levels, bars can be cleaved into 8-emitter chips.
- 2 3-emitter laser module with beam-shaping optics incl. beam twister.

The unique challenge is providing the high-speed high-current switching circuit as well as handling the parasitic inductances due to the assembly of the laser diode and the driver board. FBH drivers use GaN devices in the final stage. For different LiDAR applications, electronic circuits providing pulse widths from 2 ns to 10 ns for single or multi-emitter diode lasers with up to 5 active regions epitaxially stacked in a common vertical waveguide are developed with maximum pulse currents of 120 A, 400 A, and 1100 A (see table). A patent is pending.

DBR-BA laser diodes and bars for LiDAR applications in the 905 nm wavelength range

For LiDAR systems, wavelength-stabilized, broad area, and weakly tapered ridge-waveguide lasers with single and multiple active regions epitaxially stacked in a common vertical waveguide have been developed as single or multi-emitter devices for power levels up to 200 W and 2 kW, respectively. These devices are designed for operation temperatures in the full range between -35 °C and 85 °C. Owing their good beam quality, they can be used in scanning applications (i.e. with MEMS); the emission of 3-emitter devices can be combined by Beamtwisters®. Integrated surface Bragg gratings ensure a spectral width well below 0.5 nm. The wavelength shift with temperature is as low as 0.06 nm/K. Higher power levels up to 2 kW are available from 10 mm wide laser bars with 48 emitters, providing repetition rates between 10 kHz and 150 kHz. Long-term operation of those laser bars at a pulse power of 1.3 kW (pulse width 10 ns, repetition frequency 10 kHz) shows no performance degradation after 3.6×10^{11} pulses.



- 3** Pulsed laser source for LiDAR applications. The emission of its three emitters is collimated using fast and slow axis collimators.
- 4** The LiDAR test setup allows fast diode laser characterization with ns pulses.
- 5** 3-emitter laser module with interface board featuring an internal trigger pulse generator.
- 6** The wavelength of laser diodes for LiDAR applications is stabilized by integrating distributed Bragg reflectors (DBR). The SEM picture shows a dry etched surface grating defined by electron beam lithography.

Pulse operation parameters of wavelength-stabilized DBR-TRW, DBR-BA, and DFB-BA laser diodes with single and multiple active regions, measured at 25 °C

	1 emitter DBR-TRW	1 emitter DBR-BA					1 emitter DFB-BA	48 emitter DBR-BA bar	
no. of active regions	3	1	3	3	5	5	5	1	3
mesa width / μm	5	50	50	200	50	200	200	50	50
repetition frequency / kHz	10	10	10	10	10	10	10	10	10
pulse width / ns	10	10	10	10	10	10	10	8	8
max. pulse current / A	40	80	80	80	60	80	60	900	1100
max. peak power / W	20	40	70	160	50	220	100	640	2100
pulse energy / nJ	200	400	700	1600	500	2200	1000	5120	16800
wavelength / nm	905	905	905	905	905	905	880	907	911

Laser Technology

AllnGaAsP-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 620 nm 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 e-beam expo-

sure 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 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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