Leibniz
Ferdinand
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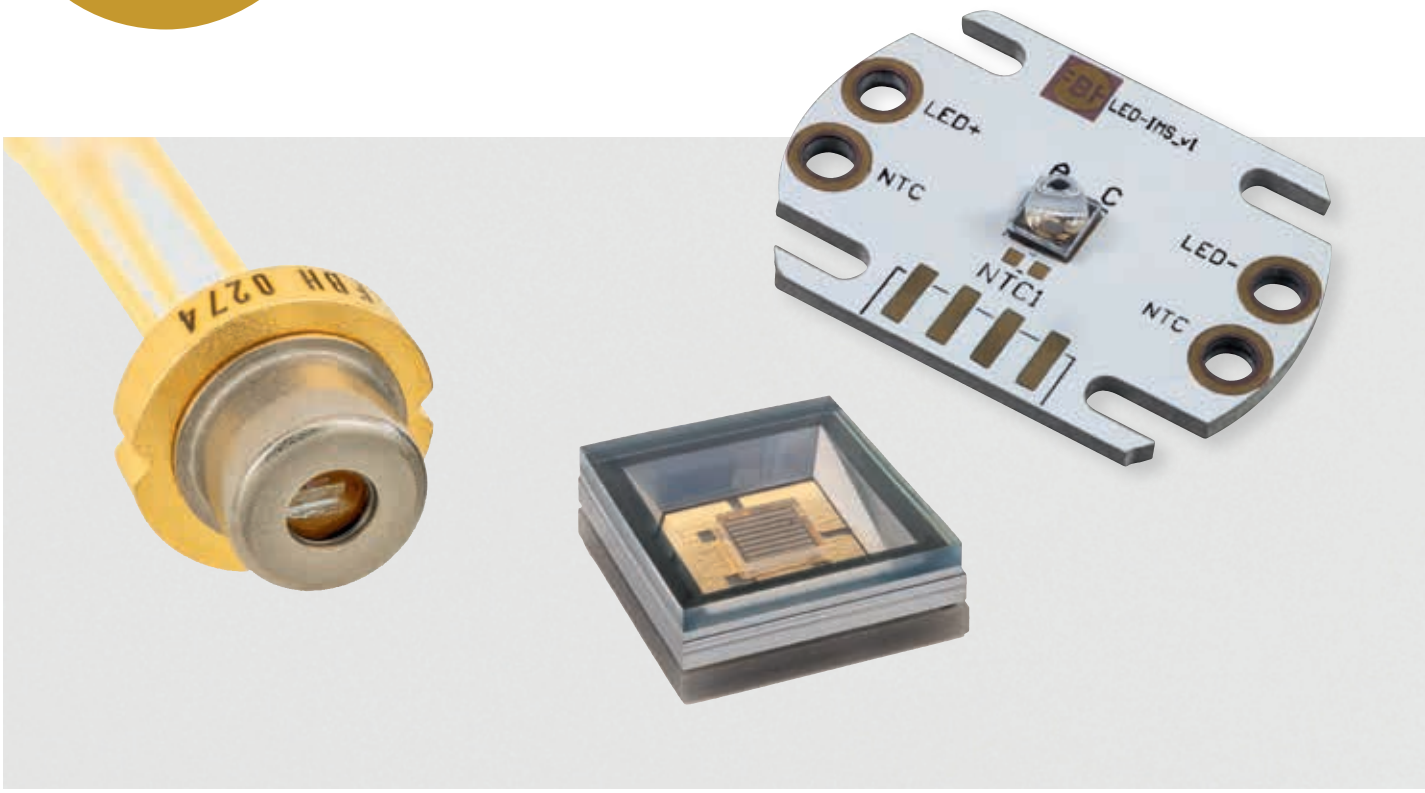
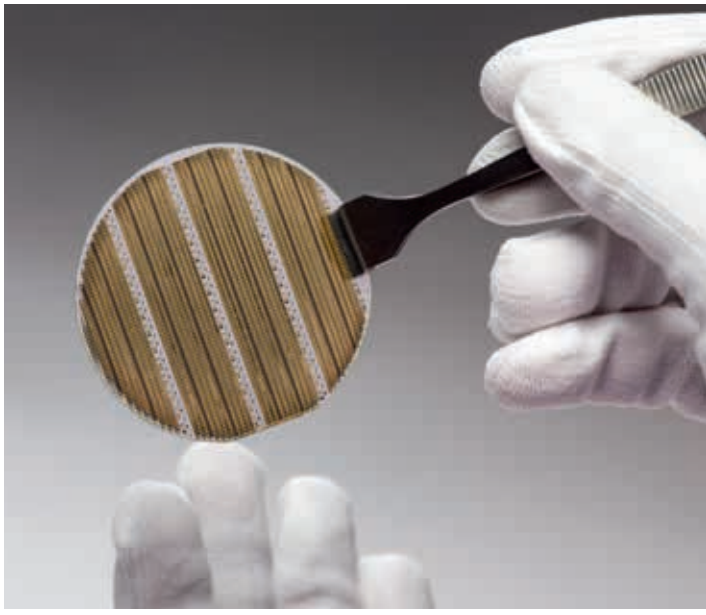
Institut





UV Optoelectronics

Competence in Device Design & Technology

The FBH develops ultraviolet (UV) optoelectronic devices comprising light emitting diodes (LEDs) in the UVB and UVC spectral range as well as diode lasers emitting in the violet and near-UV spectral range. The device performance is customized for various applications including light sources for UV curing, phototherapy, plant growth lighting, sensing, and metrology as well as for skin-tolerant inactivation of pathogens.

FBH's technical experts specializing in various fields collaborate closely to develop custom high-performance UV and violet optoelectronic devices:

- Electrical, optical, and thermal simulation of devices
- Epitaxial growth of group-III nitride layers and material analytics
- UV LED and diode laser chip processing technology
- Optoelectronic characterization of devices
- Lifetime measurements and degradation analysis
- Design and fabrication of UV modules and turnkey systems

Products & Services

UV LED chip on ceramic submount with quartz lens

The FBH conducts research and development on UV LEDs and diode lasers based on (Ga,Al,In)N. Activities target customized wavelengths in the UV and violet spectral range, high brilliance, high power, high conversion efficiency, and devices with tailored spatial and spectral emission characteristics. In accordance with the mission of the institute, FBH expertise covers fundamental experimental studies of the semiconductor materials system as well as the development and fabrication of optoelectronic devices. This also includes transfer of fabrication technologies to industrial partners.

The FBH has long-term experience in collaboration on development projects with partners from universities, research institutes, and industry, and uses an integrated management system (based on ISO 9001, 14001, and 45001).

Ultraviolet light emitting diodes, modules & prototypes

The semiconductor structures are epitaxially grown on 2" c-plane sapphire substrates. All stages of device processing are performed at the FBH. The final UV LEDs are available as fully processed wafers, bare chips, and chips mounted in ceramic or silicon packages with quartz optics, in turnkey modules and prototypes used in various applications. The following types of devices can be fabricated:

- **Bottom-emitting LEDs** with emission through the sapphire substrate in the wavelength range 300 to 325 nm and 225 to 240 nm
- **LED modules & prototypes** customized for various applications. These include water purification, plant growth lighting, and medical applications such as inactivation of multidrug-resistant pathogens.

Technology

GaN-based layers structures are epitaxially grown on 2", 3", and 4" sapphire and 2" GaN wafers in single or multiwafer metal organic vapor phase epitaxy (MOVPE) reactors. Material options include InN, GaN, and AlN as well as their ternary and quaternary alloys.

The FBH runs a highly flexible and industry-compatible process line for compound semiconductor devices on 2", 3", and 4" wafers. It includes an i-line wafer stepper and electron beam lithography for µm and sub-µm structures. Highly sophisticated optoelectronic devices are developed and fabricated in a class ISO 5 cleanroom environment.

Laser and LED chips can be mounted on submounts and heat sinks. The performance of these devices is then comprehensively characterized in FBH's test laboratories using state-of-the-art measurement equipment.

Research on Future Products

Violet & near-UV diode lasers

Diode lasers emitting in the violet and near-UV wavelength range from 390 to 430 nm have been developed and are in the testing stage. The semiconductor structures are epitaxially grown on 2" c-plane GaN substrates. Fabrication processes for the following types of lasers are available:

- **Ridge waveguide (RW) lasers** for single-mode or multi-mode operation
- **Distributed Feedback (DFB) & Distributed Bragg Reflector (DBR) lasers** with surface Bragg gratings

All stages of the fabrication process are performed at the FBH. The diode lasers developed are hence available as fully processed wafers, bare chips with customized facet coating, and chips mounted on current spreaders and heat sinks as well as in hermetically sealed TO cans. Current research focuses on the qualification of the devices as customer products.

UV micro-LEDs & micro-LED arrays

For the production of UV emitters on the micrometer scale, a technology has been developed to pattern UV LED wafers into chips consisting of single micro emitters or tighly packed arrays of these. Pitches down to 2 µm and diameters down to 1.5 µm are possible. It was shown that this technique can increase the light extraction and therefore the overall device efficiency. In the next step, arrays with individually addressable emitters will be developed.

1 UVB LED module for plant growth lighting
2 Array of UV micro-LEDs in operation
3 Violet-emitting GaN-based laser diode in TO package before capping
4 UV LED chip mounted on ceramic submount

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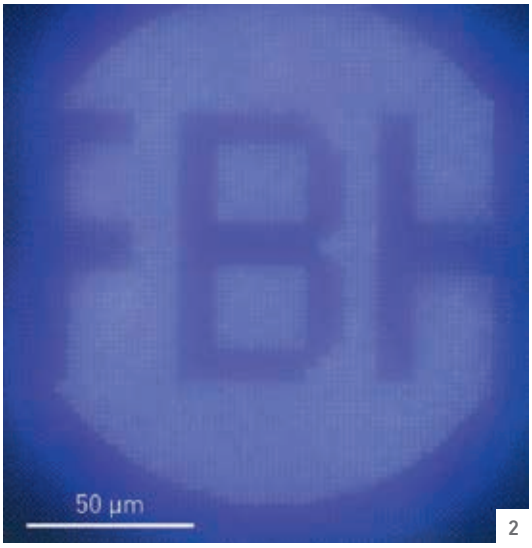

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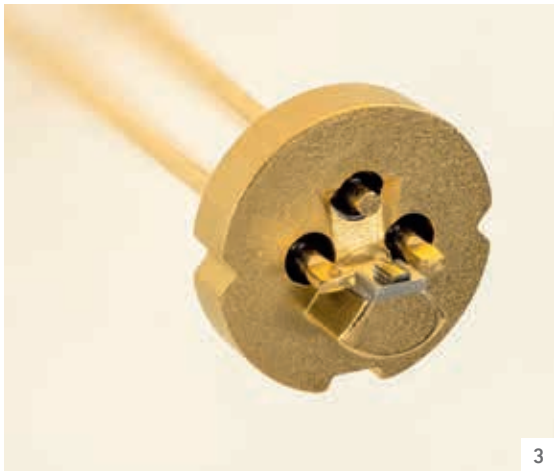
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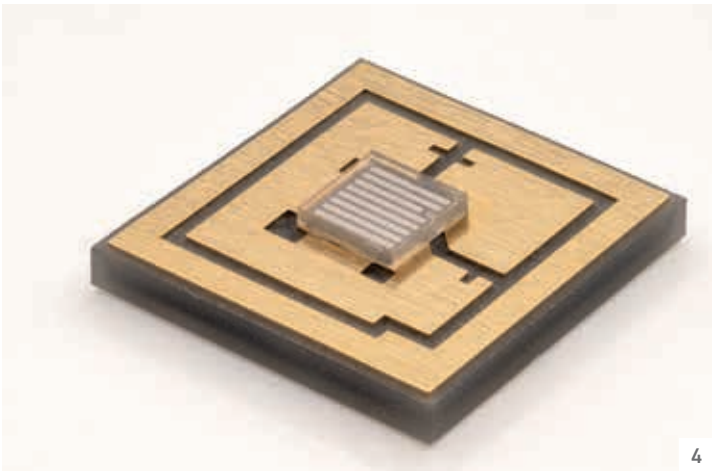
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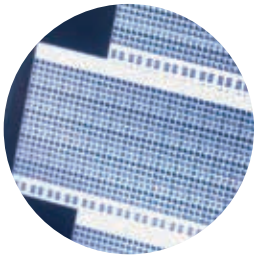
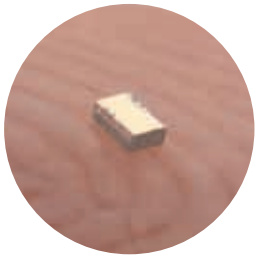
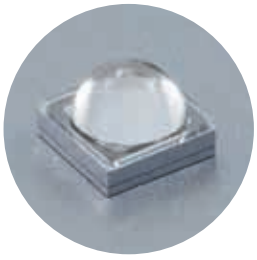

translating ideas into innovation

The Ferdinand-Braun-Institut, Leibniz-Institut 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.

contact: Joint Lab GaN Optoelectronics

Ferdinand-Braun-Institut gGmbH
Leibniz-Institut für Höchstfrequenztechnik
Gustav-Kirchhoff-Straße 4
12489 Berlin, Germany

Dr. Sven Einfeldt
Phone +49 30 6392 2630
Email sven.einfeldt@fbh-berlin.de

www.fbh-berlin.de

Technische Universität Berlin
Institut für Festkörperphysik
Hardenbergstraße 36, EW 5-1
10623 Berlin, Germany

Prof. Dr. Michael Kneissl
Phone +49 30 314 22563
Email kneissl@physik.tu-berlin.de

www.tu.berlin/ifkp

Part of
Forschungsfabrik Mikroelektronik Deutschland