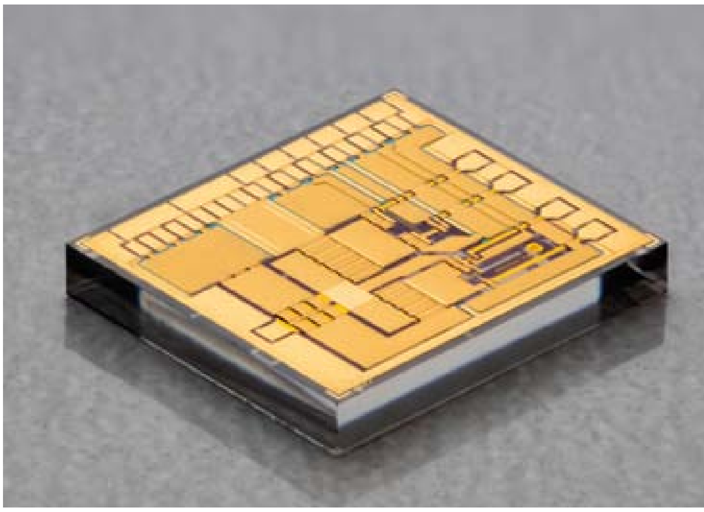
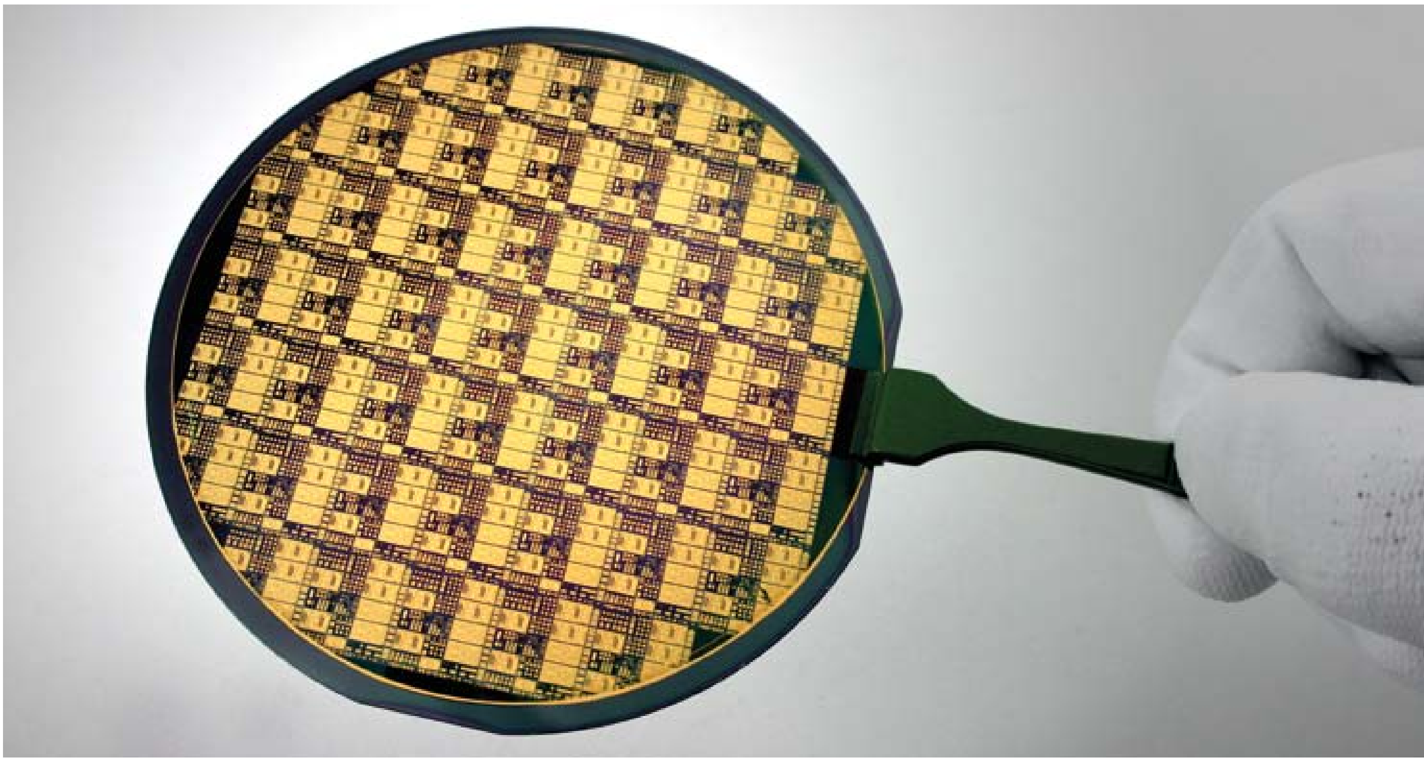
Leibniz
Ferdinand
Braun
Institut





GaN Microwave & Power Switching Devices

Competence in GaN Device Design & Technology

The FBH develops and fabricates GaN-based electronic devices for microwave power amplifiers and fast high-power switches which are used in communications and high-efficiency power electronic applications. They are realized as discrete power devices and MMICs on SiC, Si, and sapphire substrates. In order to ensure a quick transfer of technology, respective GaN microwave devices and processing services are marketed by FBH's spin-off BeMiTec.

At FBH, various fields of competence are closely intertwined to develop and further improve high-performance GaN devices:

- device simulation (physical, thermal and mechanical)
- epitaxy
- processing technology
- microwave design and characterization
- lifetime measurements and degradation analysis

Products & Services

FBH offers customized solutions in GaN electronics covering the complete range of services, from design through realization to reliability investigations.

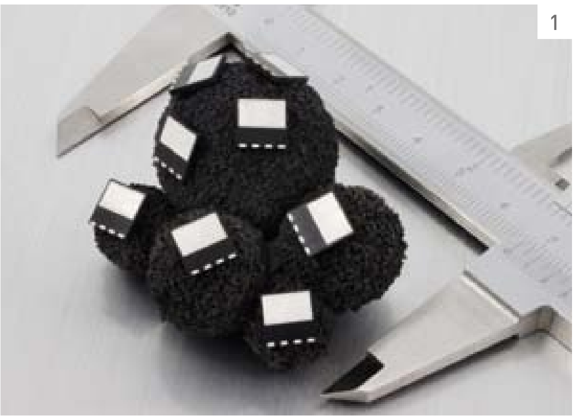
Microwave Transistors & MMICs

Highly efficient GaN power devices and MMICs are realized by combining optimized epitaxial layer design, passivation, and metallization techniques including integrated field plates. Devices are fabricated in a robust and reproducible process on 4" SiC substrates with GaN/AlGaN functional layers.

- **compact power bars:** with an output power up to 150 W at 2 GHz based on FBH's 0.5 µm gate technology. Power bar designs mainly rely on source-connected field plates enabling highly efficient devices. FBH offers thermally and electrically optimized packages with standard wire bonding as well as source-connected vias.

- **monolithic microwave integrated circuits (MMICs):** for X- and Ka-band applications integrating all active and passive components. MMICs rely on FBH's 0.25 µm and 0.15 µm GaN processes, respectively. The active components range from small-signal devices to high-power transistor cells featuring power levels up to 10 W/cell. Passive components include thin film resistors, MIM capacitors, spiral inductors, and microwave transmission-line structures.

- **multi-project MMIC wafers:** interested partners can place designs for both the X-and the Ka-band MMIC process.



1

Power Electronics

Devices for power electronic applications aim at achieving high-voltage switching capabilities combined with normally-off behavior. FBH's technological developments focus on efficient and fast power switching at 600 V and above. To bring together high-power device technology with power conversion system aspects, the **Joint Lab Power Electronics** was founded – a cooperation between FBH and TU Berlin. It aims at new concepts for device designs adapted to the specific electronic circuit concepts and monolithically integrated device solutions. In addition, reliability of these devices is studied at operating conditions close to system implementation. The following major topics are considered:

- **normally-off high-voltage switching transistors:** for voltage ratings up to 1000 V and current levels of 150 A. Enhancement behavior has been obtained by incorporating p-doped GaN gate layers. The developments focus on extremely low dispersive devices featuring fast power converters.

- **monolithically integrated device solutions:** targeting the combination of driver and / or half bridge structures on one chip in order to minimize internal loses and parasitic inductances and capacitance.

- **high-voltage lateral GaN-based Schottky diodes:** with excellent breakdown voltage above 1000 V while maintaining a turn-on voltage of only 0.5 V. The diodes fully benefit from the outstanding electron transport properties of AlGaN/GaN heterojunctions yielding very efficient switching properties.

- **true vertical GaN MISFETs:** fabricated on free-standing GaN wafers offer the potential for high-voltage operation and are suited for chip-on-chip heterointegration. The developed devices use the 'inversion gate drive principle' for controlling the drain current and are designed for low-inductance driving of diode lasers.

- **gallium oxide transistors:** offer new possibilities in efficient power switching especially at voltages exceeding 1000 V. Corresponding devices are currently being developed.

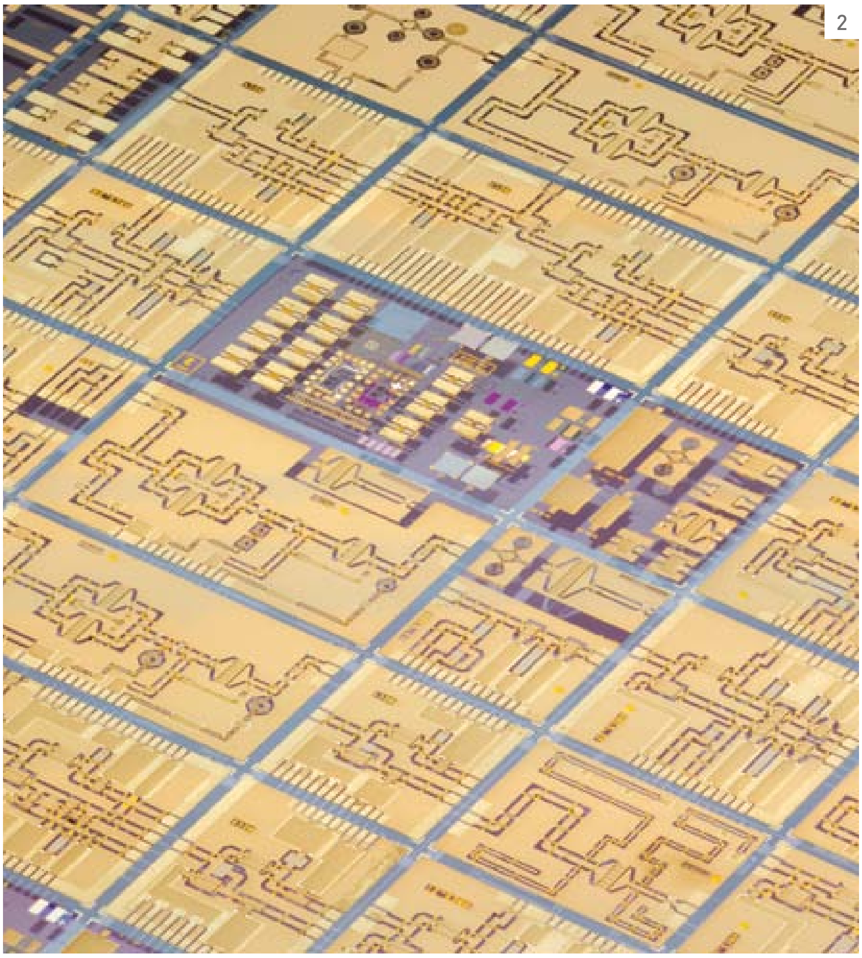
Reliability Characterization Techniques

Reliability characterization combined with analysis and understandings of possible degradation mechanisms is of paramount importance for further device development. The institute routinely performs the full scope of reliability testing for both microwave and high-voltage GaN devices:

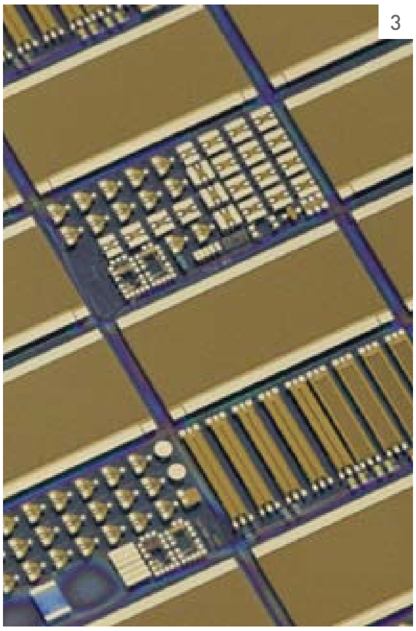
- on-wafer robustness tests
- long-term thermally accelerated DC lifetime tests up to 1200 V
- microwave accelerated lifetime tests at 2 GHz
- dynamic long-term, thermally accelerated switching tests up to 1200 V

Thus, possible degradation mechanisms are evaluated and considered for further technological development.

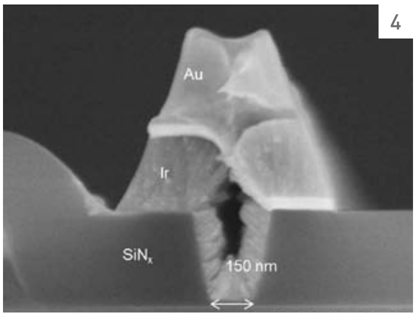
1 65 mOhm / 600 V GaN transistors in ThinPak packages
2 processed GaN X-band MMICs
3 normally off power switching transistors 65 mOhm, 600 V, 120 A
4 150 nm gate of FBH Ka-band MMIC process
5 multi-project Ka-band GaN MMIC chips
6 close-up of GaN HEMT in 0.25 µm GaN MMIC technology



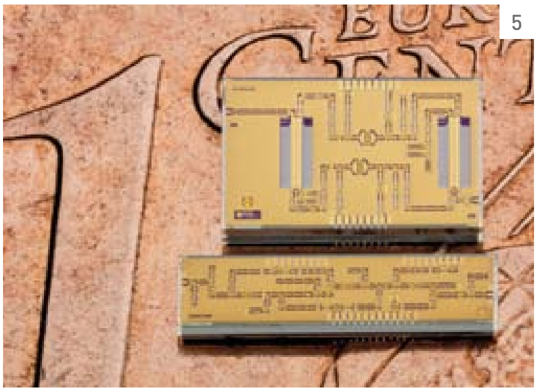
2



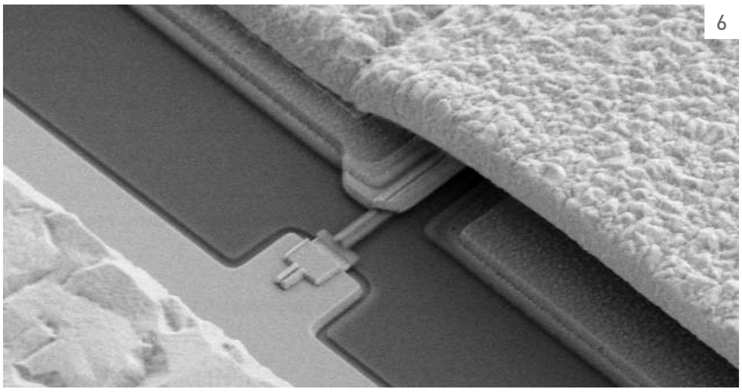
3



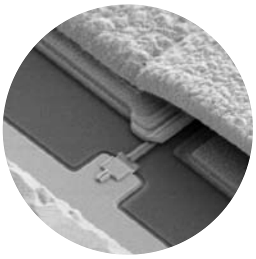
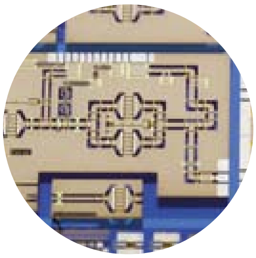
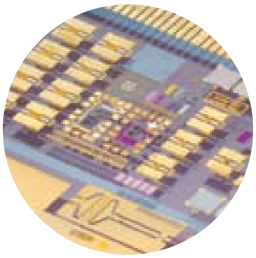
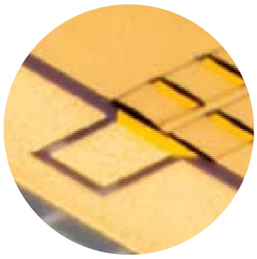
4



5



6

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 economic low-voltage drivers for use in a variety of applications.

The FBH is an internationally recognized competence center 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, its research results lead to cutting-edge products. To ensure Germany's technological competence in microwave and optoelectronic research, FBH works in strategic partnerships with industry. The institute also successfully turns innovative product ideas into spin-off companies.

contact

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

www.fbh-berlin.de

Dr.-Ing. Joachim Würfl
Phone +49 30 6392 2690
Fax +49 30 6392 2685
Email joachim.wuerfl@fbh-berlin.de