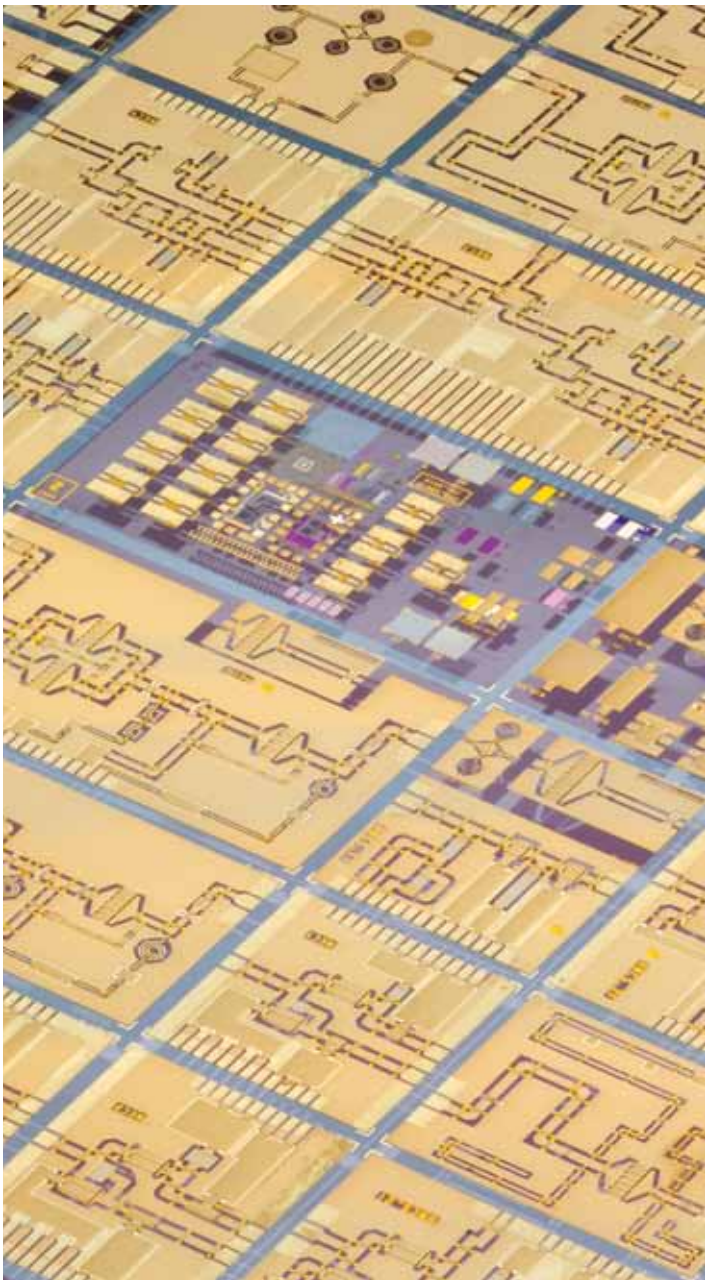
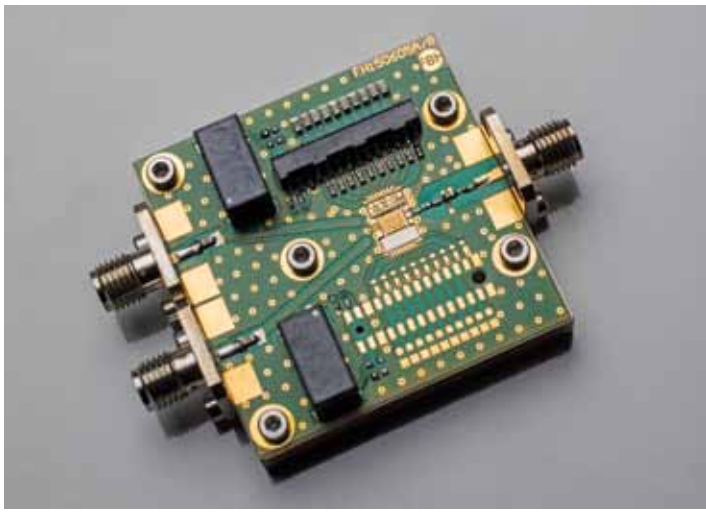
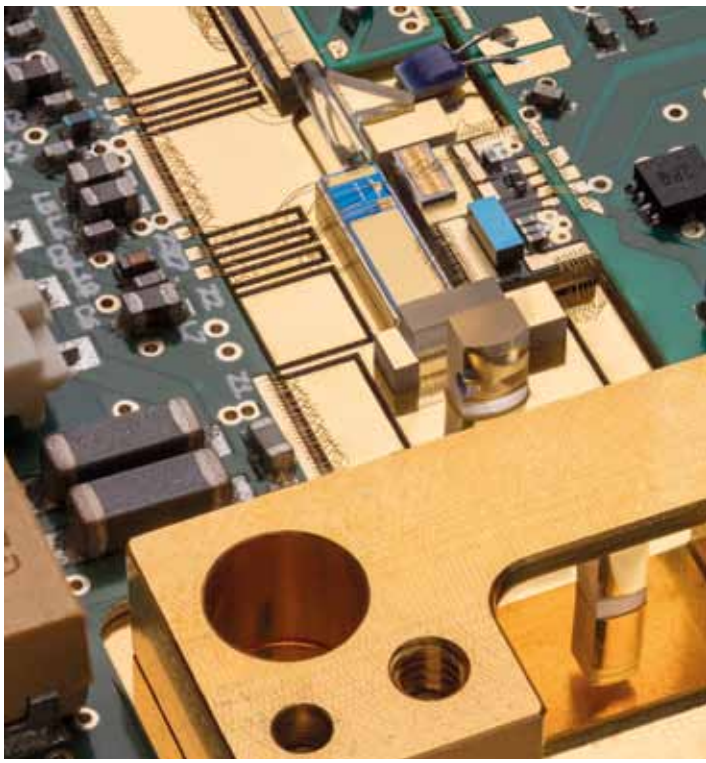
Leibniz
Ferdinand
Braun
Institut







RF, Microwaves & Millimeter Waves

Comprehensive Know-how in Microwaves & mm Waves

The FBH is a center of competence for III-V microwave and millimeter-wave devices and circuits covering the complete spectrum from epitaxy and processing to computer-aided design, measurements, and packaging. The components developed at FBH address key functions in wireless communications, radar sensors, and imaging. The institute provides industry-compatible technologies for compound semiconductor devices and runs a GaN HEMT and an InP HBT process line. Advanced methods for electromagnetic simulation as well as transistor modeling and circuit design are available. Dedicated measurement equipment enables on-wafer characterization for frequencies up to 750 GHz.

Products & Services

Devices

- **GaN power transistors:** discrete devices for the frequency range around 2 GHz with output powers up to 100 W.
- **GaN HEMT monolithic integrated circuits (MMICs):** with 0.25 µm and 0.15 µm gate lengths, addressing frequencies up to the 30 GHz band. They target power applications and robust low-noise-amplifiers (LNAs).
- **InP HBT integrated circuits:** from W-band to more than 250 GHz, based on a transferred-substrate process. The transistors have transit frequencies of more than 400 GHz. This process is also operated as an InP-on-SiGe-BiCMOS version in cooperation with the Leibniz institute IHP, thus allowing wafer-level hetero-integration of InP circuits with BiCMOS electronics.

Research Topics

- **advanced high-efficiency PA architectures:**

– discrete envelope tracking (class-G) for broadband signals: efficient power amplifier topology with GaN-based switch and RF PA for modulation bandwidths in the 200 MHz range and peak output powers of 60 W.

– digital PA: class-S and related concepts for PAs in the lower GHz range. The modules rely on dedicated GaN MMICs; a special PA test bench with digital input and time-domain characterization is available. Extension of digital concepts to mm-wave frequencies is under investigation.

- **laser drivers:** GaN-based driver circuits for fast switching of high currents, for pulsed laser sources, realized as modules with both laser and driver.
- **microplasmas:** compact low-power microwave plasma sources integrating GaN HEMT circuits with special excitation structures.

Design and Characterization Capabilities

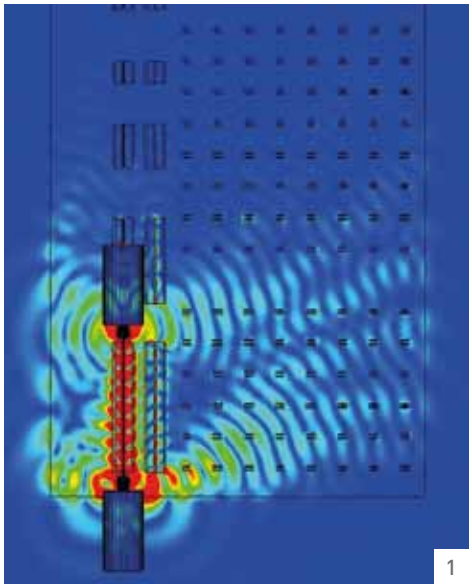
- **MMIC design and device modeling:** circuits for frequencies in the entire microwave frequency range using the FBH GaN and InP processes. Design is based on passive and active device modeling. For GaN HEMTs and InP HBTs, in-house large-signal models are being used.
- **measurements:** the comprehensive portfolio of high-frequency measurement facilities includes

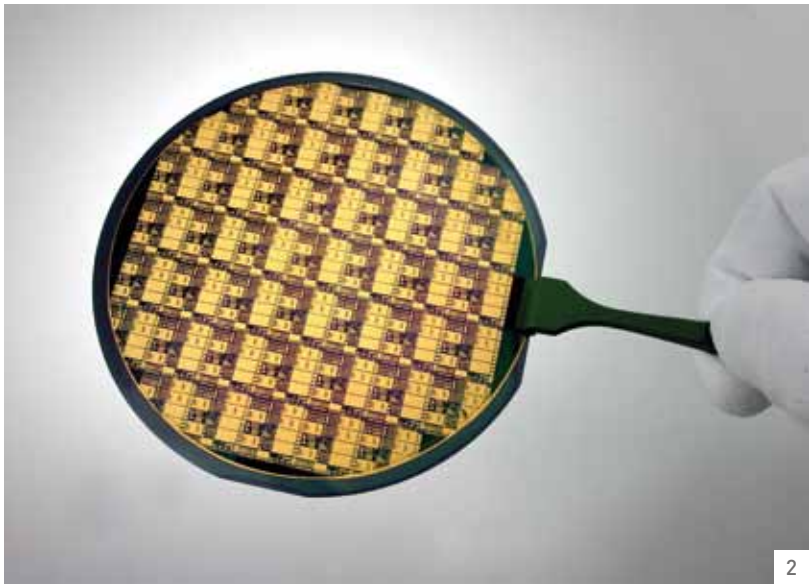
– S-parameter characterization up to 500 GHz (on-wafer)
– spectral characterization up to 750 GHz
– noise characterization including phase noise and low-frequency noise
– power characterization of transistors and circuits including load-pull (up to 50 GHz)
– non-linear network analysis and intermodulation characterization
– time-domain measurements (real-time scope with up to 70 GHz BW, multiple AWGs with 65 GS/s to provide binary input signals)
– digital predistortion (DPD): wideband characterization of 50 Ohm systems with DPD, IQ bandwidth up to 1 GHz
– metrology: accuracy of calibration routines in the mm-wave range (electromagnetic simulation and measurements)

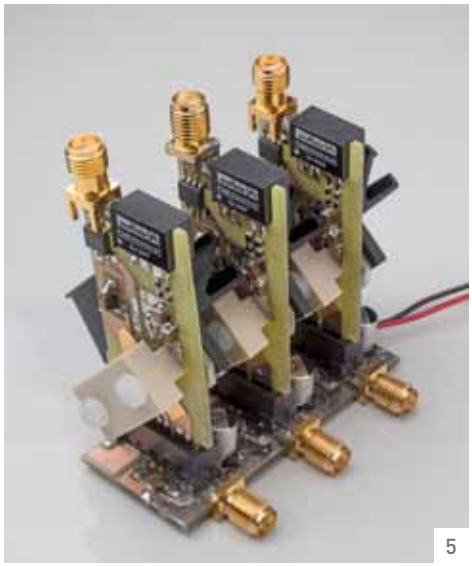
- **simulation:** electromagnetic simulation tools for design focusing on planar circuits and their environment. This includes chip design as well as packaging and housing design of mm-wave circuits and modules (MCM: flip-chip, thin-film techniques, LTCC).

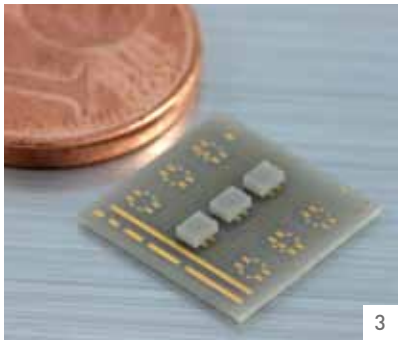
Technology

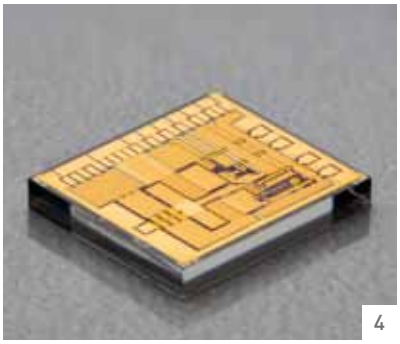
The FBH runs industry-compatible processes for compound semiconductors in a class ISO 5 cleanroom environment. Electronic devices are fabricated using the GaN HEMT (4") and the InP HBT transferred substrate (3" and 4") process lines. They include an i-line wafer stepper and electron beam lithography for µm and sub-µm structures. The InP process is also offered as an InP-on-BiCMOS version in cooperation with the Leibniz institute IHP.

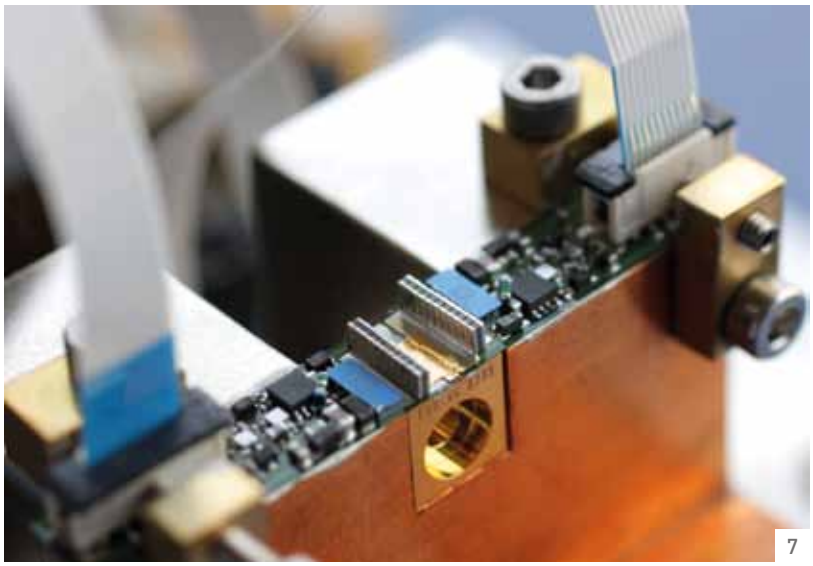


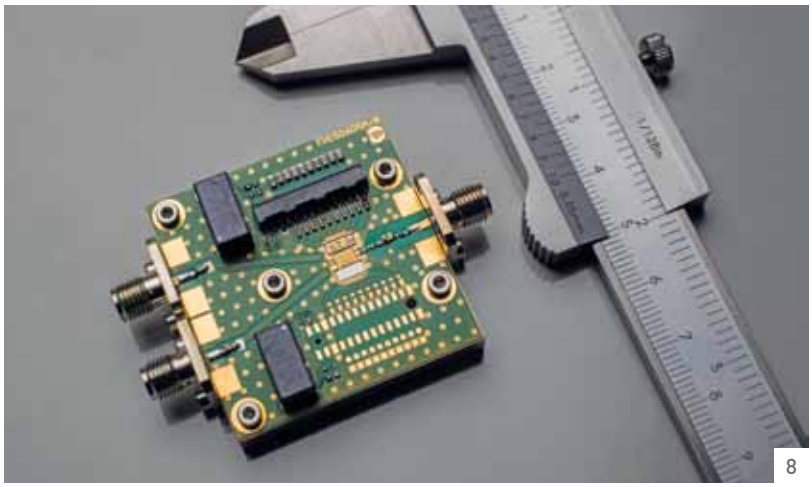




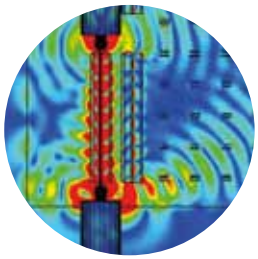


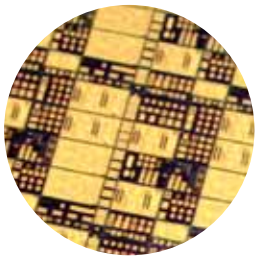






1 parasitic substrate modes in a mm-wave calibration substrate
2 Ka-band GaN wafer
3 flip chip module with test structures for 250 GHz bandwidth
4 GaN MMIC for digital microwave PA
5 high-power supply modulator for multi-level class-G operation
6 load-pull measurement set-up
7 430 A high-power laser driver
8 digital power amplifier module for 900 MHz band






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.

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