Innovations with Microwaves and Light

The Ferdinand-Braun-Institut, Leibniz-Institut fuer Hoechstfrequenztechnik (FBH) is one of the internationally leading institutes for applied research in microwaves and optoelectronics. Based on III-V semiconductors[1] it manufactures high-frequency devices and circuits for communication, power electronics, and sensor technology. High-power diode lasers with excellent beam quality are produced for materials processing, medical technology, and high-precision metrology. For application in quantum technology, FBH develops photonic components and modules as well as systems based on ultra-cold atoms. FBH researches and realizes nitride-based devices such as short-wave UV light sources or transistors for very high voltages.

To ensure rapid transfer of technology, FBH works closely with partners and customers in industry and the scientific community. As a result of the market- and customer-orientation, FBH launched eleven spin-off companies and was awarded with several prizes for its successful technology transfer. “We are not only scientists, but also an interface between research and industry”, explains Prof. Günther Tränkle, Director of the Ferdinand-Braun-Institut, “thus, in our research we take into account at an early stage the interests of potential customers.” With its Joint Labs, FBH bundles forces with university research and thus successfully bridges the gap between basic and application-oriented research.

The institute has a staff of more than 310 employees and a budget of 40.4 million Euros. It is part of the Forschungsverbund Berlin e.V., a member of the Leibniz Association and plays an active role in various networks, including Research Fab Microelectronics Germany (FMD).

Intelligent solutions in use

FBH diode lasers are characterized by small dimensions and great precision as well as by high brilliance and efficiency. In spite of its small size a single laser emits up to 30 watt (cw operation) or even 200 watt (short-pulse operation): 5,000 and 25,000 times respectively greater power than a laser in a CD player. These characteristics along with the extraordinarily high reliability under extreme conditions have earned FBH lasers approval for use in space applications, such as, for example, in atomic clocks for the latest generation of GPS satellites. There is a wide field of applications for the brilliant light sources. In medical technology they are used in photodynamic cancer therapy. During treatment tumor cells are enriched with a medication. When light of a precisely defined wavelength hits the cell, it activates the active agent and the afflicted cells are destroyed. Applications are also in optical precision spectroscopy, sensor technology, metrology and materials processing (welding, soldering, labeling).

Since several years, FBH develops hybrid laser modules integrating beam shaping optics, external resonators and oscillator-amplifier combinations. Such modules are only as small as matchboxes and may replace large-format laser types the size of a closet, which are used for example in complex large-scale projections (planetariums, flight simulators). Compact and flexible picosecond laser sources with integrated GaN-based drivers achieve peak values in terms of current and pulse width. They can be used, amongst others, in laser material processing or for biomedical examinations (fluorescence spectroscopy).

[1] III-V semiconductors = made up of group III and group V elements, as for example gallium arsenide (GaAs), a semiconductor formed by combining gallium, Ga (3rd group) and arsenic, As (5th group)

FBH's electronic devices are regularly used in communication technology and power electronics. In fields like wireless communications, environmentally-friendly information and communication technologies which additionally reduce operating costs are essential. Such Green IT applications strongly require improved amplifiers. Microwave power amplifiers do not only make the lion's share of base station's energy consumption, but are also a precondition for next-generation mobile communications providing higher bandwidths and new spectrum-efficient modulation techniques.

The Ferdinand-Braun-Institut has also expanded its activities in the field of terahertz electronics. FBH offers several microwave monolithic integrated circuits (MMIC) technologies reaching cut-off frequencies above 300 GHz. A transfer substrate process is used, which also includes InP-on-BiCMOS heterointegration at wafer level. It allows the realization of compact integrated front-end modules for radar, sensor and communication systems.

Research and development on a firm footing

The research and development activities are based on materials and process technology activities in FBH's cleanrooms. By means of epitaxy[2] gauzy layers with the desired material properties are developed on wafers[3] via MOVPE[4] and HVPE[5] techniques. Modern, industry-compatible equipment processes these wafers. The process line comprises photolithographic methods, wet and dry chemical etching and metallization. Finally, technicians separate the chips from the wafer and mount them as optoelectronic or electronic devices. Approximately 2,000 chips with microwave circuits fit on a 4" wafer. With laser chips the number can be as high as 10,000 pieces on the disc with a diameter of ten centimeters. This enables the production of a large number of items on one wafer and thus reduces manufacturing costs.

One-stop solutions & services

FBH develops high-value products and services for its partners in the research community and industry and tailors each precisely to fit individual needs. The institute offers its international customer base know-how and complete solutions as a one-stop agency, from design to ready-to-ship modules, from development to pilot series.

Services include the epitaxy of customized III-V semiconductor layer structures, structuring processes and tailored diode lasers and electronic devices. FBH also offers services in design and simulation, mounting and packaging as well as reliability testing.

For further information

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(2) Epitaxy = definite crystal growth, process by which thin layer of single-crystal material is deposited on single-crystal substrate
(3) Wafer = a round disc of semiconductor material, on which chips are produced
(4) MOVPE = kind of gas phase epitaxy where highly reactive metal organic precursors are used as sources for the epitaxial material, technique to produce complex three-dimensional device structures
(5) HVPE = Hydride Vapor Phase Epitaxy, epitaxial method used for the fabrication of single gallium nitride crystals