Semiconductor technologies for the future

Fraunhofer IAF is one of the leading research facilities worldwide in the field of III-V semiconductors. We develop electronic and optical devices based on modern semiconductor materials. Our technologies find applications in areas such as security, energy, communication, health, and mobility.
The particular strength of the Fraunhofer Institute for Applied Solid State Physics IAF lies in the research and development of micro- and nanoelectronic as well as optoelectronic components based on III-V semiconductors.

Whenever silicon technology fails to process the semiconductor devices and circuits demanded by research and industry, Fraunhofer IAF aims at providing a solution. In order to be able to take on this task, we listen very carefully to the wishes of our customers and the plans they have for future projects and products. We want to act early in order to provide prompt help in the realization of innovative and marketable products.

Listening carefully to partners, colleagues and funders is an important competence of the staff of Fraunhofer IAF, which we would like to strengthen further. It is the basis on which we systematically conduct our current projects and strategically plan future research and the development of the institute.
Millimeter-Wave Circuits
Electronic integrated circuits and modules for high frequencies

GaN RF Power Electronics
High performance transistors and circuits based on the semiconductor gallium nitride

Infrared Detectors
Detectors with high spatial resolution in the infrared and UV spectral range

Semiconductor Lasers and LEDs
Infrared semiconductor lasers, laser systems, LEDs and laser diodes

Micro- and Nano-Sensors
Micromechanics and sensors based on III-V semiconductors, metal oxides and diamond
Electronic integrated circuits and modules for high frequencies

Increasing amounts of data need to be transmitted within a very short time – be it in applications for communication, sensors or astronautics. Tomorrow’s solutions place high demands on electronic devices: they need to be fast and energy-efficient but small in size.

We develop a comprehensive range of high performance integrated circuits for frequencies up to and over 600 GHz based on III-V compound semiconductors in the business unit »Millimeter-Wave Circuits«. Moreover, we create monolithic integrated microwave and millimeter-wave circuits by means of metamorphous HEMT technology on GaAs substrate. Together with our project partners from research and industry we manufacture complete systems for sensors and communication technology.

Our electronic devices increasingly advance into the terahertz regime. It is our vision to reach the 1 terahertz mark within the next few years and to offer high performance, reliable and cost-effective electronic solutions. In order to realize this, we will increase the functionality of the circuits – up to complete systems on a single chip.
Features
- Precise geometric resolution
- Penetrates dust, fog, rain, snow and clothes
- Low noise figures
- High reliability
- Compact and light-weight devices

Applications
- Communication: Transfer of large volumes of data
- Security: Detection of concealed weapons
- Aviation safety: Landing aid for helicopters
- Medicine: Breath and heart rate detection
- Astronautics: Climate and earth monitoring from outer space

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Increasingly efficient systems to produce, distribute and use energy will be necessary to cover worldwide energy needs. Silicon technology has reached its limit. Further development of new semiconductor materials, like gallium nitride, is necessary.

The business unit »GaN RF Power Electronics« develops high performance transistors and monolithic integrated circuits on the basis of the compound semiconductor gallium nitride (GaN). The semiconductor material can realize more powerful and more efficient electronics than silicon. We use modern high electron mobility transistor technology to realize power electronics for operating frequencies between 1 MHz and 100 GHz.

Our vision is the realization of innovative modules and systems based on gallium nitride, which save energy in a wide variety of applications, thereby contributing to a greener future. They can give new drive to the market of electric and hybrid vehicles in the form of efficient voltage converters and increase the efficiency of photovoltaic systems or household appliances. Gallium-nitride-based high frequency power electronics will also be used in mobile communication and plasma generation.
Gallium-nitride-based integrated electronic circuit for broadband amplifiers.

**Features**
- Energy saving due to high switching frequencies
- Reduction of cooling effort
- Operation possible under high voltages and temperatures
- High output power
- Robust and compact devices

**Applications**
- Communication: Power amplifiers for mobile communication
- Production technology: transmitters for plasma generation
- Measurement technology: Multifunctional broadband amplifiers
- Mobility: Battery charger for electric cars

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Detectors with high spatial resolution in the infrared and UV spectral range

High performance imaging systems for wavelength regions which are not visible to the human eye have a tremendous impact on security and safety systems. They are also key enablers for industrial process control, environmental imaging as well as medical diagnostics.

Our business unit »Infrared Detectors« focuses on the development of detectors with high spatial resolution and the ability to detect infrared radiation in different wavelength ranges simultaneously – our high resolution dual-color infrared cameras are unique worldwide. Quite a large part of the research addresses bi-spectral imaging systems for infrared detectors within the two transparent atmospheric windows in the mid-wavelength infrared ($\lambda = 3 – 5 \ \mu m$) and the long-wavelength infrared ($\lambda = 8 – 12 \ \mu m$). In addition, work in our business unit includes technology development for UV and IR detectors and small scale serial production.

Our vision is to develop advanced detector concepts based on compound semiconductor heterostructures to increase the performance of bi-spectral imaging systems. Short-wave infrared detectors ($\lambda = 1.4 – 3 \ \mu m$) with very high sensitivity are required for the replacement of night vision goggles and for active imaging systems such as gated viewing cameras.
Features
- Imaging in the spectral range invisible to the human eye
- High sensitivity of the detectors
- High spatial resolution
- Simultaneous detection of IR radiation coming from different spectral ranges

Applications
- Security technology: Reconnaissance and safety
- Environmental monitoring: Tracing pollutants in water and in air
- Production: Curing adhesives and coatings
- Quality control: Monitoring industrial production processes
- Medicine: Diagnostics

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**Infrared semiconductor lasers, laser systems, LEDs and laser diodes**

Photonics has been recognized as a key enabling technology with widespread use in a multitude of applications. Most of today’s photonic applications are powered by semiconductor lasers or light-emitting diodes (LEDs) as compact and robust light sources, which directly convert electrical energy into light. A particularly prominent example is the use of high brightness LEDs for lighting (»solid state lighting«).

The main strands of research and development in the business unit »Semiconductor Lasers and LEDs« are infrared semiconductor lasers and laser systems covering the 2 – 11 μm spectral range and blue- to UV-emitting LEDs and diode lasers. This will help to extend the wavelength range where efficient semiconductor-based light emitters will replace conventional light sources, with added functionalities like wavelength tunability or the generation of ultra-short optical pulses.

Our vision is to make semiconductor-based emitters the prominent light source, not just for solid state lighting but also in a wide range of other applications including medical diagnostics, therapy and implants, process analysis and control, as well as safety and security.
Features
- Output power of up to several Watts
- High power efficiency
- High beam quality
- Robust and compact modules
- Fast and broadband tunable laser sources
- Flexible application

Applications
- Lighting: intelligent and energy-efficient lighting systems
- Environment: Tracing hazardous substances
- Production: Material treatment and process control
- Quality control: Food monitoring
- Medicine: Diagnostics and therapy

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Micromechanics and sensors based on III-V semiconductors, metal oxides and diamond

Using tiny sensors to detect hazardous materials and pathogens or monitoring industrial processes – micro- and nano-sensors find applications in many areas of daily life. The miniaturization of electronic devices, their interconnections and ever faster processing of the signals are constantly pushed forward.

Using modern materials with extraordinary physical properties, like diamond, metal oxides and III-V compound semiconductors, we develop a variety of different sensors in the business unit »Micro- and Nano-Sensors«. The spectrum of our research ranges from UV to IR lenses, gas detectors, electro- and biochemical sensors, high-energy radiation and particle detectors, heat spreaders, single photon sources to micro- and nanoelectro-mechanical systems (MEMS/NEMS).

It is our vision to develop micro- and nano-sensors which can be used in a wide variety of applications, e. g. in the identification of diseases and toxins as well as in all types of reliability testing and safety assessment. These sensors need to work reliably even in extreme conditions.
Features
- High sensitivity
- High selectivity
- High robustness
- Good reproducibility
- Proven bio-compatibility

Applications
- Bio-analytics: Analysis of gases and liquids
- Quality control: Food monitoring
- Environment: Detection of hazardous materials
- Medicine: Diagnostics

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Fraunhofer IAF covers the entire value chain in the development of mechanical, electric and optical devices on the basis of compound semiconductors – from materials research and design of the devices up to the realization of modules and systems.

**Our core competences**
- Design of devices and components
- Manufacturing of layers and heterostructures
- Processing of micro- and nanostructures
- Characterization of electronics and optics
- Manufacturing of devices and modules
- Demonstration of small series and systems

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<th>Location</th>
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<tbody>
<tr>
<td>Founding Year</td>
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<td>Staff</td>
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DESIGN WITH US THE NEXT GENERATION OF SEMICONDUCTOR TECHNOLOGY

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We are looking for staff

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- Student assistants
- Vocational training

Please find our current open positions at www.iaf.fraunhofer.de/en/career
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