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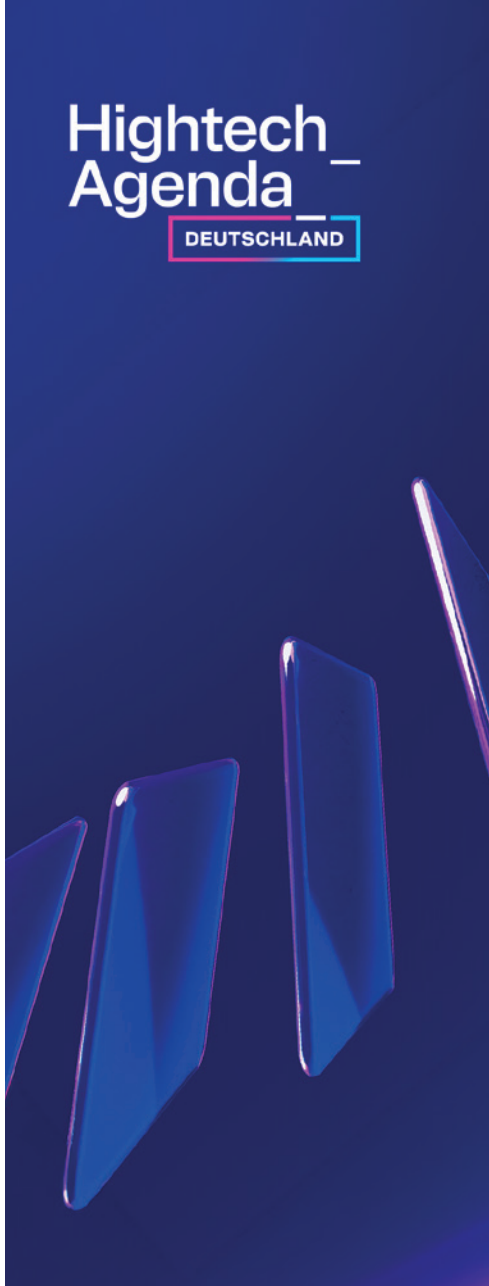
"Driving High-Tech" represents our aspiration to use excellent research on III-V semiconductors and diamond-based quantum technologies to enable the next generation of electronic, optoelectronic, and quantum-based systems. In doing so, we create the technological foundations for demanding industrial applications while at the same time strengthening Germany's competitiveness and technological sovereignty.

As part of the High-Tech Agenda Germany, we are advancing key technologies that secure innovation, resilience, and sustainable growth in business and society. With our broad research portfolio, we make substantial contributions in five out of six key technologies and develop forward-looking solutions in the fields of artificial intelligence, quantum technologies, microelectronics, fusion and climate-neutral energy generation, as well as technologies for climate-neutral mobility.



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Dear Friends and Partners of Fraunhofer IAF,

Our ambition is to be the driving force behind the cutting-edge technologies of tomorrow, to actively bring them into application, and thus strengthen the competitiveness and technological sovereignty of Germany and Europe.

Through our research in the field of III-V semiconductors and diamond-based quantum technologies, we are already making an essential contribution to the key technologies and strategic research fields of Germany's High-Tech Agenda. For the future of Fraunhofer IAF, it is crucial that we align our research in a targeted manner so that we can respond to new opportunities and developments with agility and foresight.

This strategic focus on future topics is also reflected in our new activities: In Heilbronn, we are building a research center and ecosystem for AI-based chip design and AI hardware; we are advancing European sovereignty with pilot lines such as APECS and developing technologies for the energy supply of tomorrow — for example, for the use of fusion energy. In addition, over the past year we have sharpened our research agenda, with a clear focus on scientific excellence and our core competencies. In this annual report, we present our business areas as well as selected highlight projects and results.

Driving high-tech also means actively strengthening the transfer of research into industry. As a bridge between basic research and application, we offer companies low-threshold access to new technologies — for example, through the established "Competence Center Quantum Computing Baden-Württemberg" (KQCBW), our new consulting and testing center for quantum computing, INQUBATOR, or through our support of start-ups such as Quantum Brilliance and Quantum Diamonds with customized diamond materials.

We thus look back on a year in which our strategic orientation has proven its value in many ways. We see strong opportunities to strengthen our position within the European research area and are committed to playing a leading role in advancing it through scientific excellence and our research expertise.

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"For us at Fraunhofer IAF, the key is to focus our research in a targeted manner so that we can act with agility and foresight."

Prof. Dr. Rüdiger Quay

Dr. Patricie Merkert

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Artificial intelligence, quantum technologies, autonomous systems, and fusion energy are among the key technologies transforming our industry, society, and geopolitical power structures at an unprecedented pace. Identifying these high-tech developments at an early stage, driving them forward, and actively helping to shape them is crucial for prosperity, security, and technological sovereignty.

For this reason, we are advancing key technologies such as chip design for and with artificial intelligence, developing pilot lines to accelerate progress and bring innovations to market more quickly, researching basic technologies for fusion — a key energy source of tomorrow — and paving the way for Quantum Technologies 3.0. At the heart of all this is the transfer of research into practical applications for a strong industrial base and a future-proof business location in Germany.

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AI for Chips, Chips for AI: The AI Chip Technologies of Tomorrow

Artificial intelligence and semiconductor technology are rapidly converging — with profound effects on value creation, competitiveness, and technological sovereignty. Powerful AI applications require specialized chips, while AI itself opens up new ways to design these chips more efficiently. It is at this interface that Fraunhofer IAF is strategically positioning itself.

With the long-term Research and Innovation Center (FIZ) Chip AI and the state-funded project FRAUKE ("Fraunhofer AI Design"), Fraunhofer IAF is establishing a new competence center and ecosystem for AI-based chip design and AI hardware in Heilbronn, in close collaboration with research and industry partners.

FIZ Chip AI: Efficient AI chip design and a strong innovation ecosystem

From 2026 onwards, the FIZ Chip AI will be established in Heilbronn as part of HNFIZ — a joint research and innovation center of Fraunhofer IAF and Fraunhofer IIS, funded by the Dieter Schwarz Foundation. The focus lies on two closely intertwined perspectives: on the one hand, AI methods are used for chip design in order to automate complex design processes, shorten development times, and sustainably improve the quality and efficiency of CMOS circuits (complementary metal-oxide-semiconductor), which play a central role in AI systems. On the other hand, specialized hardware architectures are being developed that execute AI algorithms in a particularly energy-efficient and robust manner — ranging from classical AI accelerators to neuromorphic systems.

At FIZ Chip AI, Fraunhofer IAF is developing CMOS-based AI chips and AI-assisted design processes to automate manual design steps and create new strategies for IP protection, verification, and certification, especially for safety-critical applications in mobility, robotics, and aerospace. CMOS proves to be a particularly suitable technology for AI, as it enables highly integrated, energy-efficient, and cost-effective implementation of complex circuits and can be seamlessly integrated into established industrial manufacturing processes. Fraunhofer IIS complements this with neuromorphic hardware based on spiking neural networks, enabling highly energy-efficient real-time AI directly on edge devices. In this way, a continuous value chain is

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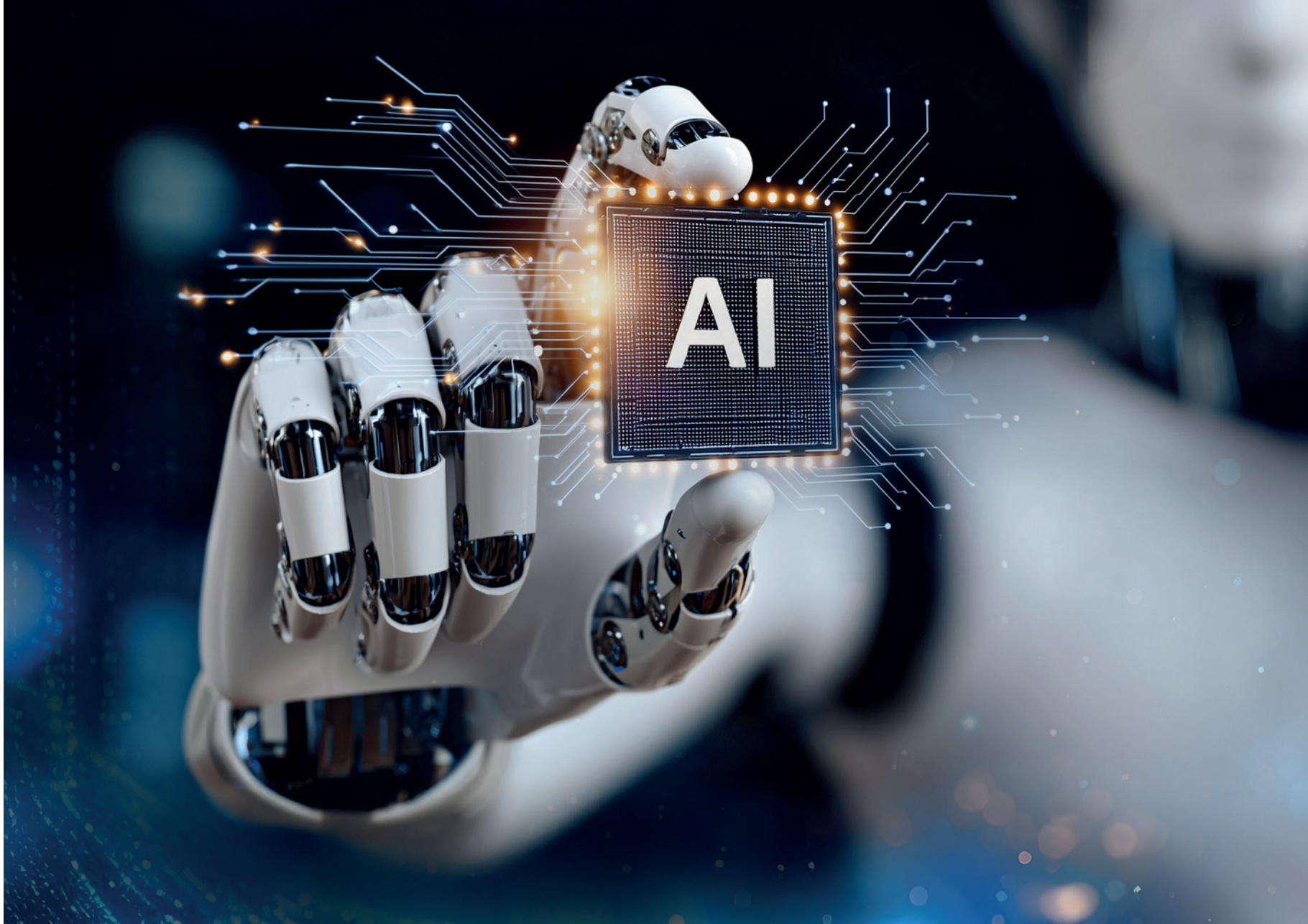

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created — from concept development and AI-based design through to hardware demonstrators.

FRAUKE: State-funded project as a trailblazer
The state-funded project FRAUKE serves as a trailblazer for the emerging ecosystem in Heilbronn. Together with the University of Stuttgart and IMS CHIPS, Fraunhofer IAF is working on AI-assisted, more efficient design processes for complex CMOS circuits. The project, funded over two years by the Ministry of Economic Affairs, Labour and Tourism of Baden-Württemberg, is creating technological and methodological foundations that will be further developed and scaled in future projects and at FIZ Chip AI.

At the same time, the project is initiating the establishment of a Fraunhofer IAF working group at the Innovation Park Artificial Intelligence (IPAI) in Heilbronn and is strengthening a networked ecosystem that integrates regional and national partners along the entire value chain from design to (sub-)system integration — from microTec Südwest, imec Germany, Hahn-Schickard and KIT to the Research Fab Microelectronics Germany and additional Fraunhofer FIZ and state-funded projects such as "Chip Connect BW".

Heilbronn as a hub for AI and microelectronics
With its recently launched activities in Heilbronn, Fraunhofer IAF is pursuing a clear strategy: the site is to develop into a hub for AI-based CMOS design and AI hardware. The establishment of a Fraunhofer Research and Innovation Center and a state-funded project complement each other. Together, these two Fraunhofer IAF initiatives form the starting point for building an ecosystem that brings together and

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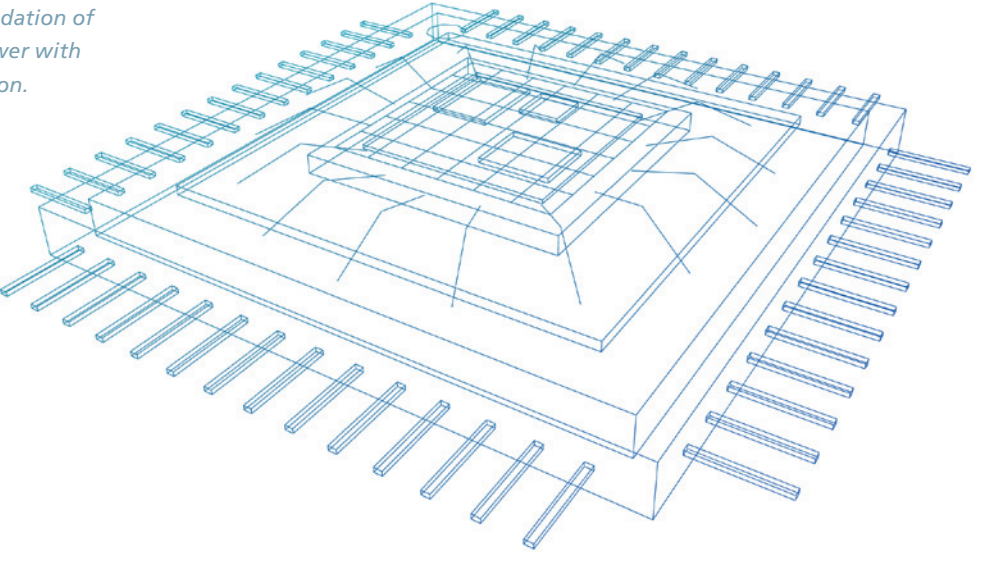
CMOS-based semiconductor chips form the foundation of AI systems, as they combine high computing power with energy efficiency and a high degree of integration.



empowers research, industry, SMEs, and start-ups in this key technology field. With FIZ Chip AI and the FRAUKE project, Fraunhofer IAF is setting a strategic focus in Heilbronn that fits seamlessly into national and European semiconductor and AI policies, the expansion of the Research Fab Microelectronics Germany, and the European anchoring of critical future technologies. In the coming years, the priorities will be the development of the FIZ Chip AI infrastructure, the successful completion of FRAUKE with transfer of the results into follow-up projects, the acquisition of additional industry partners, and the strengthening of education, training, and start-up activities in Heilbronn. Step by step, an ecosystem is emerging in which AI-based CMOS design and specialized AI hardware are developed together with partners and transferred into practical applications — as an important building block for the future viability of Baden-Württemberg, Germany, and Europe in the global competition for AI and semiconductor technologies.

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Pilot Lines and Advanced Prototyping for Europe

Fraunhofer IAF is extensively involved in establishing European pilot lines for microelectronics, optoelectronics, and quantum technologies. In addition, the institute has been operating advanced prototyping for many years, including for European space applications. With this commitment, which is unparalleled in both scope and thematic breadth, it is taking a pioneering role and making an important contribution to building resilient technological infrastructure and supply chains in Europe.

With initiatives such as the European Chips Act, Horizon Europe and the Quantum Flagship, the EU is making targeted investments in pilot lines for microelectronics and quantum technologies — with a clear objective: to secure technological independence and sovereignty in strategically important areas. The focus is on strengthening the European chip industry, accelerating innovation, and paving the way from initial prototypes to volume production. The state-of-the-art pilot lines are designed to give industrial companies, SMEs, and start-ups access to advanced technologies in Europe, together with the associated design and testing expertise.

Strong commitment in the pilot lines

No other Fraunhofer institute is involved in as many European pilot lines as Fraunhofer IAF. With its commitment and strong network, it forms a bridge between excellent fundamental research and the key EU initiatives for technological sovereignty — first and foremost the EU Chips Act and the Quantum Flagship — thereby closing the gap between research and industry. Fraunhofer IAF is contributing its microelectronics and quantum technology expertise in many ways to the APECS, SUPREME, SPINS and DIREQT pilot lines, providing industry with direct access to know-how and state-of-the-art infrastructure.

APECS

Within APECS, for example, the institute is involved in developing novel InGaAs-on-Si and GaN-on-SiC chiplets for high-frequency applications, as well as microbump interposers. Thanks to outstanding performance in key parameters such as noise, output power and efficiency, these technologies are particularly well suited for high-frequency applications and promise innovations in measurement technology, communications, radar and sensing. In addition, Fraunhofer IAF is driving the transition to industry-compatible wafer

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The institute is expanding its production capacities to 6-inch wafers in order to facilitate technology transfer to industry and improve manufacturing quality.

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sizes in manufacturing. These measures facilitate the transfer of new technologies into scalable, market-ready solutions.

SUPREME and SPINS

Another example is cryogenic measurement technology, which plays a key role in the SUPREME and SPINS pilot lines. Fraunhofer IAF already occupies a leading position in Europe in the field of characterization methods for solid-state quantum devices at low temperatures and is further expanding its expertise in this area. In addition to its extensive knowledge of characterization methods for semiconductor devices — from R&D applications through to industrial testing of 150 mm to 300 mm wafers — Fraunhofer IAF is one of the few European providers of such an ultra-low-temperature test setup below 2 K.

DIREQT

DIREQT stands for "Diamond for Industry Ready Quantum Technologies" and is establishing a pilot line for quantum technologies based on synthetic single-crystal diamond. Building on existing innovations, advanced Quantum Process Design Kits are being developed to enable robust, stable, and scalable production of quantum chips. The DIREQT consortium brings together 13 RTOs, eight universities, nine companies, and one non-profit organization, covering the entire diamond value chain. Fraunhofer IAF contributes by optimizing the growth of diamond films with single NV centers, supporting project partners in wafer-scale diamond epitaxy, and testing heteroepitaxially grown diamond for quantum applications.

The Arctic Weather Satellite collects precise weather data to improve global forecasts and climate monitoring.

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Advanced prototyping for ESA

Fraunhofer IAF has been one of the selected partners of the European Space Agency (ESA) for more than a decade. In 2013, a European microwave component based on gallium nitride flew into space for the first time on the Proba V mini-satellite: the amplifier developed at Fraunhofer IAF demonstrated that this semiconductor material is suitable for use in space. Since then, Fraunhofer IAF has realized numerous power and high-frequency amplifiers for use in satellites for ESA, most of them being high-performance and robust semiconductor components based on the material systems gallium nitride (GaN) and indium gallium arsenide (InGaAs).

Currently, researchers are working in the Magellan project on highly efficient millimeter-wave GaN power amplifiers for GEO and LEO active antennas. To this end, they have developed a GaN transistor technology with a gate length of 70 nm, which achieves record efficiencies under typical satellite operating conditions. This technology is intended to enable compact active antennas for high-bitrate data transmission in the Ka, Q, and W bands and thus support the development of seamless, resilient global communication networks using high-throughput satellites.

The ESA Arctic Weather Satellite, which carries four LNA modules from Fraunhofer IAF on board, is also currently in polar orbit on a test mission, collecting high-resolution temperature and humidity data of the Arctic. This is just a small selection of examples of how Fraunhofer IAF is advancing European spaceflight with advanced prototyping and its testing capabilities.

European pilot lines: resilient semiconductor value chains and low-barrier access

European pilot lines provide large industrial companies, SMEs, and start-ups with direct access to European and national production capacities for cutting-edge technologies.

They form the bridge between cutting-edge research and industrial application, enabling new microelectronics technologies to be developed, tested, and scaled under realistic production conditions.

Fraunhofer IAF's Contributions to the EU Pilot Lines

APECS — Advanced Packaging and Heterogeneous Integration for Electronic Components and Systems
SUPREME — Superconducting European Quantum Pilot Line
SPINS — Semiconducting Pilot Line for Industrial Quantum NanoSystems
DIREQT — Diamond for Industry Ready Quantum Technologies

Learn more about our contributions to the European pilot lines:

www.iaf.fraunhofer.de/pilot-lines

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Basic Technologies for Fusion — Towards a Fusion Power Plant

The German Federal Government has anchored the goal in its coalition agreement of strengthening fusion research and building the world's first fusion power plant in Germany. The High-Tech Agenda defines fusion as a key technology for developing Germany into a leading innovation hub. As part of the BMFTR-funded IFE Targetry HUB, the project partners have now achieved important milestones in the development of target technologies for laser inertial fusion.

The international race to build a fusion power plant is in full swing. Fraunhofer IAF is significantly involved in research on laser-based inertial fusion. In this process, a hollow sphere (target) filled with fuel is compressed so strongly by laser irradiation that the densities and temperatures required for fusion reactions are reached.

The challenge of perfect targets

With their diameters of 2.1 mm and 1.0 mm respectively, the tiny hollow diamond spheres are the central elements of laser-based inertial fusion. An ultra-precise spherical shape, an extremely smooth surface, and perfect material properties are prerequisites for ensuring that the target can be compressed in the fusion experiment without deforming asymmetrically. At present, no one in the world can produce deuterium–tritium-filled targets in sufficiently high quantities for use in a commercial fusion power plant. To move closer to the goal of a fusion reactor, entirely new manufacturing concepts must be developed over the coming years.

For this purpose, 15 partners from research and industry have launched the joint project IFE Targetry HUB. Led by Fraunhofer IAF and Focused Energy GmbH, this globally unique consortium is developing target technologies for laser inertial fusion — with a particular focus on precise and scalable manufacturing and metrology technologies. The key challenge is to produce fusion targets reliably, in sufficient quantities, and at economically viable costs.

The Fraunhofer IAF spin-off Diamond Materials has developed and evaluated target systems for production batches of over 1,000 units — including the world's only sphere with positive target gain, which is used at the National Ignition Facility of the Lawrence Livermore National Laboratory (LLNL) and is delivering continuously improved results.

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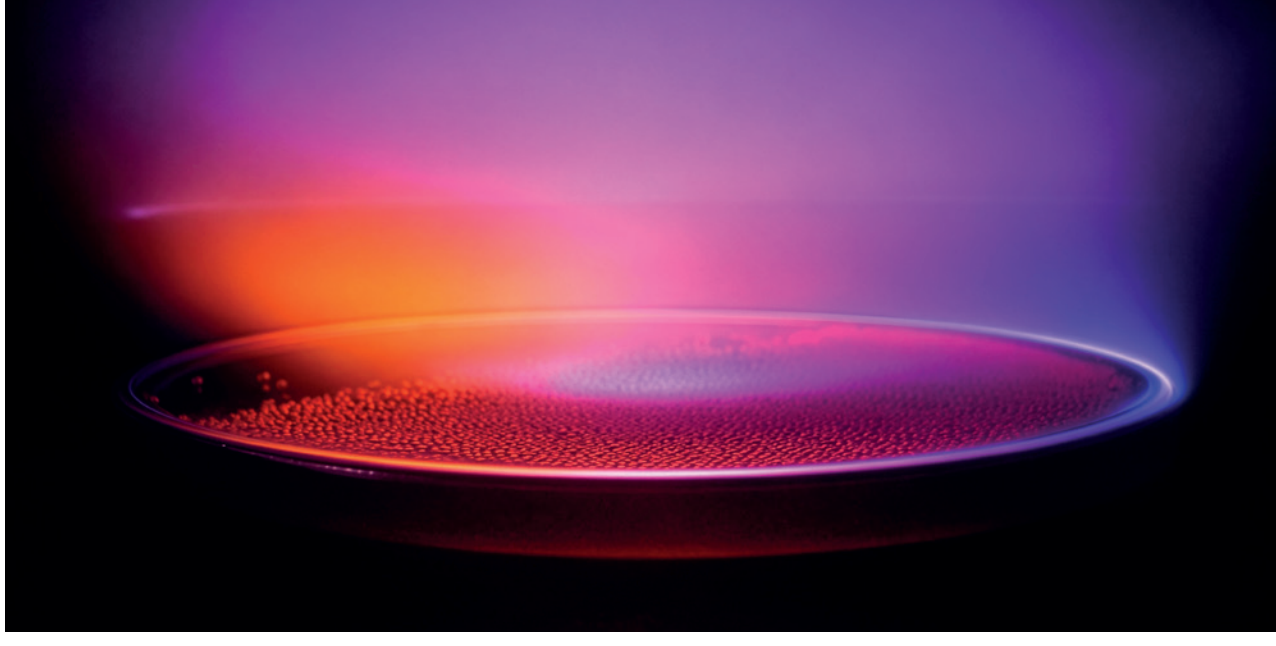

View into the chamber of the diamond reactor at Diamond Materials, in which the diamond spheres are grown.

Target gain describes the ratio between the incoming laser power and the outgoing fusion power of the target; it was demonstrated as positive for the first time in this context. In a specially developed reactor, 5,000 spheres per batch were produced with a homogeneous coating of nanocrystalline diamond (NCD).

Characterization and microchannel optimization

Fraunhofer IAF characterizes targets using secondary ion mass spectrometry (SIMS) and computed tomography in order to quantitatively determine the silicon concentration and the microchannel structure. To enable fuel filling of the targets with deuterium and tritium in Germany by KIT, microchannels were also drilled into diamond spheres at Fraunhofer IAF using UV picosecond lasers. A channel diameter as small as possible is crucial to sufficiently preserve the perfection of the target geometry. The researchers have succeeded in further reducing the channel diameter, already below the LLNL (USA) standard of 10 µm.

With these advances, the IFE Targetry HUB consortium is strengthening Germany's position in the international competition for commercial fusion energy.

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Quantum Computing for Tomorrow's Industry: KQCBW Gains Momentum

The Quantum Computing Competence Center Baden-Württemberg has successfully completed its transfer phase and is entering the next funding phase with a strong consortium. The focus is on concrete industrial collaborations and practical application-oriented use cases — from drug development to the energy sector.

The Quantum Computing Competence Center Baden-Württemberg (KQCBW), headed by Fraunhofer IAF and Fraunhofer IAO, pools the expertise of leading research institutions and companies from Baden-Württemberg in order to systematically transfer quantum computing into industrial practice. As one of Germany's most established quantum computing networks, the center addresses the key sectors for the state — from automotive and mechanical engineering to chemicals and medical technology, all the way to finance and logistics.

New phase — stronger ties to industry

In summer 2025, KQCBW launched its new funding phase with a budget of up to 20 million euros for the years 2024 to 2028. The consortium now includes 16 research partners and 13 associated industry partners. The research is divided into six focus areas: KQCBW Quantum Cloud, hardware benchmarking, error mitigation and quantum error correction, algorithms for quantum chemistry and materials science, analysis of economically relevant applications, and target group-specific knowledge transfer.

The overarching goal of KQCBW is to enable companies in Baden-Württemberg to recognize and purposefully harness the potential of quantum computing. To this end, the consortium plans, on the one hand, to provide demonstrators for simplified use cases and, on the other, to identify and further develop algorithms with promising early application opportunities — particularly in the areas of quantum chemistry and quantum simulation. In addition, access to quantum hardware developed in Baden-Württemberg will be made available.

Focus on applications

The breadth of the application cases being addressed highlights the consistently industry-focused orientation of the new phase. The simulation of NMR spectra (nuclear magnetic resonance) supports chemical sample analysis using benchtop devices. The calculation of

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the Green's function with quantum algorithms opens up new avenues for the development of functional materials — for example for catalysts and batteries. Fault-tolerant molecular simulations enable the calculation of molecular properties for pharmaceutical drug development, while quantum-assisted solution methods for partial differential equations find direct application in the energy sector — for instance in the calculation of wind turbine shadowing effects. The portfolio is complemented by the development of control hardware for diamond-based qubit systems and the integration of the KQCBW demonstrator platform with the PlanQK infrastructure for transparent benchmarking.

Building expertise for the quantum future

Alongside its research activities, KQCBW focuses on targeted knowledge transfer. With practice-oriented training formats — from the one-day introductory seminar QC Compact to the three-day Quantum Computing Industry Training — specialists from industry, research, and policymaking are being prepared for the use of quantum computing. In this way, KQCBW is becoming not only a driver of research, but also a multiplier of expertise for Baden-Württemberg as a quantum technology hub.

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From III-V semiconductors for electronics and optoelectronics to diamond-based quantum technologies — Fraunhofer IAF stands for a broadly diversified research profile. The institute covers the entire value chain: from design and material development through components and modules all the way to complete systems. Equally diverse are the fields of application.

Given this wide range of capabilities, competencies, and application areas, it is crucial to refine the research agenda of the institute and its individual business units and to prioritize those technologies that offer the greatest technological impact and the highest potential for industry. In the following, we present the further developed research profile of our business units as well as current key technological developments and projects.

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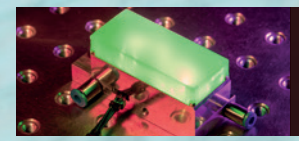
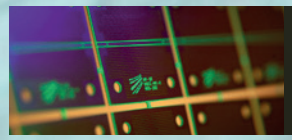


Quantum Components



Quantum Systems

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Business Unit High-Frequency Electronics

Our mission

In close collaboration with our partners, we develop and enable next-generation test instruments, high-resolution sensor systems, as well as high-speed communication subsystems and components.

What makes us unique

We master the design, processing, and integration of devices and sub-systems with extremely large bandwidths — beyond 100 GHz.
Our components achieve the lowest noise figures worldwide, up into the terahertz range.

Our value proposition

Building on our many years of experience and proven expertise, we offer design, processing, integration, and characterization of MMICs as well as modules and subsystems along the entire value chain. This ensures end-to-end, technologically consistent and optimally matched solutions from a single source.

In close cooperation with industrial and research partners, we work in a goal-oriented manner to bring innovations to market on schedule, in high quality, and at competitive cost.

Fields of application

- THz communication
- Space and satellite communication
- High-resolution sensing
- Test and measurement equipment

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Focus topics

mHEMT speed and logic components, integrated with III-V technology

Increasing switching speed and output power, and developing E/D logic and higher breakdown voltage by means of a backgate.

Improvement of the 35-nm mHEMT process

The goal is to achieve a lifetime, yield, and suitability for cryogenic applications comparable to the existing 50 nm mHEMT process.

Heterogeneous integration/packaging and interconnection technology

Interposer technology for low-loss integration, flip-chip with indium bumps and thermally coupled vias for the realization of highly integrated subsystems.

Scaling to 6-inch wafers

Manufacturing on 6-inch wafers for higher throughput and industrial access to our technology; strengthening technology transfer and optimizing the supply chain.

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More Functions per Chip: Four-Pole HEMT-on-Silicon with Integrated Logic

With its 20-nm indium gallium arsenide (InGaAs) high-electron-mobility transistor (HEMT) on silicon platform, Fraunhofer IAF integrates digital control and high-performance radio-frequency (RF) functionality on a single chip. A novel backside gate enables flexible integration of logic circuits, while a backside field plate enhances the breakdown voltage, thereby increasing the potential output power of amplifiers operating at 300 GHz and beyond. This technology paves the way for more compact, energy-efficient, multi-functional and scalable RF front-end solutions.

Future communication and sensing systems at 300 GHz and beyond require RF front ends that combine high output power, compact form factor, and intelligent control. To meet these demands, Fraunhofer IAF is developing a 20-nm $In_{0.8}Ga_{0.2}As$ HEMT-on-silicon technology that integrates more functions per chip: high-performance RF transistors together with logic components for local control and monitoring.

A HEMT is optimized for operation at extremely high frequencies. Implementing it on a silicon substrate ("HEMT-on-silicon") enables better integration and scalability. The key innovation of this platform is the localized integration of two additional electrodes: a backside gate (BG) and a backside field plate (BFP). These elements transform the conventional three-terminal HEMT into a four-terminal device expanding circuit design flexibility and enabling smarter RF front ends without increasing chip area or requiring separate control ASICs (application-specific integrated circuits).

Higher voltage robustness and output power

The backside field plate, located underneath the drain region, improves the internal electric-field distribution and increases breakdown voltage compared with conventional HEMTs. Combining the BFP with an optimized gate recess on the drain side enables enhanced high-voltage HEMTs (HV-HEMTs) with significantly improved voltage robustness while maintaining state-of-the art RF performance, including an f_{max} above 650 GHz. This forms the basis for power amplifier monolithic microwave integrated circuits (MMICs) with higher potential output power at 300 GHz and beyond, supporting longer transmission ranges, higher data rates, and more robust links in future communication and sensing systems.

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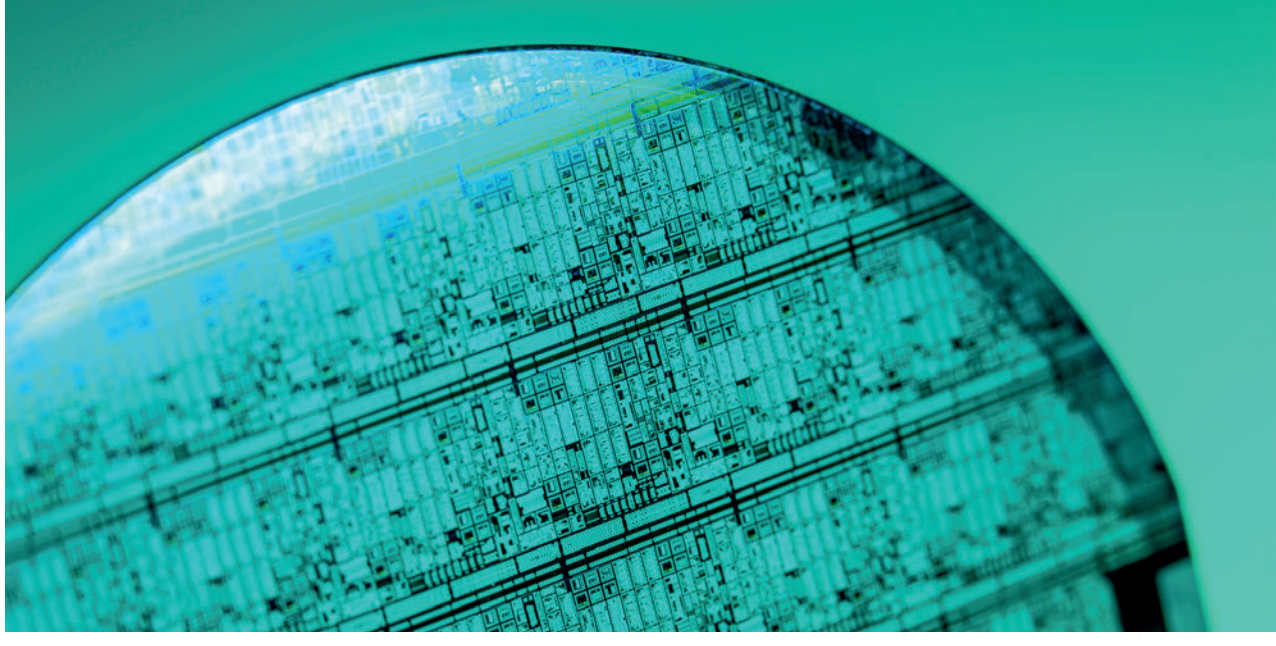

Processed 4 inch InGaAs wafers (indium gallium arsenide) with a high density of integrated microstructured mHEMT THz circuits.

In parallel, the backside gate is positioned beneath the intrinsic channel region and used to adjust the transistor threshold voltage. This allows both enhancement-mode (E-mode, normally off) and depletion-mode (D-mode, normally on) operation on the same technology platform, without any change to the epitaxial structure. Fundamental logic blocks — including inverters, NAND and NOR gates, as well as a D-latch — have been demonstrated at low supply voltages using an RF transistor layout combined with localized backside-gate integration.

Integrated bias and power control

These circuits provide the essential digital building blocks to locally control bias conditions, implement logic functions, and manage power states directly on the RF chip. As a result, operating conditions can be adjusted dynamically, energy efficiency is increased and the dependence on external control electronics is reduced. This approach lays the foundation for fully monolithic digital–RF integration within this HEMT technology, enabling advanced concepts such as digitally controlled phased-array systems and variable-gain amplifiers.

The 20-nm HEMT-on-silicon platform marks an important step toward next-generation terahertz modules that seamlessly integrate complex control functions and high-performance analog building blocks on a single chip.

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Business Unit Power Electronics

Our mission

We develop the next generation of III-V high-performance semiconductors — for high-frequency applications as well as for efficient switching in the MHz range. As an enabler for German and European industry, we transfer advanced developments in epitaxial crystal growth, process technology, and device and circuit design from university research into industrial practice.

What makes us unique

We combine the know-how of a unique value chain under one roof: from the deposition and characterization of epitaxial layers through processing all the way to the realization of complex high-frequency demonstrators. This enables us to evaluate new concepts — whether epitaxial layer structures, process modules, or innovative circuit designs — in an agile and well-considered way for our customers and to advance them to market readiness.

Our value proposition

We develop and optimize innovative MOCVD epitaxial layer structures. In addition, we enhance existing process chains by developing new process modules in the field of RF and power electronics. Through the close integration of epitaxy, process development, and circuit design, we realize integrated overall concepts that specifically maximize efficiency, power density, and integration level. At the same time, we provide our customers with production capacities within our GaN pilot lines, thus systematically closing the lab-to-fab gap.

Fields of application

- Electromobility and climate technology
- Radar
- Communication and space
- Metrology

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Focus topics

High-speed RF electronics with maximum efficiency

World-record technology for the mm-wave range up to and beyond 200 GHz: despite scaling to extremely short gate lengths, gallium nitride exhibits exceptional power density and gain.

Efficient high-voltage devices for RF

High-frequency technology with a supply voltage of 100 V and highest power density for radar, communication, and defense in the L, S, C, and X bands.

Highly robust RF electronics

Gallium nitride technology with high power density and extreme robustness for resilient low-noise amplifiers, switches, and power amplifiers up to the W band.

High-performance MHz switches

Gallium nitride devices and circuits for the highest voltages up to 1700 V for next-generation sustainable energy conversion systems.

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Advanced High-Voltage Technology for Radar and Communications

Gallium nitride (GaN) transistors already enable power amplifier stages today with an output power that cannot be achieved with any other semiconductor — for example as a high-power building block for space communications or in radar applications. Fraunhofer IAF is driving the next generation of GaN high-voltage technology, which combines extreme power density and efficiency with the space-saving integration of all components on a single chip.

Electronic systems are expected to become smaller, lighter, and more energy-efficient. This is particularly critical in satellites, aircraft, or ground-based communication stations, where weight, installation space, and energy consumption are key factors. In many of these applications, GaN amplifier stages largely determine the overall efficiency: they convert the supplied electrical energy directly into high-frequency power and are usually connected directly to the antenna.

As their efficiency increases, heat losses and cooling requirements decrease, enabling more compact cooling systems. Due to the limited output power of currently available transistors, an additional source of loss arises: the high-frequency power of many individual transistors has to be combined in a complex manner.

This is precisely where the development of GaN50X technology at Fraunhofer IAF comes in. It operates at supply voltages of up to 100 V and achieves extremely high power densities of over 15 W/mm. Another development goal is the monolithic integration of the required RF matching networks directly on the chip (MMIC). Thanks to this innovation, the space required by the amplifier output stage in the system is reduced by an entire order of magnitude, while the required cooling power is lowered.

Reliability, uniformity, and industrial pilot-line production of GaN50X technology

The high operating voltage and power density, however, place great demands on the materials used and on manufacturing tolerances: to ensure the reliable use of GaN50X technology, Fraunhofer IAF not only investigates peak values, but also parameters such as long-term behavior and uniformity. Innovative approaches in the epitaxial and technological foundations ensure consistently high device quality

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ESA's deep space antennas in New Norcia, Australia. These antennas transmit deep into space to maintain communication with distant space probes. For this, they require high RF power, which will in future be provided by GaN transistors.

as well as future series production. Comprehensive reliability studies under 100 volt operation, at high temperatures, and in humid environments stress the devices to their limits and provide valuable insights into the device physics and robustness of the technology. The goal of this development is to establish an industrial pilot-line production that provides transistors and circuits with previously unattained power density.

Over the next three years, this will create the basis for highly integrated transmit and receive modules that provide high power efficiently while requiring very little space. The areas of application range from satellite communications and high-resolution Earth observation to modern, energy-efficient radar systems. In this way, GaN50X technology contributes to more reliable and more sustainable systems in our increasingly networked world.

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Business Unit Optoelectronics

Our mission

We provide access to high-performance optoelectronic technology for lasers and detectors. For demanding sensing, security, and quantum applications, we develop state-of-the-art detector and laser devices and deliver solutions ranging from single emitters to system demonstrators.

What makes us unique

As a leading European source with many years of proven expertise and state-of-the-art infrastructure, we offer the complete value chain in infrared optoelectronics: from simulation-based device design and first-class epitaxy and process technology, through characterization, all the way to module and system demonstrators.

Our value proposition

We create value by supporting our partners in the development of innovative components, modules, systems, and applications, and by providing our industrial customers with low-barrier access to cutting-edge optoelectronic laser and detector technology — from industrial pilot production to supported technology transfer. By researching technologies with foreseeable industrial potential, we help build national expertise and thus contribute to strengthening national and European technology sovereignty and independence.

Fields of application

- Thermal infrared signatures
- Spectroscopy
- Quantum communication and sensing
- Process control

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Focus topics

Ga-free type-II superlattice detectors for the wavelength range 3 – 5 µm

Robust technology with high operating temperature and low defect density; strengthening European sovereignty in the largest market segment of the thermal infrared.

Quantum cascade lasers (QCL) & QCL-based sensing

QCL chips and modules with world-leading tuning speed for rapid spectral coverage; the European source for high-power QCLs with buried heterostructure; system demonstrators for real-time sensing.

Lasers and photon sources for quantum applications

III-V-based emitters of entangled photon-pair sources, narrowband VECSELs as pump sources for quantum frequency converters and Rydberg RF sensing.

Photonic integration

Semi-automatic assembly of miniaturized laser modules and photonic integrated circuits (PICs) for the wavelength range 4 – 12 µm.

SPAD detectors for the wavelength range up to 1.7 µm

Ultra-sensitive single-photon detection with low dark count rate; Fraunhofer is the only EU manufacturing site for this advanced detector design.

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ECOSYSTEM — a European Supply Chain for T2SL-Based IR Detector Technology

Europe's technological sovereignty requires independence in critical key components. These also include modern IR detectors, which are used in important value chains and demanding applications. For high-performance T2SL IR detectors, EU manufacturers have so far been highly dependent on non-European sources. In the EDF project ECOSYSTEM, Fraunhofer IAF is cooperating with renowned European partners with the aim of reducing this dependence by establishing a sovereign European supply chain.

Stable supply chains are of utmost importance for autonomous manufacturing capability. This applies in particular to technologies for the IR detector industry. In the EDF project ECOSYSTEM, a European supply chain for high-performance IR detectors based on type-II superlattices (T2SLs) as detector material is to be developed, since there are currently still dependencies on non EU sources. Through the cooperation of 17 EU partners from eight nations, existing capabilities are combined and expanded and technological innovation is promoted in order to catch up with world-leading companies in terms of performance and to reduce technological and economic dependencies. A central project objective is the realization of a T2SL camera demonstrator for the mid-infrared with SXGA resolution at a 7.5 µm pixel pitch and a high operating temperature of 130 K.

Ga-free T2SLs for compact, energy-efficient IR detectors
T2SLs, particularly the "Ga-free" variant, have become established in recent years as an IR detector material. Their advantageous material properties enable higher operating temperatures without performance losses compared to conventional systems. This allows size, weight, and power consumption at the system level to be reduced, resulting in a more cost-efficient IR detector technology.

Due to its many years of expertise in T2SL technologies, Fraunhofer IAF is a key partner in the project consortium. At the institute, the value chain begins with the molecular beam epitaxy of the T2SL layers on commercial 100-mm GaSb substrates, which so far are not available in the required quality from sovereign EU sources. Several ECOSYSTEM partners are therefore conducting research on the crystal growth of GaSb single crystals and their further processing into substrate wafers. Reprocessing and recycling of critical raw materials are being

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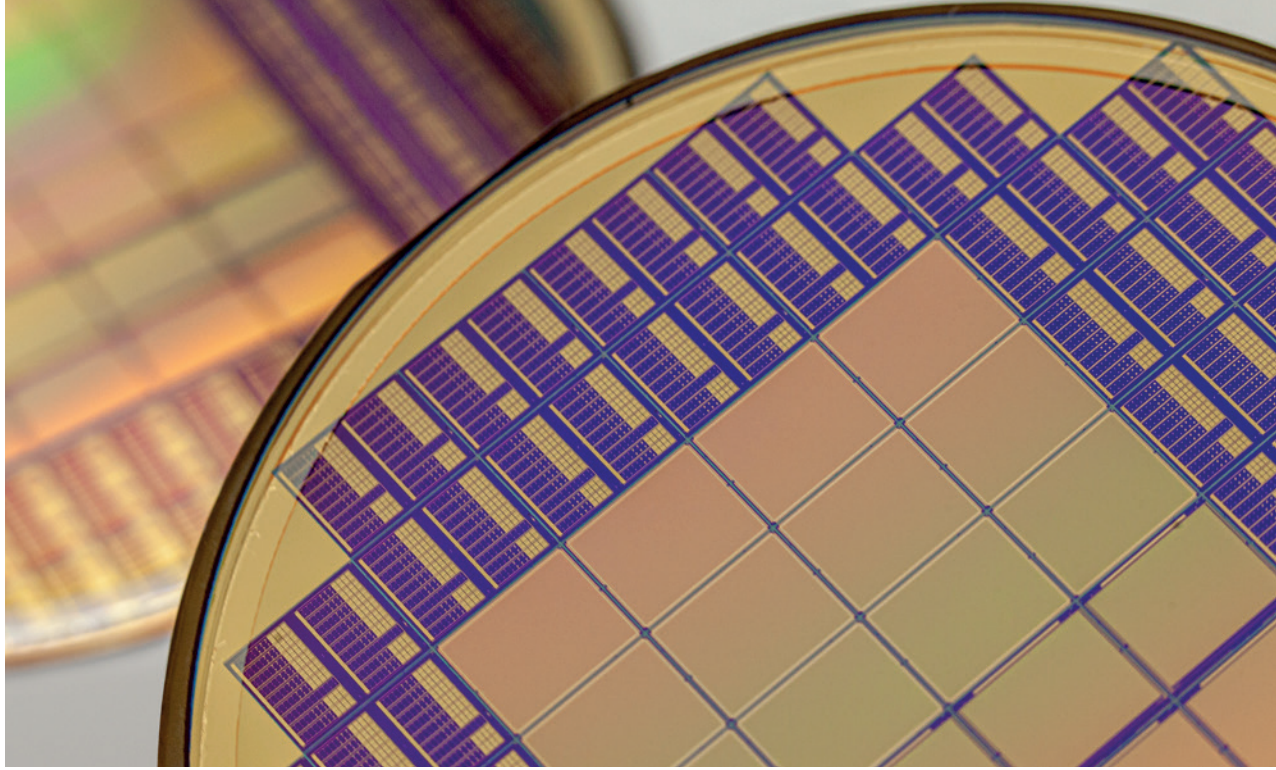

T2SL detector wafer based on a 100 mm GaSb substrate with 24 detector matrices surrounded by test structures for material and process evaluation.

investigated with the aim of moving closer to a resource-efficient, independent supply.

Building a European value chain

After the epitaxy of the T2SL layers, detector arrays are fabricated at Fraunhofer IAF using advances in etching and processing technology. These are then hybridized with readout circuits by two European project partners, combined with dedicated cryocoolers, and finally assembled and evaluated as a T2SL module. The specific requirements regarding detector material, pixel pitch, and operating temperature demand extensive research and development efforts from all project partners. The goal of ECOSYSTEM is to make the European IR detector industry more interconnected, independent, and internationally competitive by establishing this supply chain.

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Business Unit Quantum Components

Our mission

We are the enabler of quantum technology. With custom-developed components, we take quantum technology approaches from the scientific niche into real-world applications. Our goal is to turn research results into market-ready, reliable, and scalable solutions for real-world environments.

What makes us unique

Our strength lies in the high level of integration along the entire value chain: from the base material to the sensor core, electronic and optical control and readout, all the way to the application and integrated sensor modules. This is complemented by excellent facilities for growth, characterization, and packaging.

Our value proposition

We identify, support, and evaluate innovations from basic research and, where suitable, transfer them into quantum sensing technologies. We create value by systematically leveraging our many years of experience in optoelectronics, in particular in LED and laser technology, to turn lab world-record results into robust, field-ready, and readily available sensors and devices. Our research is consistently aligned with market needs. The focus is on the optimal balance of cost, performance, and quality — the economically viable sweet spot for sustainable technological success.

Fields of application

- Materials testing
- Microelectronics
- Medicine
- Navigation

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Focus topics

Laser threshold magnetometry

Diamond-based quantum sensing for mass-market/consumer applications with sensitivities down to the level of brain signals.

Monolithic/hetero-integration of an NV-based sensor core

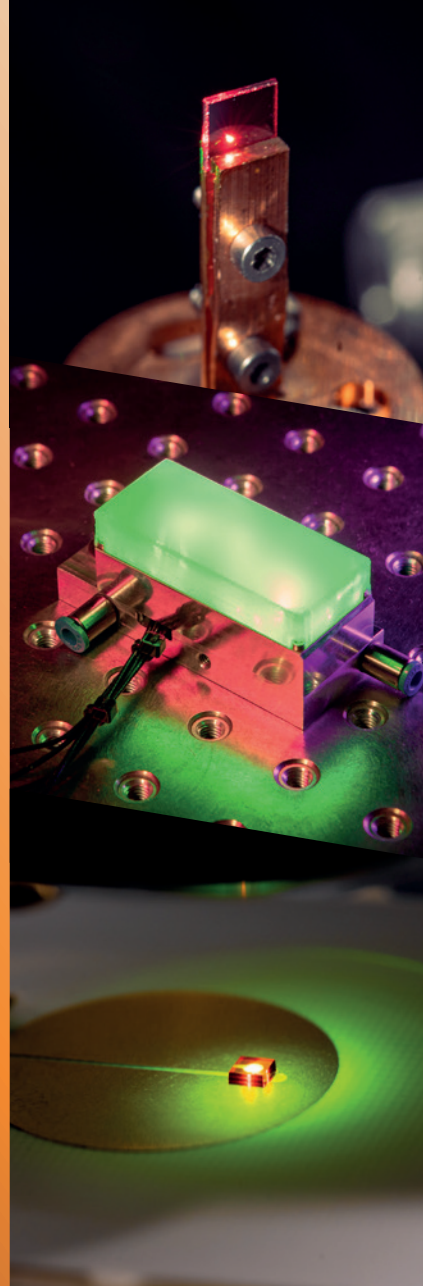
Enabling applications through SWaP, robustness, reproducibility, and scalability.

Modules for quantum sensing applications

The quantum sensing market is a growth market, which is why a large number of proofs of concept and prototypes are required to test new applications.

Diamond devices for quantum sensing applications

The core element of Fraunhofer IAF and the basis of every sensor — the amplification and specific requirements of each application leave ample room for development opportunities and optimization of light extraction through design.



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Laser-Enhanced Diamond Sensor Improves Magnetic Field Measurement 520-Fold

Quantum sensors based on nitrogen-vacancy centers (NV centers) in diamond enable highly precise magnetic field measurements even at room temperature. At Fraunhofer IAF, a research group is working extensively on implementing a fundamental improvement concept in quantum sensing: laser threshold magnetometry has the potential to boost both the sensitivity and the dynamic range of magnetic field measurements to record levels. The researchers have now succeeded in experimentally realizing the existing theoretical concept and demonstrating an outstanding improvement factor of more than 520 compared to the current state of the art.

Conventional NV magnetometers are based on detecting red light that is emitted by the NV centers after excitation with green laser light. The intensity of the red light changes when the magnetic field changes. However, these brightness changes and the intensity of the red emission are very small (typically a few per cent), which currently limits the achievable sensitivity.

Laser threshold magnetometry

A highly promising research approach for increasing sensitivity is the concept of laser threshold magnetometry (LTM). In this approach, the red-emitting diamond is placed together with a laser medium inside a cavity (an optical resonator). By carefully selecting the laser medium and optimizing the diamond parameters, the NV centers and the laser can be strongly coupled, such that the laser power depends directly on the magnetic field to be measured. If the laser system is operated close to the lasing threshold, even a small change in the magnetic field can cause the laser system to be deliberately switched off. This combination of high achievable output power and strong magnetic-field dependence promises a significant improvement in optical contrast, sensitivity, and dynamic range.

Significant increase in contrast and performance

This year, as part of the BMFTR-funded project NeuroQ, the research group was able for the first time to fully reproduce these theoretical predictions in an experiment. Due to the strong coupling of the NV centers with a semiconductor laser medium in the same cavity,

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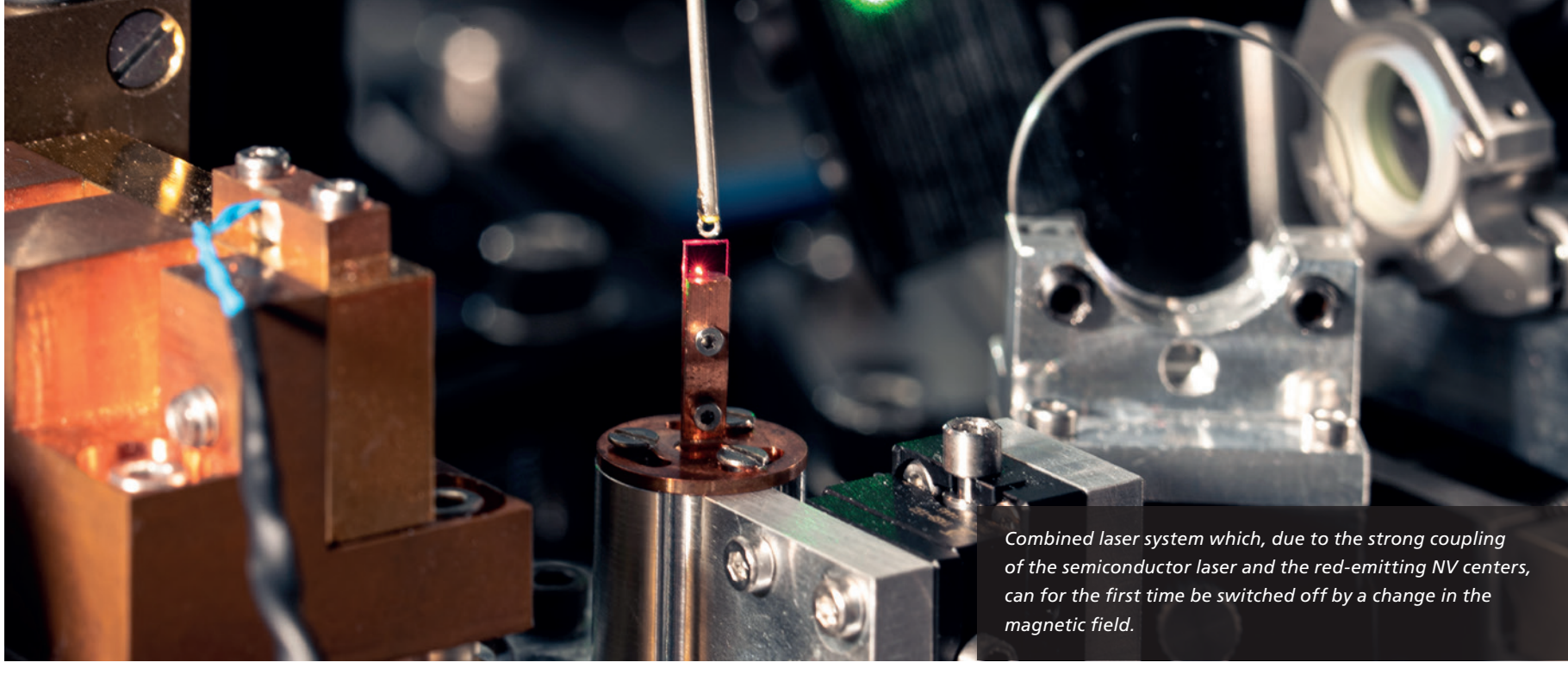

Combined laser system which, due to the strong coupling of the semiconductor laser and the red-emitting NV centers, can for the first time be switched off by a change in the magnetic field.

the properties of the combined laser system change significantly when the magnetic field is varied. In this way, the researchers achieved an optical contrast of up to 100% — compared to the few percent typically obtained with conventional NV-based magnetometers — while at the same time reaching signal powers of up to 60 mW instead of the usual few milliwatts or microwatts. In the theoretical limits of the sensor-relevant parameters, this enabled the demonstration of an improvement factor of more than 520 compared with the current state of the art.

These results form the basis for a new generation of magnetic field sensors based on LTM, which could be used in medical technology in particular for the precise measurement of weak magnetic fields such as those generated by the heart or brain.

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Business Unit Quantum Systems

Our mission

We develop scalable, color-center-based quantum computers with a focus on size, weight, and power advantages, in order to create powerful mobile systems for new applications. In addition, we design specialized algorithms and research materials for quantum technologies.

What makes us unique

Our particular strength lies in the combination of materials expertise, system know-how, and algorithms: we have decades of experience and a strong network in diamond growth, are a European leader in system engineering and testing of diamond QPUs, and provide the only security-relevant quantum algorithmics in Germany.

Our value proposition

We produce high-quality diamond films for applications in quantum computing and quantum sensing, thereby forming the basis for powerful quantum systems. We offer solutions for quantum systems: from hardware control and system integration through to the development of specialized algorithms for quantum computers and quantum sensors. With our work, we enhance security in our country and within our community of shared values.

Fields of application

- Quantum simulation
- Combinatorial optimization
- Quantum machine learning
- Quantum computing for AI

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Focus topics

NV chip — dipolar/photonic coupling

Development of a diamond-based quantum processor against the backdrop of a growing market for applications in quantum computing and quantum communication.

Diamond material/implantation

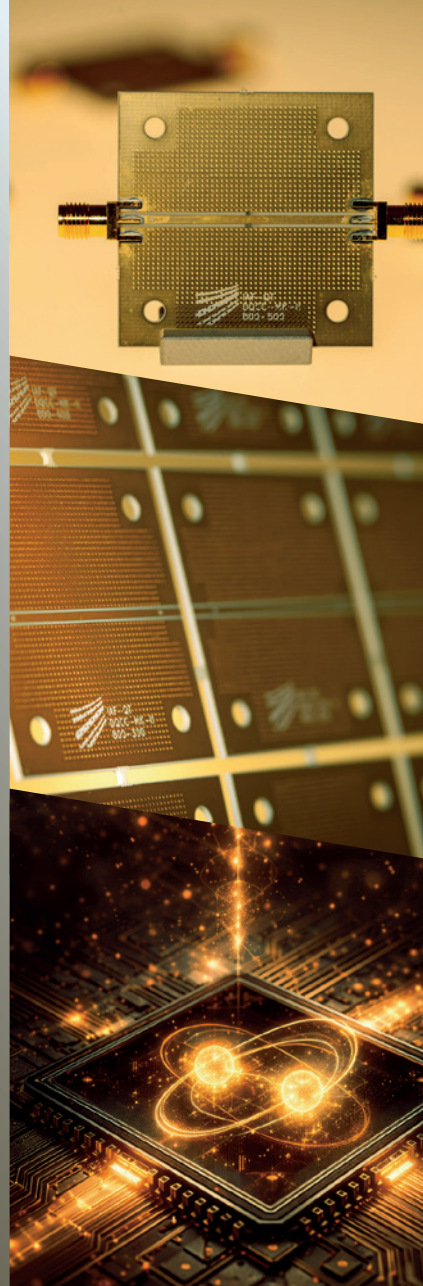
The increasing capabilities in diamond implantation are leading to new applications and driving the growing demand for diamond films with ensembles or single centers of NV diamond and other color centers.

Characterization and benchmarking of color centers

Improving the reliability and scalability of color-center-based quantum technologies requires comprehensive testing services.

Quantum algorithms

Development of software for operating quantum computers, in particular for optimization, simulation, machine learning, and error correction.



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Logical Qubits for Fault-Tolerant Quantum Computers

Quantum computers hold enormous potential for performing fast, complex computations, but their susceptibility to errors has so far limited their practical use. The snaQCs2025 project is specifically advancing quantum error correction: through robust logical qubits, optimized algorithms, and new analysis tools, the error susceptibility of physical qubits is to be significantly reduced and a complete development pipeline from simulation to validation established. The initiative is being carried out by neQxt, Fraunhofer IAF, and Point 8, and is funded by the BMFTR over a period of three years.

Quantum error correction is considered the key to the widespread use of quantum computers. This is precisely where the project snaQCs2025, funded by the Federal Ministry for Research, Technology and Space, comes in: the project partners are jointly developing robust quantum error correction methods that are tailored to scalable quantum algorithms. Funding is provided under the measure "Application-Oriented Quantum Computing" over three years, with a total of 2.5 million euros.

Qubits are extremely sensitive to external influences — even the smallest magnetic fields or temperature fluctuations can change their state and thus distort a quantum computer's calculations. The use of quantum error correction can compensate for this: by combining several physical qubits, logical qubits are created in which errors of individual qubits within the ensemble can be detected and corrected. Although the total error probability initially increases with the number of physical qubits, structured interconnection into logical qubits can effectively reduce the error rate.

At the heart of snaQCs2025 is the complete development pipeline: from the simulation of error-correction strategies and the implementation of logical qubits in existing quantum hardware through to the optimization of application-oriented algorithms, every stage is geared towards the robustness of the computations. The hardware basis of the project relies on trapped-ion quantum computing technology, which offers a high degree of controllability of the qubits.

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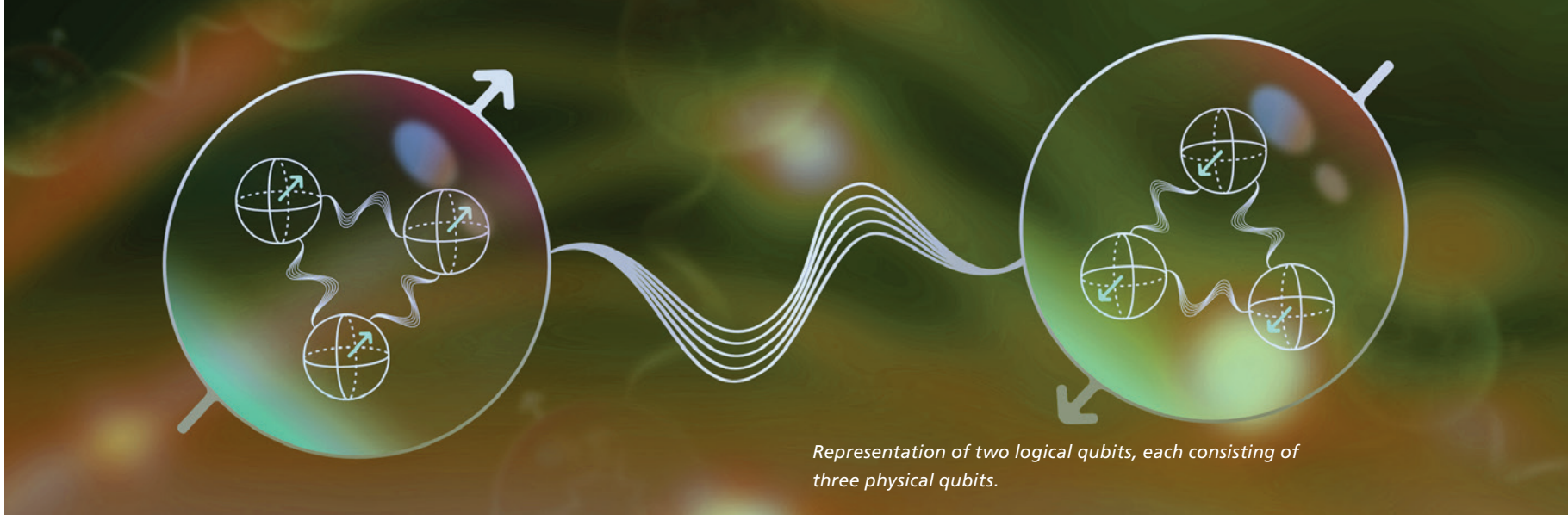

Representation of two logical qubits, each consisting of three physical qubits.

Integrated quantum error correction for scalable logical qubits and industrial applications
At Fraunhofer IAF, the integrated strategy of analytics, optimization, simulation, and fault-tolerant implementation is being advanced. The focus is on the scalability of the algorithms, their practical applicability, and their alignment with the quantum error-correction codes being developed. Close coordination with the other partners in the consortium ensures that algorithms, codes, and tools are efficiently aligned and can be specifically integrated into industrial processes.

By developing robust logical qubits, improving quantum algorithms, and providing reliable analysis and validation tools, the potential of quantum error correction becomes tangible for industrial applications as well. The use of quantum error-correction methods based on logical qubits enables the fault-tolerant execution of algorithms with quantum advantage, for example for cryptanalysis, database search, and the study of materials and chemical compounds. The results are intended to help increase the fault tolerance of quantum processors, open up applications in materials science, chemistry, optimization, and data-intensive fields, and strengthen Germany as a location for scalable quantum computing solutions.

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INQUBATOR — Quantum Computing Consulting and Testing Center

Tailor-Made Diamond Materials for Industrial Quantum Sensing

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Strengthening Industrial Transfer

Since its founding, the Fraunhofer-Gesellschaft has seen itself as a bridge between excellent research and industrial application. At its core is the ambition to bring technologies to market maturity and to transfer them into practice together with industrial partners.

Fraunhofer IAF works closely with partners from science and industry — from large corporations and SMEs to start-ups, both nationally and internationally. To specifically strengthen these partnerships, we offer low-threshold access to new technologies, such as the INQUBATOR Quantum Computing Consulting and Testing Center, and work with our customers to develop customized solutions for their specific requirements. Research needs strong partnerships and a shared goal: the industrial value creation of tomorrow.

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INQUBATOR — Quantum Computing Consulting and Testing Center

Fraunhofer IAF, together with three other Fraunhofer Institutes, has established the INQUBATOR Fraunhofer Quantum Computing Consulting and Testing Center. This is an innovative, low-threshold offering that makes it easier for companies to get started with quantum computing. Concrete, practice-oriented use cases are investigated, in which quantum computers may offer an advantage.

The goal of INQUBATOR is to systematically prepare the German economy for the technological disruption brought about by quantum computing and thus safeguard its international competitiveness. It is particularly aimed at companies that have not yet been part of the quantum ecosystem. Through joint R&D activities, they are to be introduced to the topic at an early and proactive stage and given the opportunity to test this important future technology in practice. Realistic technology assessment and tailored support for companies are the main focus.

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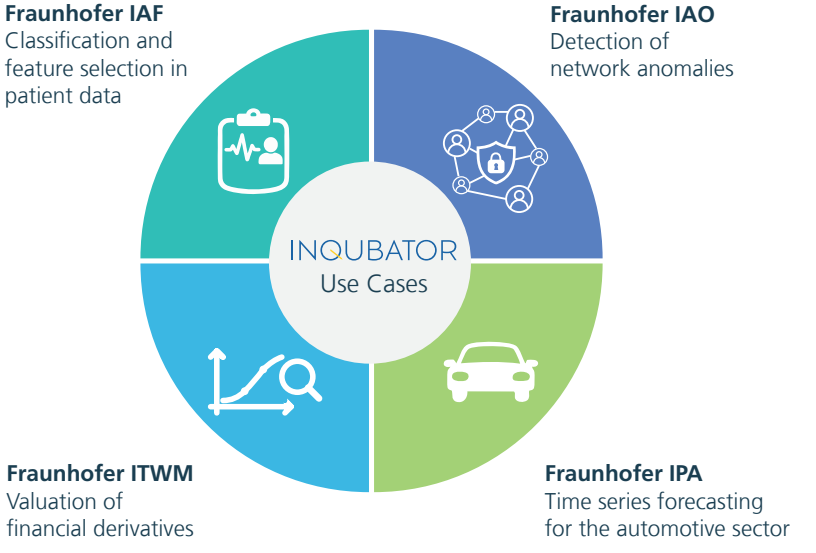
Four predefined use cases

The four-year INQUBATOR project begins with four predefined use cases from the fields of medicine, cybersecurity, automotive, and insurance. Other companies are explicitly invited to approach the center with their own challenges in order to work on them jointly. The implementation of at least eight additional use cases is planned, which will be acquired through an informal call for proposals. Methodologically, the initial focus is on various quantum machine learning (QML) algorithms, for which a quantum advantage appears particularly promising. The use cases of the second phase will considerably broaden the range of topics and will not be limited to QML-based problems. The next call for proposals will start in mid-2026.

The participating institutes Fraunhofer IAF, ITWM, IAO, and IPA pool their extensive expertise in working with quantum hardware and application-oriented quantum software. In addition, users have access to extensive computing time on modern quantum computers from various manufacturers, including IBM, IQM Quantum Computers, and AQT (Alpine Quantum Technologies). This removes key entry barriers: on the one hand with regard to the radically different solution approaches of quantum computers compared to classical algorithms, and on the other hand the high costs of quantum computing time.

In this way, a framework is created in which companies can purposefully build up expertise and gradually transfer quantum computing into their specific applications in a beneficial way.



The overall project goal is to systematically investigate innovative quantum computing approaches in an economic context, to cover a broad spectrum of algorithms currently considered particularly promising, and to test them on state-of-the-art quantum computers.

For more information visit:

www.fraunhofer-inqubator.de/en

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Tailor-Made Diamond Materials for Industrial Quantum Sensing

Fraunhofer IAF is one of the pioneers in the field of synthetic diamonds. The institute conducts research on the production and optimization of diamond-based materials and applies this expertise for industrial partners in quantum sensing, metrology, and quantum communication. But Fraunhofer IAF not only performs cutting-edge diamond research, it also manufactures customized synthetic diamonds for industry.

At Fraunhofer IAF, ultra-pure single-crystalline and polycrystalline diamond substrates as well as thin films are produced by chemical vapor deposition (CVD) — both homoepitaxially and heteroepitaxially. For this purpose, the institute operates ten microwave plasma reactors, which are run entirely in-house and are continuously further developed.

The ongoing improvement of this reactor technology — tailored to new requirements from industry and research — has given Fraunhofer IAF deep expertise in diamond reactor design, which in turn feeds into the development of customer-specific processes and materials.

Tailor-made doping and color centers

To realize specific electrical and quantum-physical properties, Fraunhofer IAF offers application-optimized dopants and defects (color centers) for industry. Nitrogen-vacancy (NV) centers are particularly well established and serve as quantum devices up to the level of individual qubits. Thanks to diamond's very rigid crystal lattice, the quantum effects of these color centers remain stable and usable even at room temperature — a key advantage for robust, real-world applications.

The ultra-pure, single-crystalline CVD diamond layers developed at Fraunhofer IAF with precisely engineered NV centers open up new possibilities in quantum sensing, metrology, and quantum communication. Through controlled nitrogen doping, defined crystal orientations, and precisely adjustable defect densities, tailor-made quantum materials are created, featuring exceptional coherence, stable fluorescence, and robust performance.

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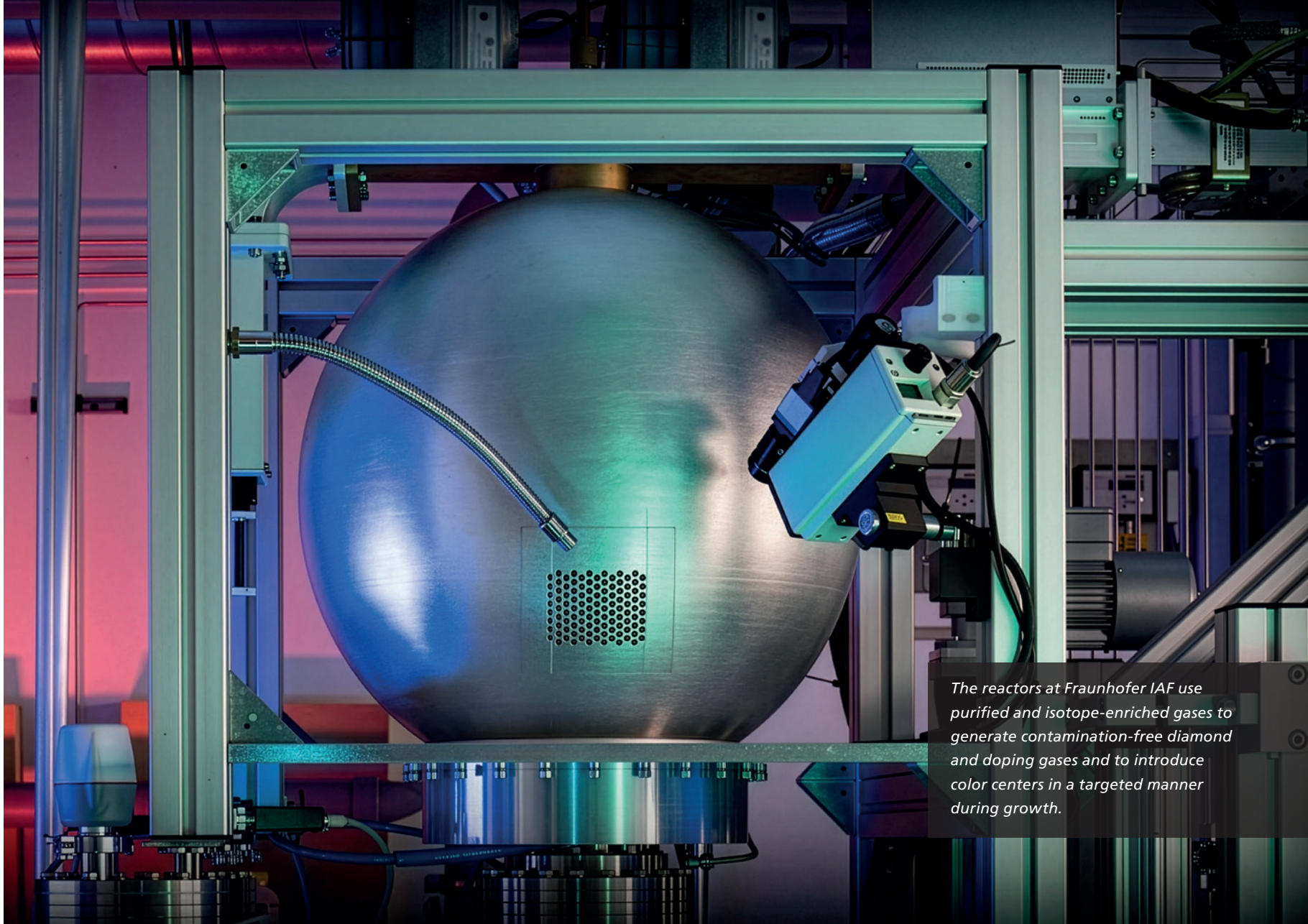

The reactors at Fraunhofer IAF use purified and isotope-enriched gases to generate contamination-free diamond and doping gases and to introduce color centers in a targeted manner during growth.

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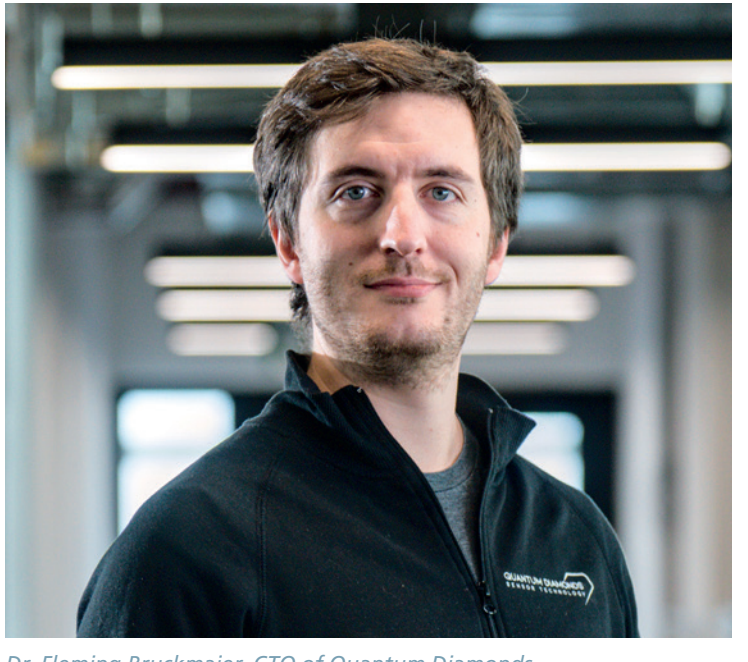
"Fraunhofer's Support Was an Important Accelerator"



Dr. Fleming Bruckmaier, CTO of Quantum Diamonds

Dr. Fleming Bruckmaier is co-founder and CTO of Quantum Diamonds (QD), a Munich-based start-up that develops highly sensitive diamond-based quantum sensors for fault diagnostics in microchips. In this interview, he talks about the start-up's vision, quantum diamond microscopes, and the collaboration with Fraunhofer IAF.

What vision was Quantum Diamonds founded with, and where does the company stand today?

Bruckmaier — Quantum Diamonds was founded with the vision of bringing quantum sensing out of the research lab into industrial applications — in particular for analysis and fault diagnostics in the semiconductor industry. Today, we are developing high-resolution quantum diamond microscopes for chip inspection and are working with industry and research partners to deploy this technology in semiconductor manufacturing. The first devices have already been delivered to customers worldwide, and the development of high-throughput inspection is in full swing.

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Why is the quality of the NV diamond film crucial for the performance of your quantum microscopes?

Bruckmaier — The NV centers in diamond are the actual quantum sensors. Their properties — such as coherence time, stability, and density — directly determine the system's sensitivity and spatial resolution. A high-quality NV diamond film ensures that magnetic fields, currents, or temperature differences can be measured with high precision. Defects or inhomogeneities in the diamond, on the other hand, would significantly degrade the signal-to-noise ratio and thus the measurement accuracy.

What advantage do your quantum sensors offer over conventional measurement techniques for chip manufacturers?

Bruckmaier — Quantum sensors based on diamond enable measurements with significantly higher sensitivity and spatial resolution than classical methods. For example, magnetic fields and current densities in chips can be visualized with sub-micrometer resolution while still achieving high penetration depth. In addition, these measurements can be performed at room temperature and over large areas, enabling fast, non-destructive failure analysis in complex semiconductor modules. Particularly for the next generation of AI chips, magnetic field imaging is the most promising tool for fault detection, which is why we are also working closely with well-known manufacturers in Taiwan, Korea, and the USA.

Which specific technological hurdles were you able to overcome through the collaboration with Fraunhofer IAF?

Bruckmaier — The collaboration with Fraunhofer IAF was particularly helpful for the development and optimization of the diamond-based quantum sensing. This includes the production and characterization of suitable diamond materials and the overgrowth of substrates with thin, nitrogen-doped films. There is a clear synergy here between QD and Fraunhofer IAF. We work closely with the group led by Dr. Peter Knittel, whom I have known since my PhD days. Our collaboration has existed for several years, primarily in a transactional form, and has intensified significantly in recent months through several joint projects.

Could you have brought the technology to market maturity this quickly without Fraunhofer's support?

Bruckmaier — Support from Fraunhofer Institutes was an important accelerator. Thanks to the existing infrastructure, materials expertise, and experience in industrializing quantum technologies, development cycles could be significantly shortened. Without this collaboration, we would have had to invest quite some time in building an alternative supply chain.

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Groundbreaking ceremony for the Engineering Center for Sustainability (IZN)

The groundbreaking ceremony on July 22, 2025 marked the start of construction for the Engineering Center for Sustainability.

Around 90 invited guests from politics, academia, and industry celebrated the groundbreaking ceremony for the Engineering Center for Sustainability (Ingenieurzentrum Nachhaltigkeit — IZN) on the Freiburg campus "Flugplatz". With this new building, the Fraunhofer-Gesellschaft is strengthening its close collaboration with the University of Freiburg, embedded in their joint Institute for Sustainable Systems Engineering (INATECH). Occupancy of the IZN is planned for 2028.

ERC Synergy Grant

The European Research Council (ERC) has awarded a prestigious Synergy Grant to the DISRUPT project, led by TU Delft, the Netherlands, in partnership with Fraunhofer IAF, Germany, and University College Dublin (UCD), Ireland. The groundbreaking project has secured nearly €10 million in funding to develop a fully digital RF power architecture that aims to cut the energy consumption of next-generation wireless networks by as much as 50 percent.

DISRUPT team: Prof. Anding Zhu (UCD), Prof. Rüdiger Quay (Director at Fraunhofer IAF and professor at the University of Freiburg), Prof. Leo de Vreede (TU Delft) and Prof. Bogdan Staszewski (UCD)

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Industry Innovation Days

To strengthen collaboration with industry, Fraunhofer IAF has launched a new strategic event format. In November 2025, the Industry Innovation Days took place for the first time. Over two days, Fraunhofer IAF welcomed numerous company representatives from start-ups, SMEs, and large corporations from across Europe to present the latest research results, showcase the roadmaps of the individual business units, and discuss potential avenues for cooperation.
The program offered exclusive insights into laboratories and technology areas, live demonstrations of various use cases, as well as an innovation fair featuring market-ready technologies. Due to the successful launch, this format will continue to be held on a biennial basis.

INDUSTRY INNOVATION DAYS

If you would like to participate in the 2027 Industry Innovation Days, please contact us by email:
event@iaf.fraunhofer.de.

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PCIM Best Paper Award

Dr. Michael Basler

Dr. Michael Basler has won the Best Paper Award at the PCIM Conference 2025 for his paper "Highly-Integrated 1200 V GaN-Based Monolithic Bidirectional Switch." In his paper, he presents a monolithic bidirectional switch with two integrated free-wheeling diodes and a blocking voltage of 1200 V. The development results are part of the GaN4EmoBiL project.

Two awards at IMS 2025

At the International Microwave Symposium (IMS 2025) in San Francisco, two researchers from Fraunhofer IAF were honored: Dr. Bersant Gashi received the IMS Early Career Paper Award for his paper entitled "300 GHz 8×1 Active Phased Array MMIC with On-Chip Power Amplifiers, Vector Modulators, and Antennas." Thomas Zieciak received the Advanced Practice Paper Competition Award for his paper titled "A D-Band Front-End T/R MMIC in a 70-nm GaN HEMT Technology."

Dr. Bersant Gashi and Thomas Zieciak

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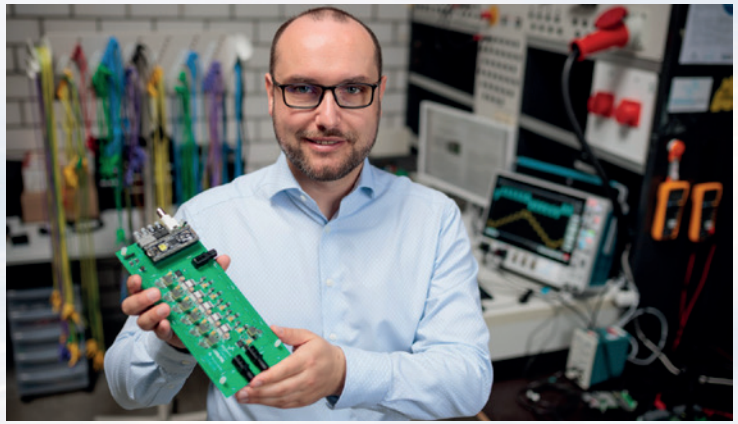
ERC Starting Grant



Dr. Stefan Mönch, ERC Starting Grant awardee

As a junior professor at the Institute of Electrical Energy Conversion at the University of Stuttgart, Dr. Stefan Mönch is continuing his pioneering research on electrical energy conversion, which he began at Fraunhofer IAF. For his project TolleConverter ("Towards lossless electrical energy conversion"), he was awarded one of the prestigious ERC Starting Grants, amounting to around 1.5 million euros, to advance his work on highly efficient and nearly lossless intelligent energy conversion.

Two prizes at EuMW 2025

Patrick Umbach received the EuMIC 2025 Young Engineer Prize at EuMW 2025.

Two researchers from Fraunhofer IAF have been awarded at the European Microwave Week (EuMW) in Utrecht. Patrick Umbach received the EuMIC 2025 Young Engineer Prize for his paper, entitled "Resistive D-Band Mixers with Monolithic Integrated Broadband IF Balun and LO Amplifier." Dr. Philipp Neininger was awarded the EuMC Best Poster Prize for his paper "An Integrated W-Band Dual-Polarization Receiver Front-End Featuring Ultra-Low Noise Figure."

Take a look at the photo gallery of our 2025 highlight events in the digital annual report:

s.fhg.de/iaf-jb26-53-en

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Institute Management and Division Directors

Dr. Patricie Merkert
Institute Management

Prof. Dr. Rüdiger Quay
Institute Management

Dr. Michael Stoebe
Business Units
(acting)

Dr. Jutta Kühn
Departments

Dr. Daniel Auer
Administration

Dr. Martin Walther
Research
Infrastructure

Business Units

Dr. Jens Flamm
High-Frequency Electronics

Dr. Philipp Neininger
Power Electronics

N. N.
Optoelectronics

Dr. Michael Stoebe
Quantum Components

Dr. Florentin Reiter
Quantum Systems

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Employees

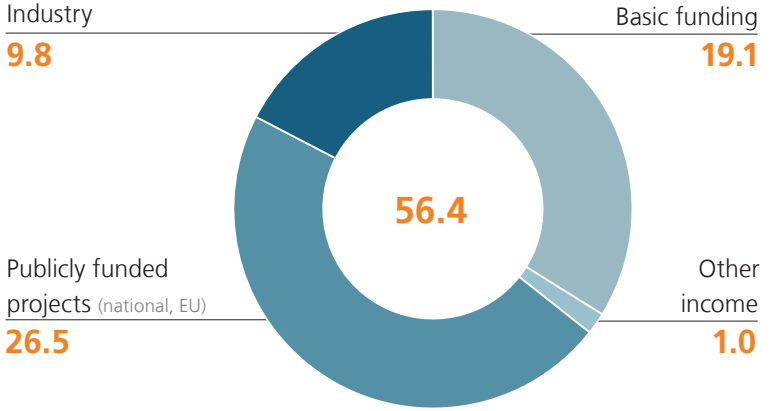
323

Of which

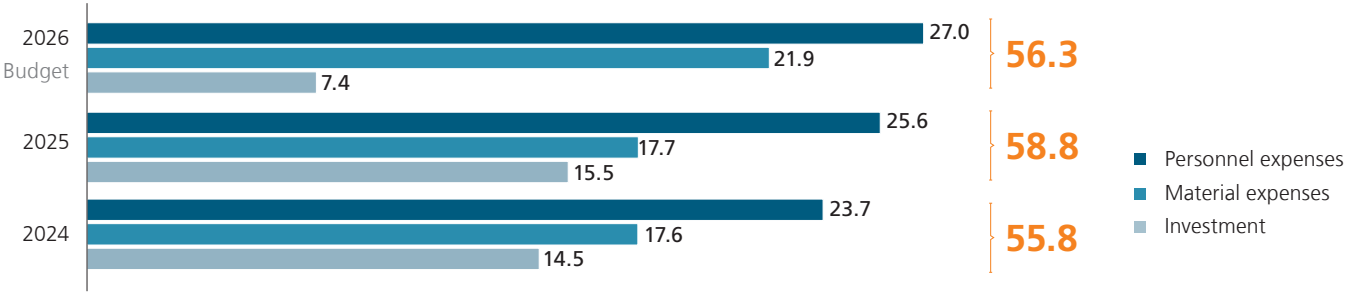
205 employees in research departments

108 female employees in total

Total budget 2025 (in million €)



Total budget outlay (in million €)



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Advisory Board

The Advisory Board, an expert committee with representatives from industry, research, and politics, supports the research activities of Fraunhofer IAF and advises the institute's management as well as the Executive Board of the Fraunhofer-Gesellschaft.

Prof. Dr. Jasmin Aghassi-Hagmann
Karlsruhe Institute of Technology (KIT), Karlsruhe

Dr. Klaus Beilenhoff
United Monolithic Semiconductors, Ulm

Dr. Dennis Cherka (Institute Liaison)
Fraunhofer-Gesellschaft, Munich

Prof. Dr. Oana Cojocaru-Mirédin
INATECH, University of Freiburg

Prof. Dr. Jérôme Faist
Eidgenössische Technische Hochschule Zürich (ETH), Switzerland

Mehran Ghahremanpour
Ministry of Economic Affairs, Labour and Tourism Baden-Württemberg

Dr. Gerd Hechtfischer
Rohde & Schwarz GmbH & Co. KG, Munich

Dr. Renata Jovanovic
Deloitte GmbH Wirtschaftsprüfungsgesellschaft

MinR Maik Kammermann
Federal Ministry of Defense, Bonn

Dr. Katrin Kobe
Bosch Quantum Sensing, Ludwigsburg

Dr. Johannes Koeth
nanoplus GmbH, Gerbrunn

Dr. Nicolai Künzner
Diehl Defence GmbH & Co. KG, Überlingen

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Ralf Lerner
X-FAB Silicon Foundries SE, Erfurt

Dr. Ulf Meiners (Chairman)
NICHIA Europe GmbH, Kronberg i. T.

Dr. Thomas Metzger
Qualcomm Germany RFFE GmbH, Munich

Dr. Heike Riel
IBM Research, Zurich, Switzerland

Dr. Thomas Roedle
Infineon Technologies AG, Regensburg

Dr. Dietmar Schill
Sony Europe B.V., Stuttgart

Dr. Gregory U'Ren
United Monolithic Semiconductors, Paris, France

Andreas Wälti
Evatec AG, Trübbach, Switzerland

Prof. Dr. Jörg Wrachtrup
3. Physikalisches Institut, University of Stuttgart

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Patents

Patent applications

M. Dall´Ara, W. Hahn
Method for controlling a quantum system using a control operator
10 2025 152 461.0, 12.12.2025, Germany

C. Giese
Method for Producing a Component
19/403 934, 30.11.2025, USA

C. Giese
Verfahren zur Herstellung eines Bauelementes
25 219 392.5, 28.11.2025, EU

M. Basler, S. Mönch
Verfahren und elektronische Schaltung zur Messung eines Gesamtstroms mehrerer Halbleiterbauelemente
10 2025 141 932.9, 14.10.2025, Germany

S. Leone
Schicht und Verfahren zu ihrer Herstellung
10 2025 132 956.7, 10.08.2025, Germany

P. Schätzle, P. Knittel, N. Lang
Verfahren zur Abscheidung von Diamant
10 2025 127 020.1, 10.07.2025, Germany

L. Lindner, F.P. Schall, J. Jeske, Y. Rottstaedt
Magnetometer und Verfahren zur Erfassung eines zeitlich variablen Magnetfeldes
10 2025 126 504.6, 07.07.2025, Germany

V. Lebedev, J. Weippert
Halbleiterbauelement und Verfahren zu seiner Herstellung
10 2025 121 315.1, 01.06.2025, Germany

M. Krebsbach, T. Wellens, A. Abedi, H.-H. Kowalski
Datenkodierung zur Verwendung für ein trainierendes maschinelles Lernmodell und zur Erzeugung synthetischer Daten
10 2025 121 128.0, 28.05.2025, Germany

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M. Basler
Halbleiterbauelement mit integrierter galvanischer Isolation und Verfahren zur Herstellung dieses Halbleiterbauelements
10 2025 110 895.1, 20.03.2025, Germany

Q. Yang, T. Passow, H. Wenzel, J.-P. Koester, T. Tenzler
Elektrisch gepumpte Photonenpaarquelle mit vertikaler Lichtkopplung
10 2025 109 998.7, 14.03.2025, Germany

L. Lindner, Y. Rottstaedt, J. Jeske, F.P. Schall
Magnetometer und Verfahren zur Erfassung eines Magnetfeldes
10 2025 109 708.9, 13.03.2025, Germany

J. Engels, J. Kustermann
Verfahren zur heteroepitaktischen Abscheidung von Diamant und damit hergestellter Wafer
10 2025 106 576.4, 20.02.2025, Germany

Patents granted

S. Leone, C. Manz, H. Menner, J. Wiegert, J. Ligl
Method and Apparatus for manufacturing a Semiconductor layer and substrate provided therewith
12 394 621, 19.08.2025, Germany

S. Leone, C. Manz, H. Menner, J. Wiegert, J. Ligl
Verfahren und Vorrichtung zur Herstellung einer Schicht, damit versehenes Substrat und dessen Verwendung
10 2019 212 821 B4, 12.06.2025, Germany

S. Kaspar, M. Rattunde, T. Töpper, H. Wagner
Optisch gepumpter Halbleiter-Scheibenlaser
10 2014 205 022 B4, 16.01.2025, Germany

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Doctoral theses

Konstantin Kuliabin
Investigation of Scalability Challenges in Advanced RF Circuits and Systems, University of Freiburg

Niklas Mathes
Widefield NV-Center Quantum Sensing for Non-Destructive Materials Testing, University of Freiburg

Philip Schätzle
Stickstoffdotierte Diamant-Dünnschichten für das Quantencomputing, University of Freiburg

Matthias Sinnwell
On the Vertical Fin Field-Effect Transistor in Gallium Nitride: Experimental Realization and Evaluation of the Frequency Capability for High-Power, High-Frequency Applications, University of Freiburg

Moïse Safari Mugisho
Highly Efficient Digital Amplifier Architecture Based on GaN Technology, University of Freiburg

Video series: “My Dissertation in 90 Seconds” with Moïse Safari Mugisho

youtu.be/KsVlkEQgxA0

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Master's theses

Ravi Teja Aditya
Title not disclosed due to a confidentiality agreement, University of Freiburg

Alen Sebastian
Investigation of the Enhancement/Depletion-Mode mHEMT Logic, University of Freiburg*

Leon Büttner
Development and Characterization of a Diamond Quantum Chip, University of Freiburg

Anton A. Cholakov
Active Cold-Load Gate Terminations in a 220 GHz Distributed Amplifier for Baseband Noise Figure Reduction in 35-nm InGaAs-mHEMT Technology, Eindhoven University of Technology

Andreas Ehrat
Investigation and optimization of ultra-wideband bias tees up to 110 GHz, University of Freiburg

Jonas Hasenkrug
Title not disclosed due to a confidentiality agreement, University of Freiburg

Pit Hüne
Quantum Control Pulse Translation and Simulation for Computing with Nitrogen-Vacancy Centers in Diamond, Hochschule Hannover

Karthik Jayadevan
Classical v/s Quantum Optimization: Comparison of Runtime Scaling, University of Freiburg

Nikhil Kabbur
Development of an Embedded System for Inline Elemental Detection in Laser Micromachining, University of Freiburg*

Sahil Sarbadhikary
Impact of the structure of the wave-function ansatz on accuracy and performance of quantum-chemistry calculations on Quantum Computers, RWTH Aachen

Priyansh Shankhdhar
Investigation of millimeter-wave Frequency Doublers in GaN HEMT MMIC Technology, University of Freiburg*

Pedro Weiler-Perez
Title not disclosed due to a confidentiality agreement, University of Freiburg

*Thesis written at the University of Freiburg, supervisor at Fraunhofer IAF

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universität freiburg

Dr. Patricie Merkert
"Grundlagen und mechanische Eigenschaften technischer Keramik" *Lecture and tutorial*
"Grundlagen des Innovationsmanagements für nachhaltige technische Systeme" *Lecture and tutorial*

Prof. Dr. Rüdiger Quay
"RF and Microwave Circuits and Systems" *Lecture*
"RF and Microwave System Design Course" *Lab course*
"Sustainable Systems Engineering" *Study seminar*
"Energy Efficient Power Electronics" (with O. Ambacher) *Lecture and tutorial*
"Schaltungstechnik/Circuit Technology" *Lecture*

Dr. Bersant Gashi
"RF and Microwave Devices and Circuits" *Lecture*

Dr. Florentin Reiter
"Semiconductor and Quantum Devices" *Lecture and tutorial*

Dr. Thomas Wellens
"Quantencomputer/Quantum Computing" *Lecture and tutorial*

Dr. Martin Walther
"Optoelektronische Quantenbauelemente" *Lecture*

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Universität Stuttgart

Jun.-Prof. Dr.-Ing. Stefan Mönch
"Elektromechanische Grundlagen der Medizintechnik — Elektrotechnik" *Lecture*
"Einführung in die Elektrotechnik" *Lecture*

Dr. Sébastien Chartier
"SiGe BiCMOS Monolithic Microwave Integrated Circuit Design" *Lecture*

Dr. Daniel Auer
"Personalmanagement & Leadership" *Seminar*

Technische Universität München

Dr. Peter Knittel
"Farbzentren in Festkörpern" *Lecture and tutorial*

ETH zürich

Dr. Florentin Reiter
"Quantum Information Processing I: Concepts" *Lecture and tutorial*

DHBW Duale Hochschule Baden-Württemberg

Dr. Michael Basler
"Leistungselektronik" *Lecture*

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Newsletter and Digital Annual Report

Newsletter

Our newsletter provides information on exciting research findings, new project initiatives, upcoming events, and latest job vacancies.

s.fhg.de/iaf-nl-en

Digital annual report

The Annual Report 2025/26 is also available as an e-paper with additional digital content.

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70 Years
Fraunhofer IAF

In 2027, we mark our 70th anniversary!
The celebration will take place on June 29, 2027, in Freiburg. You can find more information about our anniversary year on our website. We look forward to celebrating this special year with you!