Fraunhofer
IMS

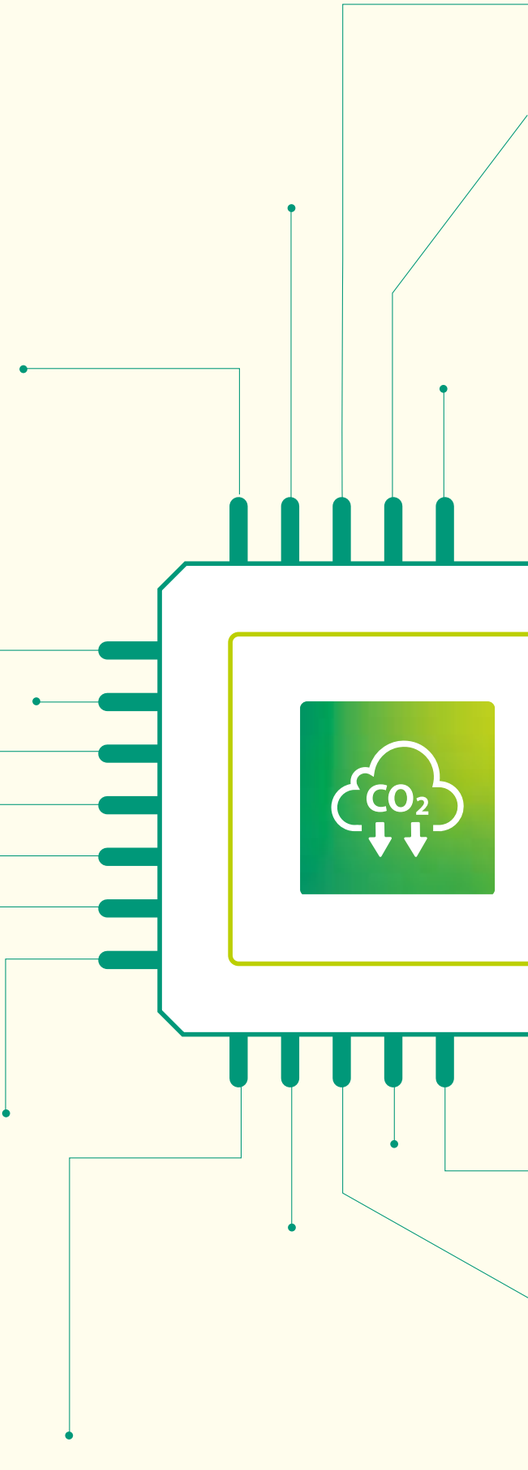
Fraunhofer Institute for Microelectronic Circuits and Systems IMS

Sustainable smart sensor solutions

Annual Report 2021 | 2022

Fraunhofer IMS annual report 2021 | 2022

Smart Sensor Systems for a safe, secure and sustainable future



Sustainability in focus

The world is constantly changing, today more and faster than ever. Even though no one can predict exactly what kind of world we will live in tomorrow, we are clearly aware of how the rapid development of our society is damaging our living space. However, we know in which direction we want to define our future collectively. This includes a society of wealth, freedom, safety, and security, combined with a completed energy transition and sustainable resource use.

At Fraunhofer IMS, we are convinced that our research team shares responsibility for what happens next in the ecosystem, whether in in vehicles, medical devices, robots, or in space.

Since microelectronics accompany us almost everywhere, the potential to contribute to energy- and resource-efficient processes is enourmous.

In 2021/22, we made greater use of our microelectronics know-how in various projects to develop sustainable solutions and thus contribute to a respectful approach to our world.

Fraunhofer IMS annual report 2021 | 2022

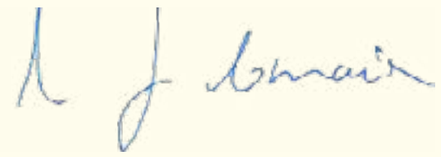
Preliminary words

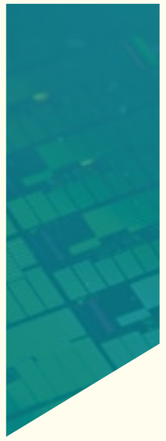
Our institute has undergone extensive changes over the past two years. We welcomed Prof. Dr. Axel Müller-Groeling to our institute's management and also bid him farewell due to his appointment to the Fraunhofer Executive Board. Through his support and that of all colleagues at Fraunhofer IMS, we have repositioned ourselves sustainably for the future.

We have placed even greater emphasis on sustainable application-oriented research and development in our four business areas. The realignment of our clean room capacities goes hand in hand with the goal of focusing on new, forward-looking technologies. Our reorganization enables us to concentrate more effectively on developing innovative pilot series that are as climate-friendly as possible. Every day, we face new challenges in our society that drive us to contribute even more to sustainability. In this annual report, we provide insights into the projects we dedicated ourselves to in 2020 and 2021 on the topic of sustainable microelectronics. We want to showcase how integrated circuits can be operated more energy-efficiently. Moreover, we aim to utilize AI-based monitoring to prevent disasters in our wastewater systems and demonstrate how mobile robots can support the industry in a more autonomous, safer, and energy-saving manner, enabling more effective collaboration with humans. These topics, along with our work on resource-efficient information and communications technology, can be explored in this year's annual report.«

Prof. Dr. Anton Grabmaier
Institute Director, Fraunhofer IMS

We look forward to the future with more exciting collaborations on smart and sustainable sensor solutions and beyond.





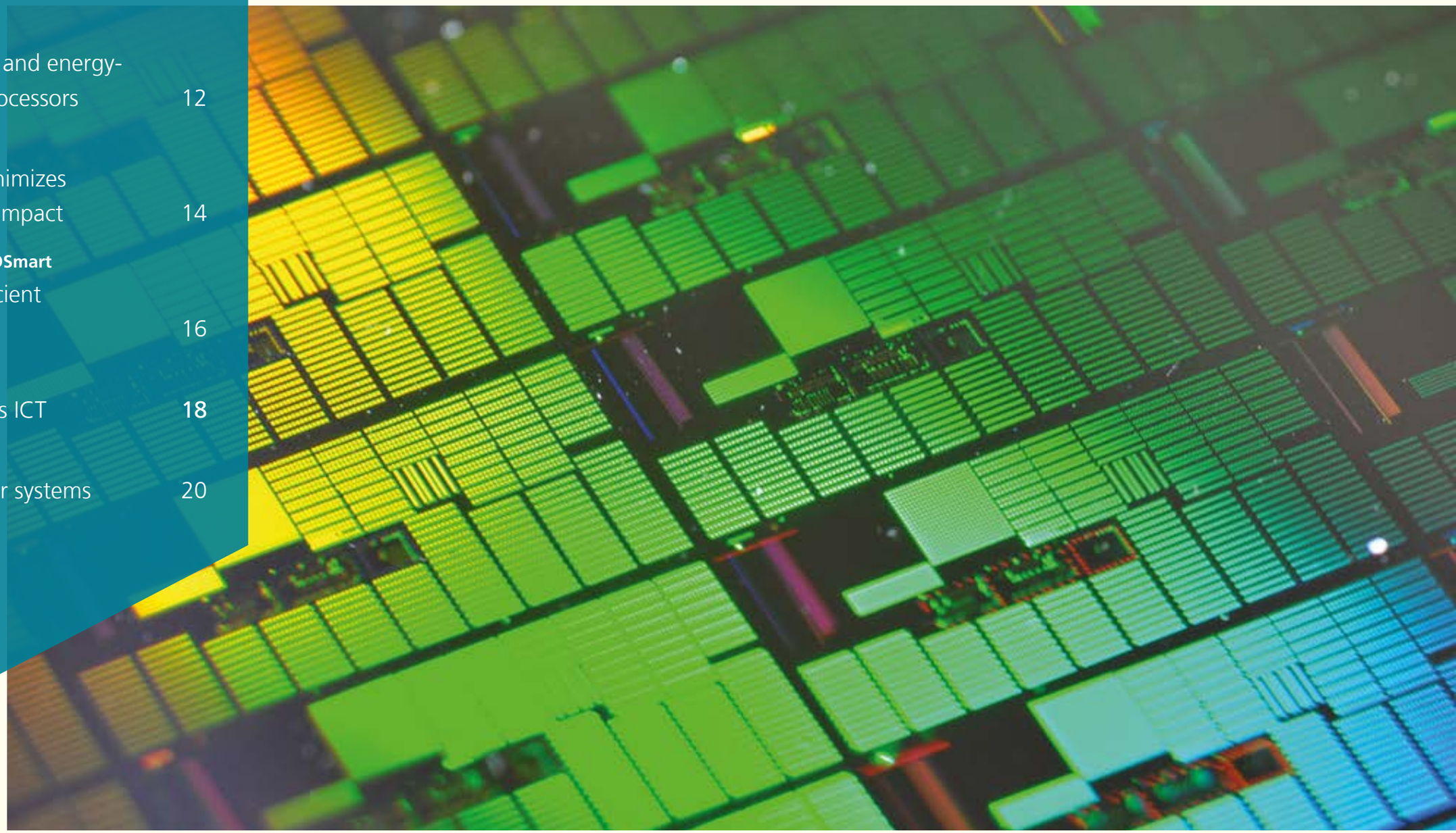
Sustainable smart sensor solutions

Facts and figures

Organization

Publications

Sustainable smart sensor solutions



RISC-V processor AIRISC: Proven high performance and energy efficiency

RISC-V instruction set architecture enables the production of high-performance and low-power processors

With the introduction of RISC-V, a trend with new possibilities in processor manufacturing has been set that has dominated the market so far. First, RISC-V is an instruction set architecture that is fully open-source. Secondly, it contains a simple base instruction set that is modular and extendable. Because of these properties, special processors with various features can be developed at low costs and with greater flexibility. Due to their exact adaptation to the required application, they convince with the following properties:

- High energy-efficiency
- High performance at the same time
- Improved security against cyberattacks

First tests on the RISC-V processor AIRISC for mobile embedded applications have shown significant energy savings

Fraunhofer IMS wants to use the full potential of RISC-V and has therefore developed the AIRISC implementation that is tailored for small, low-power AI applications. The strong performance and energy efficiency of AIRISC has already been demonstrated in several use cases. We were particularly successful in a medical application for detecting atrial fibrillation in ECG data, where we achieved a processing speed advantage of over 80% with only a 10% increase in area and energy requirements. This significant reduction in energy requirements, right from the start of testing, shows the great potential of domain-specific processors in terms of resource-saving microelectronics.

Customized AIRISC processors and AI for energy autonomous mobile applications

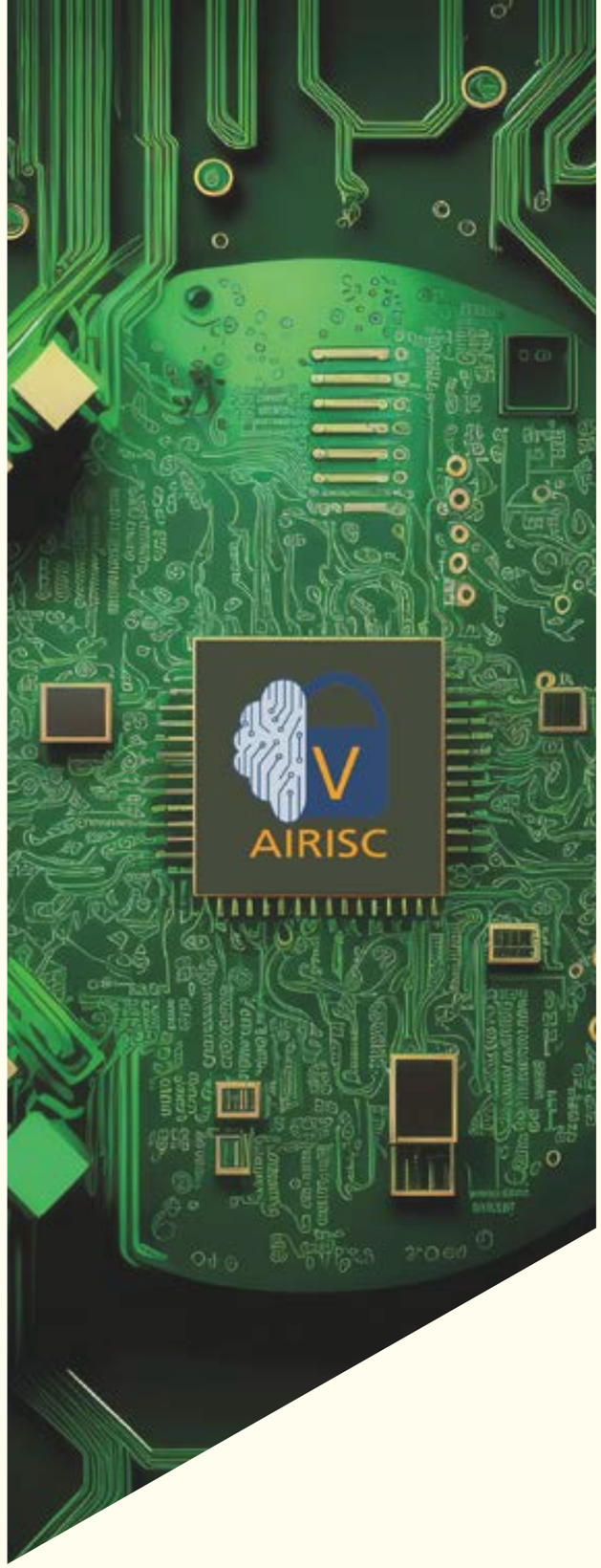
The measurement of ECG data is just one of many applications for which AIRISC processors are suited in data processing. We have generally focused on four different use cases. For each case, we offer specialized AIRISC processors. These use cases are:

- Signal analysis in medical wearables
- Mobile control systems (e.g., flight controllers for drones)
- LiDAR signal processing in 3D cameras
- Safety-critical applications

AIRISC plus AIfES®: Tiny embedded systems combined with AI

AIRISC supports cost- and energy-efficient extensions for customer applications. While maintaining an optimum chip area or FPGA footprint, this enables signal processing that would otherwise not be feasible in a tiny and low-cost device. A popular use case is running AI models on tiny devices, like sensor frontends and medical wearables. For these embedded AI applications, AIRISC can be combined with the AIfES software stack to further simplify development and integration. AIfES® (AI for Embedded Systems) can be used to run and even train artificial neural networks in microcontrollers and embedded systems. Leveraging efficient algorithms and energy-saving AIRISC hardware, this can contribute to a significant reduction in CO2 emissions, cost, and latency compared to deep learning and inference using high-performance computers and fast data links. These AI capabilities expand the range of potential applications for smart wearable sensor systems. For example, in the field of sustainable production, we utilize AIRISC and AIfES® in the context of:

- Optimization of raw material and energy use in production facilities
- Use of alternative energy sources and energy-autonomous sensors
- Product carbon foot printing of ICT components, as in the research project Green ICT



Sustainable smart sensor solutions

The license-free RISC-V instruction architecture makes it possible to develop special processors individually adapted for the respective applications. With our own RISC-V implementation AIRISC, we have succeeded in producing specific processors that are particularly suitable for small, low - power embedded applications. Here, we are particularly pleased about being able to show a significantly higher performance speed while simultaneously reducing the energy requirements.«

Alexander Stanitzki, Head of Industry

Further information

Find more information on licensing, our RISC-V ambassadorship and try it for free on GitHub.

Project page

GitHub

PENTA project GaNext: semiconductors made of gallium nitride instead of silicon can minimize environmental impact of power electronics

Smaller, faster and more energy-efficient through performance and sustainability leaps in microchips with gallium nitride (GaN)

GaN has garnered increased attention in the field of electrical engineering. It is a material with the potential to replace silicon semiconductors in power electronics applications.

GaN has numerous superior properties compared to silicon. Semiconductors made of this material are:

- Lighter
- More compact
- Significantly more energy-efficient

PENTA project GaNext (next-generation GaN power modules): Solutions for the simplified use of Gallium Nitride in microelectronics

Together with five other consortium partners, Fraunhofer IMS conducted research on lowering the entry barriers to GaN semiconductor applications in order to increase the switching speed of GaN power electronics modules. This was done in the following steps:

1. A so-called »intelligent power module« (IPM) was developed on the basis of GaN components. The GaN devices were combined with gate drivers and a programmable, fail-safe control unit with integrated protection circuits. For this, the RISC-V-based processor **AIRISC**, an implementation developed by Fraunhofer IMS, was utilized.
2. In a second step, the research group used various applications to demonstrate the extent to which microelectronics based on GaN semiconductors function in a significantly more energy-efficient and powerful manner than semiconductors made of silicon.

Novel and CO_2-saving microelectronics made of gallium nitride promise far-reaching perspectives for numerous industries

The GaNext project has taken another step towards sustainable microelectronics. By increasing the switching speed of GaN power modules, numerous applications could be equipped with microchips based on GaN semiconductors. The expanded range of applications for GaN modules could lead to enormous energy and CO_2 savings in the future, especially in the transportation and industrial sectors.

GaNext

»Gallium nitride has the potential to transform the microchip industry fundamentally, as it can be used to create more compact, powerful, and efficient microchips. Until now, it has not been easy to process the sensitive material in microchips. Therefore, solutions must be developed to facilitate the processing of gallium nitride in microchip fabrication. We have addressed exactly this problem with GaNext. By providing a full-featured and safety-conscious RISC-V power controller for GaN-based converters, Fraunhofer IMS has succeeded in simplifying the development of these converters.«

Alexander Stanitzki, Head of Industry

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Federal Ministry of Education and Research

Sponsored by:
Penta

Projekt partners:

United Kingdom: Cambridge GaN Devices, CSA Catapult, Lyra Electronics Ltd. | Netherlands: Besi Netherlands BV, Eindhoven University of Technology, Neways Technologies BV, Signify | Germany: advICo microelectronics GmbH, Maccon Elektroniksysteme GmbH, Infineon Technologies AG, Sumida GmbH, Technische Universität Dortmund, Fraunhofer IMS

Further information

Duration: 05/2022 - 04/2023

Official website

Our project page

Penta project page

Flagship project NeurOSmart[1]: smart, energy-efficient robot sensors for more autonomy and safety in cobots and vehicles

Future robots need to »think« more complex and energy-efficient

In the future, robotic systems will be able to perform increasingly autonomous tasks without putting humans at risk. However, as tasks complexity grows, so does the demand for computing power. Therefore, intelligent systems that meet future performance and safety standards while operating in an energy-efficient manner must be created.

The NeurOSmart flagship project: Creating intelligent hybrid computing architectures in autonomous machines and transportation systems

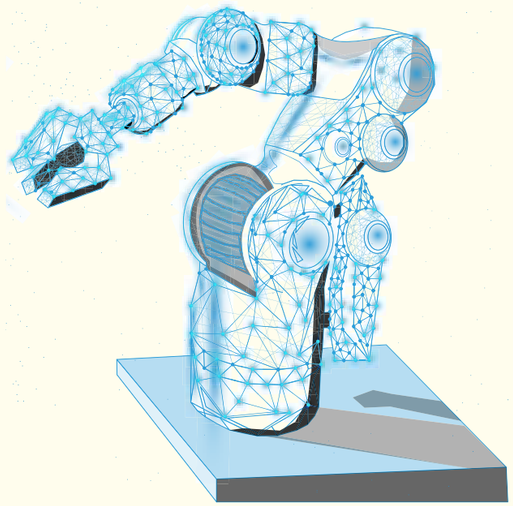
In the flagship project NeurOSmart, five Fraunhofer institutes are researching how robot systems can attain higher autonomy while also enhancing energy efficiency. They aim to achieve this through the utilization of decentralized and neuromorphic artificial intelligence. On this basis, the machines should be able to process the gathered environmental data in three steps while gradually filtering it:

1. A LiDAR camera captures the environment in 3D and processes the data directly on site.
2. Using RISC-V processors based on the Fraunhofer IMS' own implementation, the **AIRISC**, the raw data will be pre-filtered to differentiate irrelevant information, such as pixel numbers, from the truly essential data, including potentially hazardous objects and, above all, people. Thus, irrelevant images can be sorted out at an early stage.
3. With the help of a neuromorphic chip, the sensor records the exact position and movement of the object or person in the final step. Based on this processed information, the robot is able to exert appropriate reactions.

The approach of decentralized data processing and early, gradual reduction of data volumes allows the robot to operate with low latency while saving energy.

Application scenarios for intelligent and energy-efficient robot systems

The industry, in particular, would gain substantial benefits from the continued advancement of smart sensors. With increasingly intelligent robotic systems and a higher safety level, robots would be better equipped to identify hazardous situations and undertake more complex tasks. As a result, human-robot collaboration in an open environment can be significantly expanded. The reduction of the restricted area for humans needed around industrial robots would lead to a more efficient floor layout in production sites. Especially, lifting heavy loads could provide enormous support to workers in this way without exposing them to a hazardous situation. In addition to safer human-robot collaborations, the machines would be capable of more complex autonomous tasks. Examples are autonomous transportation in warehouses, manufacturing and driving, or the usage of flying drones.



More complex acting robot systems that still process less data – what may seem contradictory at first glance is the key to energy-efficient, autonomous machines for us in the NeurOSmart flagship project. Like in an intelligent funnel, image data is reduced more and more directly on the device. In the end remains the only relevant information about people or objects, positions and potentially dangerous situations. In this way, we can build a significantly lower-power system that is also safer and more efficient.«

Alexander Stanitzki, Head of Industry

Projekt partners:

Fraunhofer ISIT, Fraunhofer IPMS, Fraunhofer IMS, Fraunhofer IWU, Fraunhofer IAIS

Further information

Duration: 01/2022 - 12/2025

Official website

Project site

[1]NeurOSmart: Analog neuromorphic accelerators that enable efficient and smart sensors.

Green ICT: a paradigm shift towards resource-conscious ICT through sustainable microelectronics

Environmentally friendly information and communications technology (ICT) starts with microelectronics

Digitization is rapidly permeating everyday and work life. It is a trend that will not abate any time soon. In the future, we will face growing energy and resource consumption due to the proliferation of sensors, electronics, and AI. Not only the technologies need to be power-efficient, but the microchips themselves also necessitate energy-efficient and resource-saving manufacturing. Therefore, significant advances in micro- and power electronics, including their manufacturing processes, are needed.

Fraunhofer IMS as a partner in the Green ICT project: Cross-technological overall solutions will be researched and bundled in one competence center

Fraunhofer and Leibniz institutes cooperating in the Research Fab Microelectronics Germany (FMD) are already thinking ahead in the Green ICT project. Here, the members form a central competence center for companies, in which they use their know-how to create a comprehensive environmental assessment for productions. In this context, the team wants to develop innovative processes that build on each other to improve sustainability in the ICT sector. The Fraunhofer IMS contributes to the following topics:

- Evaluation of the resource efficiency of embedded AI hardware to determine the most sustainable hardware for AI applications
- Optimization of energy consumption in clean rooms for electronics production, so that chips can be produced with less resource input and less power consumption
- Evaluating the resource efficiency of devices that convert electrical energy (e.g., in solar panels, e-mobiles, or cell phone chargers)

Through three interconnected core projects (hubs), FMD aims to develop sustainable solutions for ICT

The hubs are intended to map comprehensive, sustainable ICT and are divided into the following topics:

- Optimized sensor edge cloud systems, including the **NeurOSmart** project
- Energy-saving communication infrastructures
- Resource-optimized electronics production

Sustainable ICT with commitment beyond research: securing skilled workers, attracting young talents and supporting start-ups

Sustainable ICT is not only to be addressed in the research project itself. Rather, the competence center wants to initiate a comprehensive paradigm shift. Therefore, it also wants to make a trend-setting contribution with the following offer:

- The Green ICT Camp for young students, where awareness, enthusiasm, and networking within the realm of sustainable microelectronics from an early stage shall be risen
- Providing additional training opportunities for specialists, where much-needed experts in science and industry can be promoted
- Giving support for small and medium-sized enterprises as well as start-ups in resource-conserving product development, including the formulation of suitable development paths

greenict
Forschungsfabrik Mikroelektronik Deutschland

Sustainable smart sensor solutions

As far as environmental protection is concerned, ICT shows countless potentials. Intelligent energy management systems in buildings to reduce CO2 emissions are just one of many examples. However, this is of little use if ICT itself is not green, due to high energy and resource consumption in the manufacturing process. This is precisely where we come in with our Green ICT concept center. By taking a holistic view right from the root, we want to ensure that ICT is comprehensively designed to be sustainable.«

Alexander Stanitzki, Head of Industry

SPONSORED BY THE
Federal Ministry of Education and Research

Forschungsfabrik Mikroelektronik Deutschland

Projekt partners:

Fraunhofer EMFT, Fraunhofer ENAS, Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik (FBH), Fraunhofer FHR, Fraunhofer HHI, Fraunhofer IAF, IHP: Leibniz Institute for High Performance Microelectronics, Fraunhofer IIS, Fraunhofer IISB, Fraunhofer IMS, Fraunhofer IPMS, Fraunhofer ISI, Fraunhofer ISIT und Fraunhofer IZM

Further information

Project duration: 08/2022 - 07/2025

Official website

RIWWER[1]: Flood and environmental protection with digitized and AI-supported wastewater systems in Duisburg

We want to create orientation in highly complex underground worlds

A sewage system is similar to the German highway network: it is crisscrossed by many turns, branches, and intersections on the waterways. When overloaded, congestion can occur in some parts of the pipes, even though other parts of our sewer network still have spare capacity. Such overloading occurs especially when heavy rainfall events or floods, for example, due to intense snowmelt in winter, put a strain on our rivers. The resulting water backups in the system cause stormwater retention basins or streets to flood elsewhere. Ultimately, untreated wastewater ends up in our rivers.

The leakage of untreated wastewater has serious consequences for the economy, ecology, and residents

Pollutants from wastewater affect the habitat of our flora and fauna with profound long-term consequences. A current example is the fish kill that recently occurred on the Oder River in Poland and Brandenburg. But the negative consequences for people are also immense. Cellars fill up with water and cause damage that threatens people's livelihoods. In addition, the costs for the municipal water supply rise temporarily. Flooding also poses a threat to industry. Logistics chains are impaired, and production losses are recorded. In addition, companies face high penalties if their untreated wastewater enters our rivers and canals.

The project partners want to develop a digitized wastewater system in which high volumes of water are optimally distributed with the help of AI

Fraunhofer IMS is part of a strong, interdisciplinary team of experts from research, applied sciences, local and global companies, as well as other public partners. In order to be able to prevent water damage and environmental pollution in our rivers, such as the Rhine or the Ruhr, the project partners want to gain a better understanding of the sewer system. Their common goal is to develop an intelligent wastewater system with the help of a digitized network and AI-supported monitoring. At the right moment, water gates should open and close underground or pump water from the system into rainwater retention basins at other points. To make this possible, the RIWWER project is digitizing key points in the municipal wastewater system as a first step. Analog measurement and control points will be transferred to automated operations monitored in real time. Water volumes can thus be efficiently distributed in the sewer system and stormwater basins during rainfall and heavy rains with the help of decentralized and AI-driven decision support. This minimizes the discharge of pollutants into the environment and counteracts disasters as a result of extreme situations. For the implementation of the projects, the Wirtschaftsbetriebe Duisburg provided their sewers and the wastewater treatment plant in Duisburg-Vierlinden.

RIWWER

[1]**R**eduction of the **I**mpact of untreated **W**aste **W**ater on the **E**nvironment in case of torrential **R**ain

With RIWWER, we aim to take a pioneering step in combating the leakage of harmful, untreated waste water into our environment. We want to find out how we can make smart use of the capacities of our complex wastewater system to distribute water volumes evenly into the stormwater basins from the outset and thus avoid overflows. Through our research at the Duisburg wastewater treatment plant, we want to show how AI-supported monitoring and situational decision-making support smart water distribution.«

Gerd vom Bögel, Project Manager RIWWER

Supported by:

Federal Ministry for Economic Affairs and Climate Action

on the basis of a decision by the German Bundestag

Projekt partners:

Stadt Duisburg, Wirtschaftsbetriebe Duisburg, Universität Duisburg - Essen, RWTH Aachen, Berliner Hochschule für Technik, KROHNE Messtechnik GmbH, HST Systemstechnik GmbH & Co. KG, Okeanos Smart Data Solutions GmbH, Fraunhofer IMS

Further information

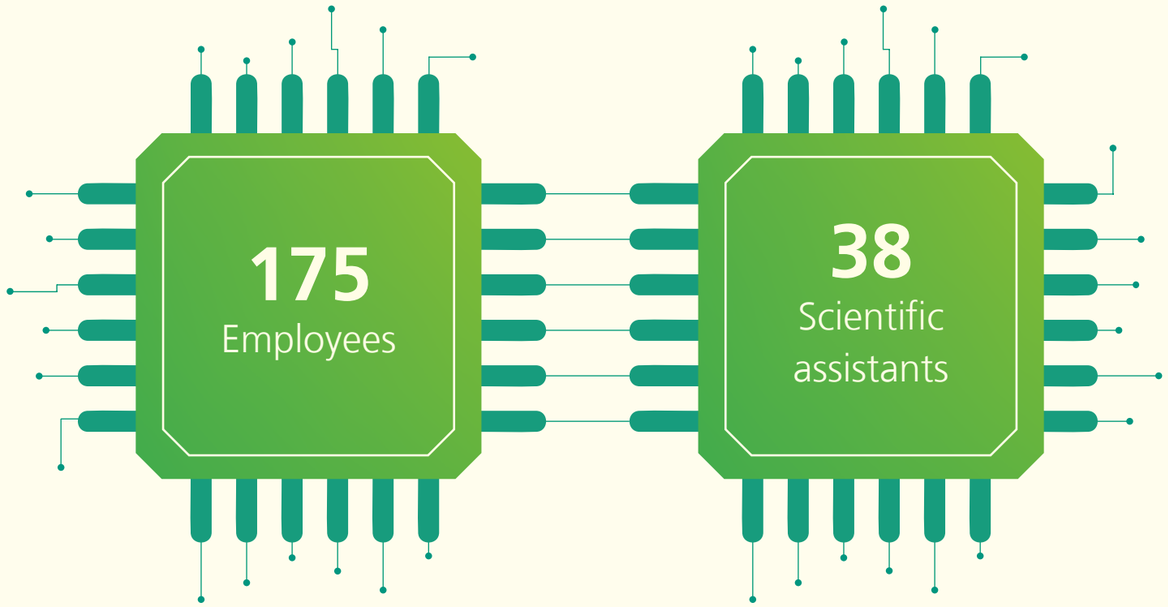
Project duration: 08/2022 - 07/2025

Official website

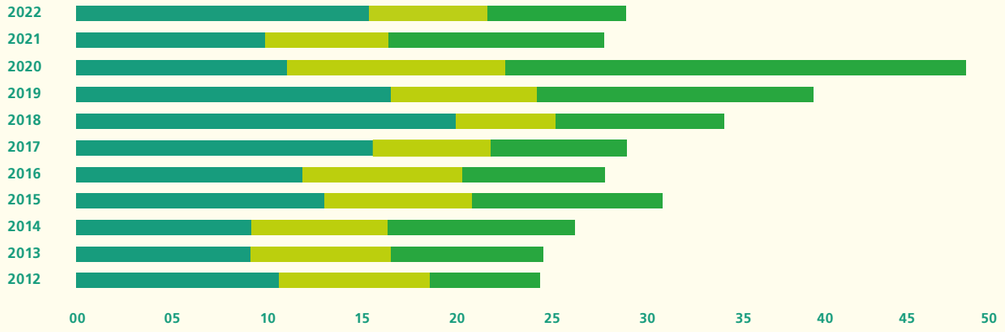
Facts and figures

Staff

We build a strong team of

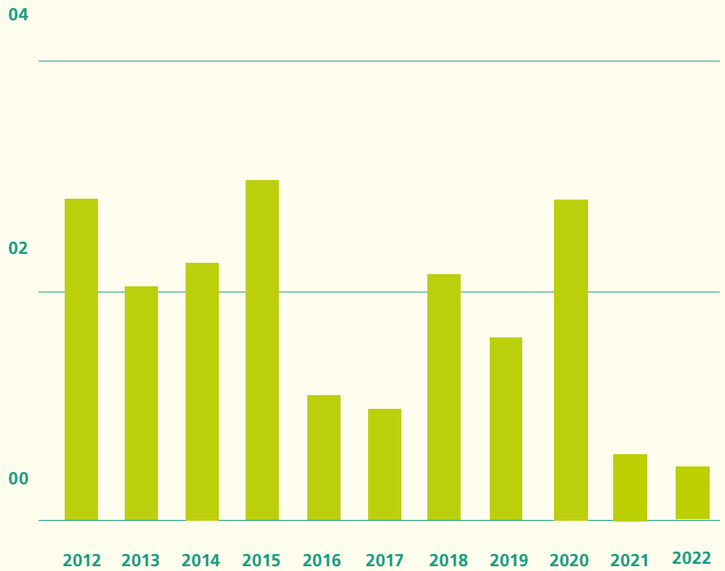


Budget **(in million euros)**



Industrial projects
Public projects
Fraunhofer based funding

Capital investements **(in million euros)**



Measurement laboratories

During development, numerous investigations are required to characterize sensors, circuits and systems. Fraunhofer IMS therefore has a number of specialized laboratories available:

- Test lab for Application Specific Circuits (ASICs)
- Pressure Sensor Lab
- High Frequency Lab
- Biosensor Lab
- CMOS Imager Lab

Organization

The Fraunhofer IMS offer: from the first idea to the final product

Find a competent research partner for the development and pilot production of innovative microelectronic systems at Fraunhofer IMS

The scientists of Fraunhofer IMS focus in four **Business Units** and four **Core Competences** on offering solutions and developing marketable technologies and processes in the field of microelectronic circuits and systems that can be used in virtually all industries. Fraunhofer IMS accompanies your development from the very start until successful finalization, adding unique selling points and competitive advantages to the product along the way. All from one source, the institute provides concept and feasibility studies, comprehensive development, prototyping, product qualification, and pilot fabrication. Fraunhofer IMS is a globally recognized research and development partner because of its extensive know-how, access to technology and outstanding technical infrastructure. As an independent institute, Fraunhofer IMS has been working together with private and public partners to provide a direct benefit to the economy and society for more than 35 years.

Cooperations and partnerships

Microelectronics is the decisive key factor that makes innovative technologies possible in the first place

Future topics such as renewable energies, automated environmental monitoring, artificial intelligence, machine learning, robotics, or even autonomous driving are essential reference points for the research at Fraunhofer IMS. Promoting these technologies with a team of smart and motivated individuals is how the institute wants to protect and strengthen the ecosystem as well as life quality.

Cooperation in publicly funded projects creates opportunities to develop new products and solutions by combining knowledge, resources, and technologies from various partners of excellence. Fraunhofer IMS has been cooperating in publicly funded projects since the institute's funding in 1984/1985 and has since then developed a well-established network of partners from industry and research. As part of the **Research Fab Microelectronics Germany (FMD)**, a global innovation driver, Fraunhofer IMS profits from the knowledge of eleven Fraunhofer and two Leibniz institutes.

Another great example of cooperation is the Fraunhofer-inHaus-Center. Within the ecosystem, we pool the potential of Fraunhofer IMS and many hundreds of business partners to exchange ideas, develop products and test them for real-life usability.

Further information

Find new application fields and innovative technologies:

Take a look at the current national and international cooperations and associations.

Organization structure

Director Prof. Dr. rer. nat. Grabmaier

BUSINESS UNITS

- **Health** – Prof. Dr. Seidl
- **Industry** – Stanitzki
- **Mobility** – Dr. Ruskowski/ Dr. Knieling
- **Space and Security** – Dr. Weiler

CORE COMPETENCES

- **Embedded Software and AI** – Heidemann
- **Smart Sensor Systems** – Kappert
- **Technology** – Dr. Weyers
- **Center for Sensor Technology** – Dr. Kolnsberg

Administration – Benninghoff

Innovation Center and Sales – Gröting

Quality Management – Kelter

Our organization

The bridge between customer and product: Fraunhofer IMS Business Units

In the four Business Units Health, Industry, Mobility, and Space and Security Fraunhofer IMS channels and transports the results and findings from our research directly to the customer.

Each Business Unit is thematically focused and pursues a holistic, systemic approach. The bundled know-how in a targeted manner enables Fraunhofer IMS to offer tailored and future-relevant solutions for application fields in specific markets and industries.

Further information

Business Units website

Health

Affordable health through intelligent medicine

Personalized medical solutions to improve prevention, diagnostics and therapy in care, hospitals and at home through an enormous reduction of complexity and costs.

Industry

Production without downtime, emissions and cyber incidents

Smart industrial applications for industry control systems and monitoring in tough work environments to predict further work steps and make intelligent decisions.

Mobility

Sustainable and safe transportation for all users

Future mobility is autonomous, smart, sustainable, and safe through smart environmental detection for traffic safety and environmental detection.

Space and Security

Protection from natural and human-made threats on our earth and in space

Imaging sensors for satellites and space robotics, as well as for space debris removal, to secure homes and public spaces.

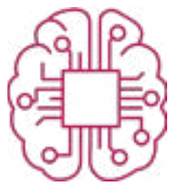
Our organization

Innovative technologies for powerful products: Fraunhofer IMS Core Competences

In the four Core Competences Embedded Software and AI, Smart Sensor Systems, Technology, and Center for Sensor Technology, Fraunhofer IMS researches and develops new technologies to provide the four Business Units with innovative and smart technologies for their application fields.

Further information

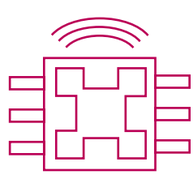
Core Competences website



Embedded Software and AI

Creating high performance AI software solutions for the next generation of smart systems

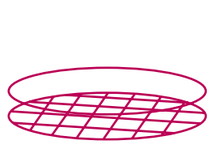
Providing easy to use and resource saving AI algorithms for small, energy efficient platforms with maximum data security.



Smart Sensor Systems

Creating the most innovative sensors for tomorrow's cutting-edge systems

Leveraging advance research to engineer systems to be more than the sum of their parts by combining application specific sensors and intelligent readout circuits.



Technology

Enabling smart sensors through superior technology

Developing, simulating and evaluating CMOS devices, microsystems and bionanosensors with material and physical stability and possible system integration in mind creates building blocks for new systems.

Center for Sensor Technology

Transferring ideas into silicon

A large, modern infrastructure and facilities provide the technological basis for the production and development of sensor systems including their automated assembly, calibration and testing.

Research Fab Microelectronics Germany (FMD)

As the largest cross-site R&D alliance in Europe, we want to drive micro- and nanoelectronics as a key industry with a strong team of smart minds

Fraunhofer IMS is part of the Research Factory Microelectronics Germany (FMD), a cooperation of the Fraunhofer Group for Microelectronics with the Leibniz Institutes FBH and IHP. As a pioneer for cross-site and cross-technology collaboration, the FMD addresses current and future challenges in electronics research and provides important impetus for the development of elementary innovations for the world of tomorrow.

In the area of resource efficiency, FMD pools the know-how it has developed over many years at a central location and intensively drives research for sustainability in electronics. The goal here is always the development of resource- and energy-efficient technologies and systems along the entire value chain - from the manufacturing process to the supply chains. The focus here is, among other things, on innovations in the areas of Green ICT, Green by ICT, Green Energy Systems as well as EcoDesign and closed-loop technologies. FMD also provides support on the way to the energy-saving clean room of the future.

The FMD also conducts research and development in mobility, production, communication, next-generation computing, and security.

As a one-stop shop for micro- and nanoelectronics, FMD offers customized technology and system developments along the entire value chain under one roof

FMD pools its extensive expertise to offer customized technology and system developments for customers and partners from industry and science.

Technology platforms

By combining a wide range of leading technologies, FMD uses its comprehensive know-how to create market- and application-oriented system solutions in numerous areas of industry and science. Find an overview of our applications on the right.

Further information

For more information about FMD and our virtual 3D showroom follow the links below:

Official website

3D Showroom

Extended CMOS

Design, manufacturing and system integration of CMOS circuits.

Optoelectronic systems

Completely integrated optoelectronical systems for image generation and processing, as well as communication at Tbit/s speed.

MEMS actuators

Design and manufacturing as well as characterisation, testing and system integration.

Microwave and Terahertzsystem

Design, manufacturing and system integration of CMOS circuits.

Power electronics

Design and manufacturing of power components and their integration into modules and systems.

Sensor systems

Sensor design, manufacturing, integration, characterisation and testing of sensors, as well as in systems.

The Fraunhofer-Gesellschaft

The Fraunhofer-Gesellschaft, based in Germany, is the world's leading applied research organization. Prioritizing key future-relevant technologies and commercializing their findings in business and industry plays a major role in the innovation process. A trailblazer and trendsetter in innovative developments and research excellence, the Fraunhofer-Gesellschaft supports science and industry with inspiring ideas and sustainable scientific and technological solutions and is helping shape our society and our future.

At the Fraunhofer-Gesellschaft, interdisciplinary research teams work with partners from industry and government to turn pioneering ideas into innovative technologies, coordinate and implement system-relevant research projects, and strengthen the German and European economies with a commitment to value creation that is based on ethical values. International collaboration with outstanding research partners and companies from around the world brings the Fraunhofer-Gesellschaft into direct contact with the most prominent scientific communities and most influential economic regions.

Founded in 1949, the Fraunhofer-Gesellschaft now operates 76 institutes and research units throughout Germany. Currently, around 30,800 employees, predominantly scientists and engineers, work with an annual research budget of about 3.0 billion euros, of which 2.6 billion euros are designated as contract research. Around two-thirds of Fraunhofer contract research revenue is generated from industry contracts and publicly funded research projects. The German federal and state governments contribute around another third as base funding, enabling the Fraunhofer institutes to develop solutions now to problems that will drastically impact industry and society in the near future.

The impact of applied research goes far beyond the direct benefits to the client. Fraunhofer institutes strengthen companies' performance and efficiency and promote the acceptance of new technologies within society, while also training the future generation of scientists and engineers that the economy so urgently requires.

As a scientific organization, the key to our success is highly motivated employees engaged in cutting-edge research. Fraunhofer therefore offers its researchers the opportunity to undertake independent, creative and, at the same time, targeted work. We help our employees develop professional and personal skills that will enable them to take up positions of responsibility within Fraunhofer itself, or at universities, within industry and in society at large. Students involved in projects at Fraunhofer institutes have excellent career prospects on account of the practical vocational training they enjoy and the opportunity to interact with contract partners at an early stage in their careers.

The Fraunhofer-Gesellschaft is a recognized non-profit organization named after Joseph von Fraunhofer (1787–1826), an illustrious researcher, inventor and entrepreneur hailing from Munich.

Figures as of: March 2023

Further information

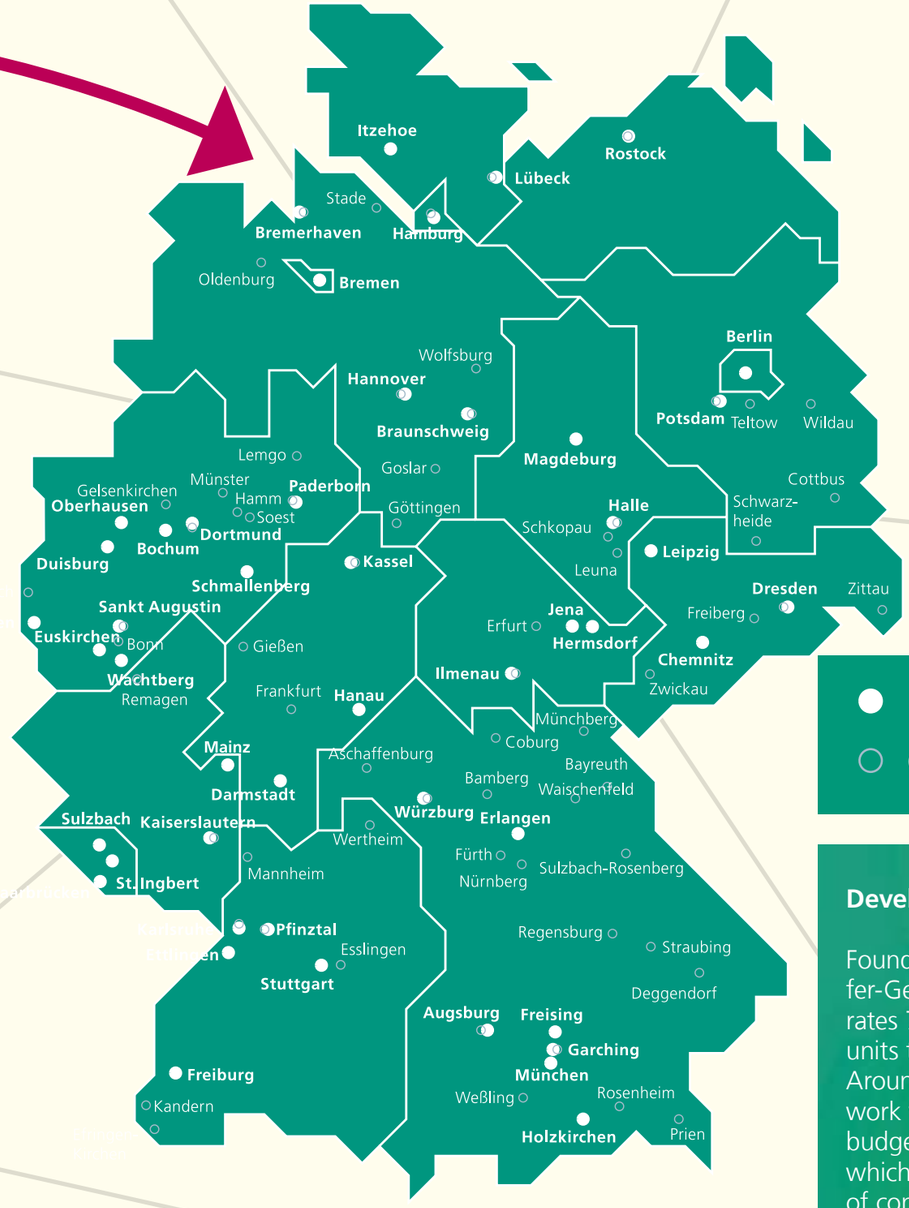
Official website

Fraunhofer worldwide

World-wide commitment

As the world's leading applied research organization, the Fraunhofer-Gesellschaft has cooperations all around the world. Foreign independent Fraunhofer Institutes, Fraunhofer Representative Offices and Fraunhofer Senior Advisors on virtually every continent provide a bridge into the local markets and a foundation for successfull international collaboration.

Fraunhofer in Germany



- **Main locations**
- Other locations

Development in Germany

Founded in 1949, the Fraunhofer-Gesellschaft currently operates 76 institutes and research units throughout Germany. Around 30,800 employees work with an annual research budget of roughly €3.0 bn, of which € 2.6 bn is in the area of contract research.

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