Fraunhofer
IPMS

Annual Report

2023/2024

Fraunhofer IPMS

Annual Report 2023/2024

We do research for the people. Application-orientated, innovative and professional.

With over 500 employees, Fraunhofer IPMS develops innovative, customer-specific solutions in the fields of intelligent industrial solutions, medical & health technologies and mobility at four sites in Dresden, Cottbus and Erfurt.

Our research focuses on miniaturized sensors and actuators, integrated circuits, wireless and wired data communication, customer- and application-specific micro-electro-mechanical systems (MEMS) as well as leading-edge 300 mm technologies for future applications in digital, neuromorphic and quantum computing.

As a reliable and competent research partner, we provide our customers with complete solutions from the initial concept and technology development to the model and pilot production on 200 mm wafers in our own cleanroom using qualified, industry-orientated processes. The development of processes and materials on 300 mm wafers completes our range of services.

Video „Our insitute in Dresden from above“

Fraunhofer IPMS

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Foreword

Dear friends and partners of the Fraunhofer Institute for Photonic Microsystems,

the past year was characterized by positive developments, challenging tasks and important milestones that we have mastered together.

One of the most positive aspects in 2023 was undoubtedly the unbroken upward trend in the semiconductor and microelectronics sector, which was further strengthened by industry expansions and new companies relocating to Dresden.

The European Chips Act is also continuing to take shape. As a contribution to this, the Research Fab Microelectronics Germany (FMD) is planning the most comprehensive and advanced pilot line for "Advanced Heterogeneous System Integration" in the coming years. We are eagerly awaiting the decision on this in mid-2024. All these dynamic developments not only represent important steps for Fraunhofer IPMS, but also make a significant contribution to strengthening technological sovereignty in Germany and Europe. In this context, we would like to draw particular attention to the strategic importance of these advances, which further consolidate our position as an innovation leader.

However, we also want to actively shape the future in other areas with our cutting-edge research. We pay particular attention to the topic of climate neutrality, including energy and resource efficiency. Fraunhofer IPMS is also working intensively on future technologies in the digital world. These include **Green Microelectronics, Neuromorphic Computing and Quantum computing**.

The challenges of the past year, in which we had to face a difficult financial environment due to the critical federal budget situation and planning uncertainties, should not go unmentioned. Rising material costs and high energy prices have further restricted our financial scope. Despite these conditions, we would like to emphasize that we at Fraunhofer IPMS remain well positioned. Following our extensive strategy process, our strategic plan was positively evaluated by an external group of independent auditors in May 2023. **Their statements** confirm our excellent work and give us the certainty that we are on the right track.

In this context, we would also like to highlight the progress made in construction over the past year. The renovation of parts of our main building is an important step towards creating a modern and efficient working environment. At the Center Nanoelectronic Technologies, we celebrated the topping-out ceremony for our new office building in February 2024. We plan to move in at the end of 2024.

We thank you for your loyalty as a customer, sponsor or partner of our institute and our research. We are proud to present another successful year for Fraunhofer IPMS on the following pages. Find out more about our innovative ideas and developments, which we successfully translate into customized solutions for industry and society. Thank you for your trust and continued support. Together, we look to the future with optimism and are ready for the challenges ahead.

Harald Schenk Hubert Lakner

Prof. Dr. Harald Schenk
Executive Director

Prof. Dr. Hubert Lakner
Director

Fraunhofer IPMS

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Pioneering semiconductor technology

Our cleanrooms for your developments

200 mm

- MEMS Technologies Dresden: 1500 m² clean room (class 4 according to ISO 14644-1)
- Technology development through to pilot production of innovative microsystems on 200 mm
- Micro-electro-mechanical systems (MEMS) and micro-opto-electro-mechanical systems (MOEMS)

MEMS Technologies Dresden
Virtual clean room tour
CNBC interview with Prof. Dr. Hubert Lakner

Video: „From Wafer Level Test to MEMS Modules“
Webinar „Managing a High-Mix and Low-Volume MEMS R&D Fab by Applying KPIs“
Webinar „Customized BSOI using CMOS compatible Wafergrinder“

300 mm

- 2700 m² class 6 and 3 clean room (according to ISO 14644-1)
- Development services on 300 mm wafers in the field of FEoL and BEoL
- Services at Ultra Large Scale Integration Level (ULSI)
- Analytics, Metrology & Characterization

300 mm semiconductor processes
Analytics and metrology
RF characterization

Video „KLA CIP Tech M300 Metrology“
Video „TEL Test System“
Video „ASM Eagle XP4 for ALD“
Video „Lesker PVD200 load deposition system“
Video „Quantum Design OptiCool Cryostat“
Video „Wafer Prober Characterization System“

Green ICT – Sustainable Microelectronics

Sustainability is playing an increasingly important role in microelectronics – right from the manufacturing stage. In order to contribute to reducing the carbon footprint of digital technologies through research and development, we are part of the "Green ICT @ FMD" competence center. As coordinator of Hub 3 – resource-optimized electronics production – we use our two cleanrooms as references for evaluating improvement measures in electronics production.

Overview of our Green ICT research projects
Green ICT Space of the Research Fab Microelectronics Germany (FMD)

Video "Hub 3: Ressource-optimized electronics production" Talk by Marco Kircher (German with English subtitles)

Video "Sustainability – An Obligation or an Opportunity?" Discussion round with Jörg Amelung (German with English subtitles)

Video „Green ICT Space: Accelerator for sustainable start-ups and SMEs“ (German with English subtitles)

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Research Projects

Reduction of PFAS in microelectronics

The group of PFAS, short for "perfluorinated and polyfluorinated alkyl substances", is large. These are organic compounds in which the hydrogen atoms are completely ("perfluorinated") or partially ("polyfluorinated") replaced by fluorine atoms. PFAS have water and grease repellent properties and are very stable and durable. They are therefore widely used in many industrial sectors and also in the household. PFAS are also used in microelectronics production, for example as an anti-static surface on chips or to hydrophobize the chip surface.

The disadvantage: many PFAS are classified as toxic. Once they have been released into the environment, they are very difficult, if not impossible, to remove. Solutions must therefore be found.

Regulation of PFAS by the EU can be countered, for example, by retrofitting existing systems. Another way is to replace them with chloroalkanes without fluorine at chip and wafer level.

At Fraunhofer IPMS we are conducting research on:

- Development of processes with harmless substances as substitutes for e.g. PFAS
- Evaluation of processes and systems to prevent PFAS leakage
- Use of new, less environmentally harmful materials without compromising product quality
- Verification through analysis, e.g. determination of hydrophilicity
- Assessment of the long-term effects of alternative materials

Project website

Hyperspectral imaging inspection tool for efficient semiconductor production

Together with DIVE imaging systems GmbH, we are working on a joint project as part of the GreenICT Space – the accelerator program of the "GreenICT @ FMD" competence center.

The overarching aim of this project idea is to establish hyperspectral imaging technology as a production-accompanying screening tool for semiconductor production. The aim is to make the semiconductor production chain more efficient and therefore more environmentally friendly.

Based on the information collected, it will be possible, for example, to significantly reduce the number of system control wafers required to date, detect and subsequently avoid production errors at an earlier stage, create new (wafer) designs more efficiently and optimize production capacities overall and make more efficient use of resources.

This significantly reduces the consumption of materials, energy and consumables per wafer in semiconductor production.

Project website

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Ressource- and energy-efficient ISFET-based sensing

The aim of the project Resource- and energy-efficient ISFET-based sensing (REISen) is to research material-related methods for chemical sensors based on ISFETs (ion-sensitive field-effect transistors). These sensors are used to measure the pH value in the food sector, for example.

The focus is on three main areas of work:

- Research into processes to replace tantalum as a sensor material for ISFETs using pH sensors as an example. As a critical and expensive material, tantalum is of great importance for high-performance pH measurement technology. Although alternative materials often do not offer the same performance, they are sufficient for many applications and are also cheaper. In addition, there are energy savings during processing.
- Research into resource-saving characterization and integration of ISFETs. According to the state of the art, bonding processes, circuit boards and conductor tracks made of palladium/platinum and silver alloys are used. The aim is to avoid these processes and materials.
- Development of resource-efficient sensor functionalization methods: The state of the art is flat coatings with subsequent structuring. More than 99% of the materials used are lost in this process, as the sensor-active areas are only a few square micrometers in size. The aim is therefore to save material by structuring directly at wafer level using microfine dispensers. This not only saves on reactive and therefore often toxic materials, but also reduces the health burden on workers and protects the environment.

The REISen project addresses several UN sustainability goals: e.g. health and well-being, clean water, and climate protection.

Project website

Substitution of NMP

N-methyl-2-pyrrolidone (NMP) has proven to be an essential material for lift-off processes and resist removal. This chemical enables precise structuring of thin films and cleaning of surfaces, which is particularly important to ensure the quality and performance of semiconductor devices.

As of 2018, NMP has been included in Annex XVII of the REACh Regulation due to its reproductive toxicity and irritant effect on the eyes, skin and respiratory tract. Since May 2020, consumer products with an NMP content of ≥ 0.3% have been banned in the EU.

We focus on the development of processes using safer products. Our research aims to identify and explore substitutes for NMP.

Project website

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Environmentally friendly silicon oxide-based slurries for microelectronics production

In today's conventional transistor production, the individual components are electrically separated from each other by deep trenches of insulating silicon oxide. A chemical mechanical planarization process (CMP) is required to adjust the dimensions of the insulation trenches to nanometer precision. Today, a polishing suspension (slurry) based on cerium oxide abrasive particles is used for this step. As cerium is a rare earth element whose oxide is suspected of being carcinogenic, Fraunhofer IPMS is conducting tests with more environmentally friendly alternative slurries based on silicon oxide.

As silicon oxide is removed during the manufacturing process and the topography is adjusted with the aid of a polishing stop layer made of silicon nitride, (at least) two parameters are of central importance for evaluating a slurry: The oxide removal should be sufficiently high to enable a high process throughput. A high selectivity of the removal is required to end the process when the polishing stop layer is reached. The removal rate of the silica slurry is parameter-dependent and similar to one of the ceria slurries. The target parameter of the removal rate, to which normalization was performed, is achieved. Ceria slurries can generally deliver significantly higher removal rates, which means that production processes can potentially run faster.

The comparison of the selectivity between oxide and nitride removal shows sufficiently high values for the silica slurry.

Based on these data from wafers with a homogeneous material layer, a cerium oxide-free slurry has recently been applied to production-like structured 300 mm wafers at Fraunhofer IPMS. The comparison of the selectivity between oxide and nitride removal shows sufficiently high values for the silica slurry.

Project website

Environmentally friendly cleaning technologies in microchip manufacturing

Many individual process steps are necessary before a chip is created in microelectronics. It is always necessary to clean wafers or remove some or all of the layers. This is usually done using aggressive chemical cleaning processes. Together with partners, Fraunhofer IPMS is developing an alternative technology that is more efficient, more cost-effective and, above all, more environmentally friendly.

The phase fluid-based technology sets new standards in terms of environmental friendliness, occupational safety and tool compatibility and represents a major step towards the Green Fab in semiconductor manufacturing. In addition, process sequences can be simplified, resulting in savings in production time and consumables and enabling new application scenarios in process integration.

In contrast to conventional processes, in which, for example, photoresists are dissolved using aggressive solvents and sometimes toxic chemicals and then disposed of at great expense, phase fluids infiltrate the corresponding layers, fragment them and "lift" them off the wafer surface without leaving any defects. The phase fluid and the dissolved photoresist are then rinsed off with DI water and removed without leaving any residue.

Project website

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More informationen on the

Climate strategy of the Fraunhofer-Gesellschaft

Increased cooperation at European level – CEA-Leti, Fraunhofer, imec and VTT jointly develop Edge AI technologies

The EU's four leading research and technology organizations (RTOs) – France's CEA-Leti, Germany's Fraunhofer-Gesellschaft, Belgium's imec and Finland's VTT – are working together on the PREVAIL project. Launched at the end of 2022, the project uses the RTOs' advanced 300 mm manufacturing, design and testing facilities to develop high-performance and low-power edge AI hardware.

In order for the industry to transfer these technologies into commercial products and innovations as quickly as possible, they must be further developed from basic research towards commercial applicability and the necessary development and pilot manufacturing infrastructure must be established. The aim of the PREVAIL project – "Partnership for Realization and Validation of AI hardware Leadership" – is to offer a technological platform that is capable of designing, manufacturing and testing prototypes for advanced neuromorphic chips for edge AI applications.

The ultimate goal of the PREVAIL project is to provide Europe with an easily accessible, advanced manufacturing infrastructure that enables users to produce early research prototypes of innovative and trustworthy products and accelerate their commercialization.

In addition to providing high-performance, low-power edge components and technologies to support the massive data processing requirements of AI, the project will help drive the EU's digital transformation. It is a precursor to the objectives of the European Chips Act.

Press release "EU consortium to develop next-generation edge AI technologies adopts design proposals"

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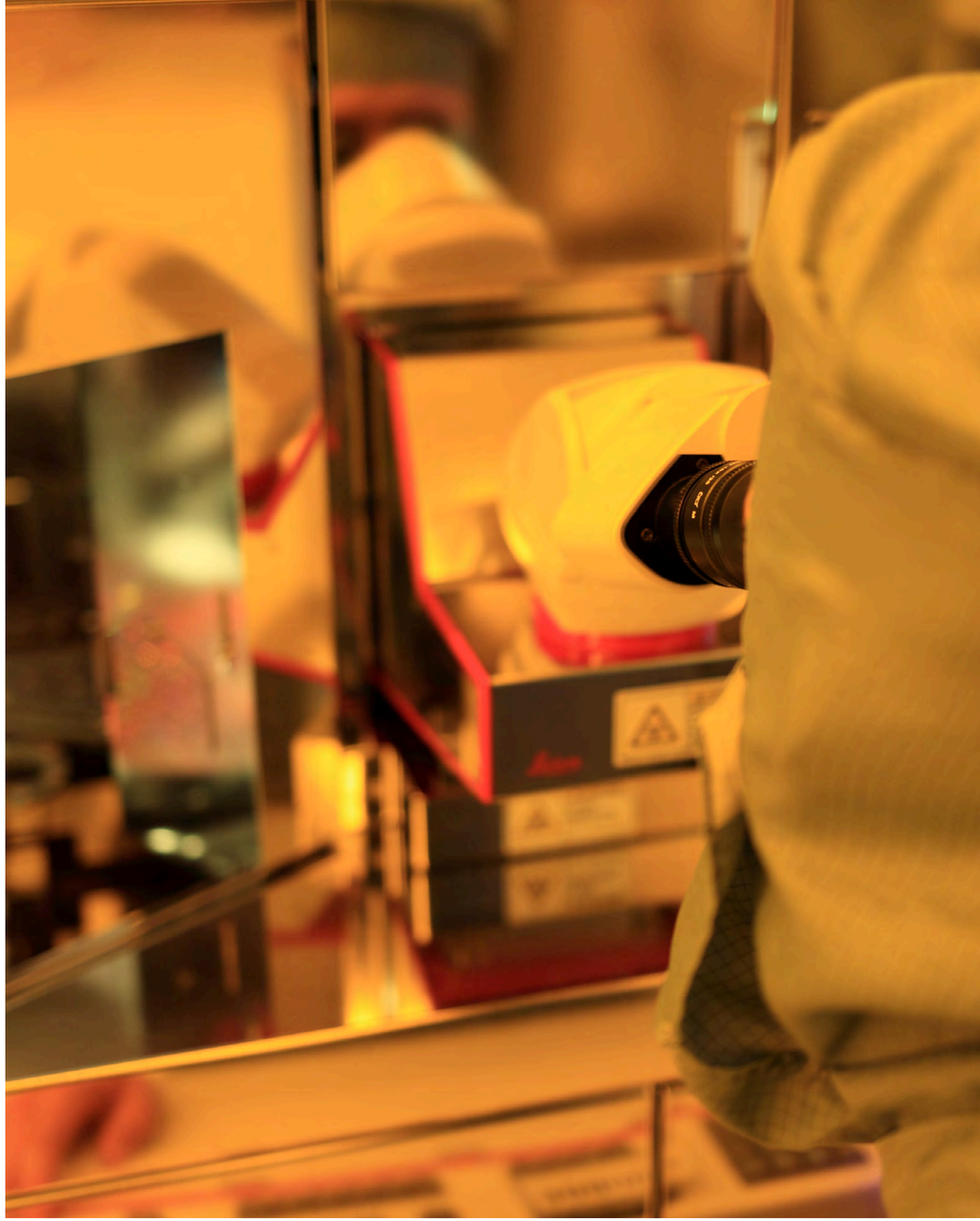

Bridges of Innovation: Fraunhofer IPMS and NY CREATES strengthen cooperation

The New York Center for Research, Economic Advancement, Technology, Engineering, and Science (NY CREATES) is one of the world's leading research and development institutions for digital technologies, energy technologies and microelectronics. In May 2023, Dr. Wenke Weinreich, Deputy Director of Fraunhofer IPMS, traveled to Albany, New York, with a Saxon delegation led by Prime Minister Michael Kretschmer for a meeting with NY CREATES. She signed a memorandum of understanding and said: "With our expertise and technologies in advanced microelectronics, we ideally complement the capabilities of NY CREATES. Together we can make significant progress in the development of future semiconductor systems".

The return visit took place at the end of November in Munich and Dresden. First there was an exchange at the semiconductor industry's leading trade fair, SEMICON Europa. Representatives from NY CREATES then visited the Fraunhofer IPMS in Dresden and the Silicon Saxony office.

Press release "Bridges of Innovation: Fraunhofer IPMS and NY CREATES strengthen cooperation"

Video "Fraunhofer IPMS' Wenke Weinreich: Why Partnerships are Critical for Semiconductor Organizations"

Saxonian delegation visiting NY CREATES in May 2023.

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Strengthening scientific cooperation with Taiwan

The establishment of TSMC in Dresden, in the heart of Silicon Saxony, is a clear sign of increased cooperation between Taiwan and Germany. Fraunhofer IPMS set the course here at an early stage: In early 2023, the institute and TU Dresden signed concrete agreements on scientific cooperation with several universities in Taipei and Hsinchu in Taiwan in the presence of Science Minister Sebastian Gemkow.

Among other things, the following agreements were reached:

- Joint research activities in the field of microelectronics and semiconductor technologies
- Joint research activities in the field of microelectronics and semiconductor technologies
- Exchange of teaching staff and joint lectures
- Mutual facilitation of the admission of qualified students
- Exchange of researchers
- Student exchange program
- Implementation of joint projects
- Conducting lectures and organizing symposia and conferences
- Exchange of academic information and materials

The conclusion of the cooperation agreement with the National Yang Ming Chiao Tung University (NYCU) is an important step for Fraunhofer IPMS. It gives us a strong research partner in the country that produces the world's most advanced semiconductors. In particular, joint research projects, publications and the exchange of scientific personnel are planned with the International College of Semiconductor Technology at NYCU. We are aiming for close cooperation in microelectronics research, particularly in the area of memory development and reliability testing.

In November 2023, we welcomed a Taiwanese delegation from the National Taiwan University of Science and Technology, led by the university's president, Prof. Jia-Yush Yen (p. 46).

Press release "Scientific cooperation with universities in Taiwan significantly expanded"

Signing of the MoU (from left to right: Prof. Edward Yi Chang - Dean NYCU, Prof. Chen-Yi Lee - Senior Vice President NYCU, Sebastian Gemkow - Minister of Science Saxony, Dr. Thomas Kämpfe - Fraunhofer IPMS).

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Technology center for semiconductor metrology on 300 mm wafers with Applied Materials

Together with Applied Materials, Inc., we founded one of the largest technology centers for semiconductor metrology and process analysis in Europe in mid-2023.

The technology center, which is based at our Center Nanoelectronic Technologies, is located in the heart of Silicon Saxony, the largest semiconductor cluster in Europe. The technology center will be equipped with state-of-the-art eBeam metrology equipment from Applied Materials, including the VeritySEM® CD-SEM system (a critical dimension scanning electron microscope), and will be staffed by Applied Materials engineers and R&D experts.

The new technology hub will enable advanced wafer-level metrology in an industrial CMOS environment with Fraunhofer IPMS' unique ability to exchange wafers directly with semiconductor manufacturers. This will allow processes to be tested and qualified on a variety of substrate materials and wafer thicknesses that are critical for applications in the diverse European semiconductor landscape. These primarily include the areas of Internet of Things, Communications, Automotive, Power and Sensors (ICAPS).

Press release "Applied Materials and Fraunhofer IPMS establish technology center for semiconductor metrology"

Analytics and metrology website

Webinar „300 mm Semiconductor Analytics: XPS/ HAXPES Scanning Microprobe“

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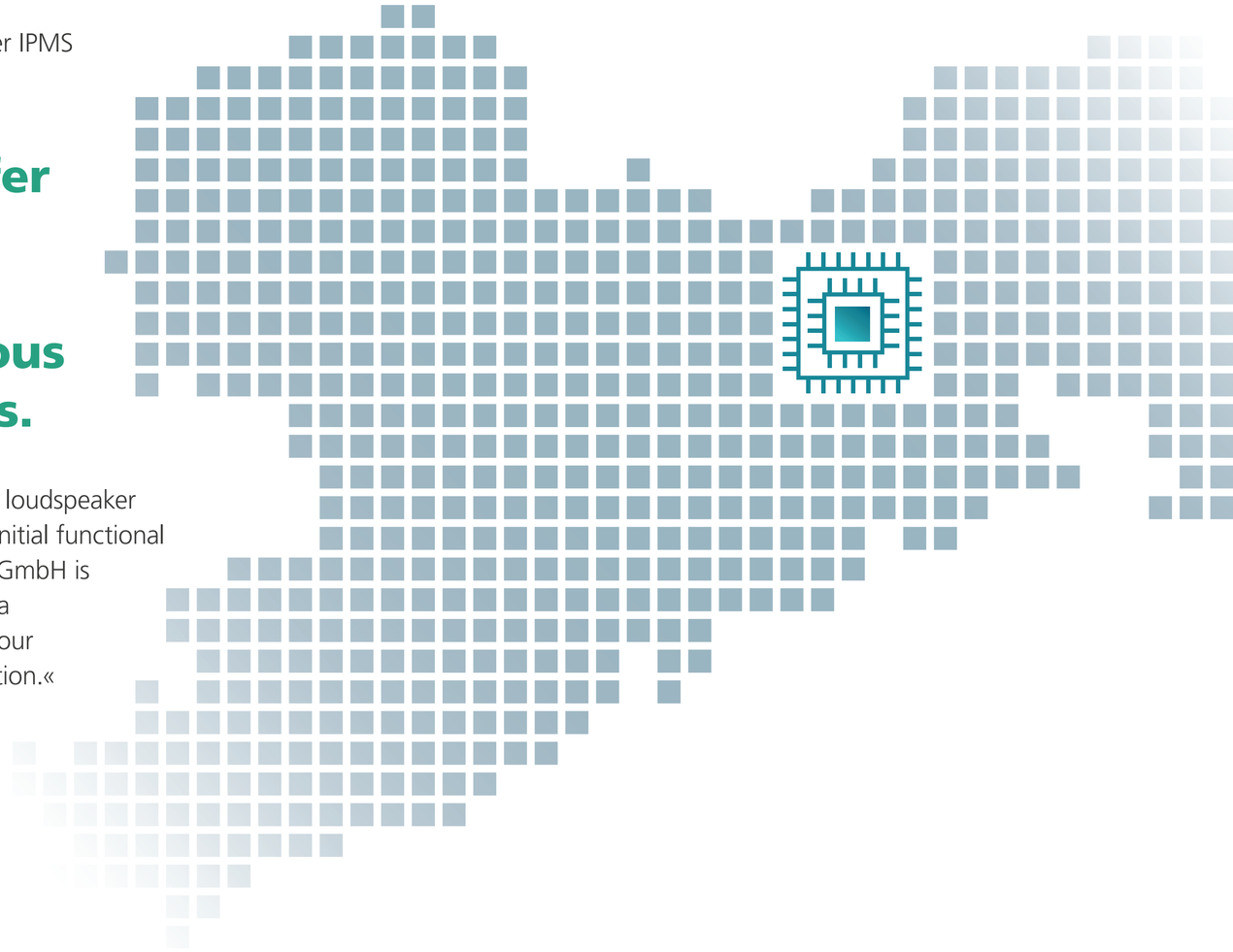
Our role in the Silicon Saxony ecosystem

We have a long-standing partnership with Fraunhofer IPMS in the development of MEMS sensor technology.

The expertise of the Fraunhofer team is very valuable and helps us to design innovative solutions and realize continuous improvements in our products.

One concrete example of this successful collaboration is the micro loudspeaker for consumer electronics, which Fraunhofer IPMS developed into initial functional samples as part of a research project and which Bosch Sensortec GmbH is now developing to market maturity. The Fraunhofer IPMS acts as a reliable partner that provides us with decisive support in realizing our goals and further strengthening our technological leadership position.«

Robert Bosch GmbH + Bosch Sensortec GmbH



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Next Generation Technologies

- Quantum Computing
- Quantum Communikation
- Neuromorphic Computing

European pilot infrastructure for a faster market introduction of quantum technologies

The success of European start-ups and small and medium-sized enterprises (SMEs) depends to a large extent on the efficient transfer of prototypes and pilot projects into production. However, the pilot phase takes time and requires significant investment in infrastructure. These high costs are a major obstacle for start-ups and SMEs to enter the highly competitive quantum technology market early enough with their product.

The Qu-Pilot project wants to change this. The aim is to improve the existing pilot line infrastructures in Europe, which are mainly distributed among the research and technology organizations, and to enable product development loops together with the hardware industry in the field of quantum technology in Europe. The ultimate goal is to accelerate the market introduction of European industrial innovations in the field of quantum technology and to support the establishment of a trustworthy supply chain.

Fraunhofer IPMS contributes its expertise in modern, industry-compatible CMOS semiconductor manufacturing in the 300 mm wafer standard to advance semiconductor and superconductor platforms. This concerns, for example, manufacturing processes such as deposition and nanostructuring or electrical characterization on a wafer scale. A particular focus is on improving metallization and BeoL modules. Several technological modules are being optimized for superconducting local and global connections, which are essential for the integrated excitation, control and readout of semiconductor qubits. The ultimate goal is the demonstration of an improved process and materials for low-loss superconducting electrodes and the demonstration of a superconducting BeoL module comprising at least a via and trench level.

The Qu-Pilot project consists of 21 partners from 9 countries and is funded by the European Union with 19 million euros under the project code 101079926. The project started in April 2023 and will run for 3.5 years.

- **Project website Qu-Pilot**
- **Press release "European pilot infrastructure for a faster market introduction of quantum technologies"**
- **Webinar "Advanced Technology and Hardware for Next Generation Computing"**

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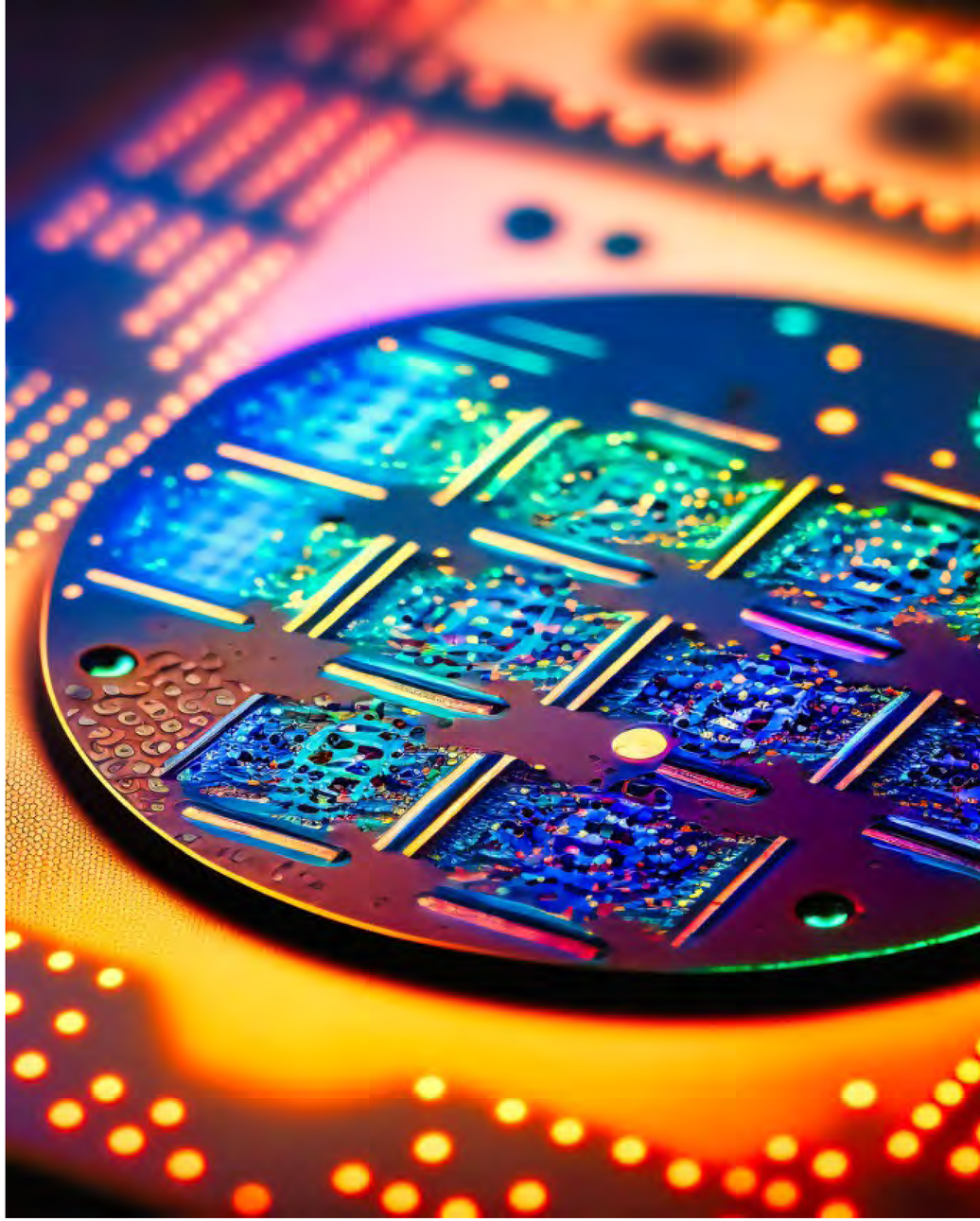


Research projects

New materials for quantum computing

In the MATQu project, Fraunhofer IPMS and its partners are aiming to expand existing European expertise in the field of materials and production processes. The goal is to pave the way for solid-state quantum computers in European industry.

Fraunhofer IPMS's focus in the project is on bringing existing concepts and technologies from the laboratory to industrial production. In doing so, we are drawing on our expertise in 300 mm manufacturing, which already serves as the industry standard for CMOS computing platforms.

Project website MATQu

Scalable silicon qubits for quantum computers

In the QLSI project, Fraunhofer IPMS is working with 18 European partners on a silicon-based 16-qubit chip. This lays the foundation for the industrial implementation of semiconductor quantum processors in Europe.

With the Center Nanelectronic Technologies, we are contributing a 4000 m² clean room and expertise in state-of-the-art, industry-compatible CMOS semiconductor production on 300 mm wafer standard. This concerns, for example, manufacturing processes for nanostructuring, but also material development and electrical control in the CMOS area.

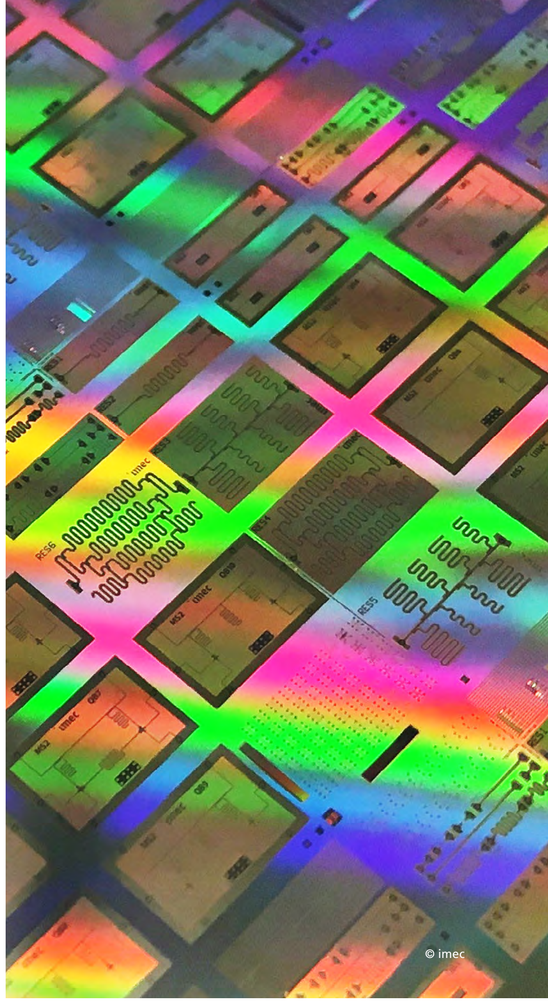
Project website QLSI

On the way to the quantum processor "Made in Germany"

In the QUASAR joint project, Fraunhofer IPMS is working with Forschungszentrum Jülich, Infineon in Dresden and the Leibniz Institute for Innovative Microelectronics IHP to develop scalable concepts for quantum computing at wafer level. This creates the basis for the industrial production of quantum processors "Made in Germany".

We are using adapted processes from CMOS manufacturing. Based on its many years of experience in the field of electron beam lithography and in close cooperation with Infineon, we are involved in the production of complex "Gate 1" quantum gates.

Project website QUASAR



Test chip with supraconducting qubits

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Quantum Computer in the Solid State

Together with 24 German research institutions and companies and under the coordination of Forschungszentrum Jülich (FZ Jülich), Fraunhofer IPMS is working on a quantum computer with improved error rates.

The aim is to make Germany a world leader in the field of quantum technology and open up numerous new applications for science and industry. The first demonstrator will go into operation in mid-2024.

Project website Q-Solid

FMD for neuromorphic and quantum computing

In order to bundle and expand the existing micro-electronic R&D in Germany with regard to quantum and neuromorphic computing, the FMD launched a joint project with four other Fraunhofer Institutes, Forschungszentrum Jülich and AMO GmbH: The "Research Fab Microelectronics Germany – Quantum and Neuromorphic Computing Module". The equipment and structural set-up required for this is being funded by the Federal Ministry of Education and Research. The "QNC Space", the Deep Tech Accelerator for research groups, start-ups and SMEs, will also ensure that this infrastructure is widely available for innovations from Germany.

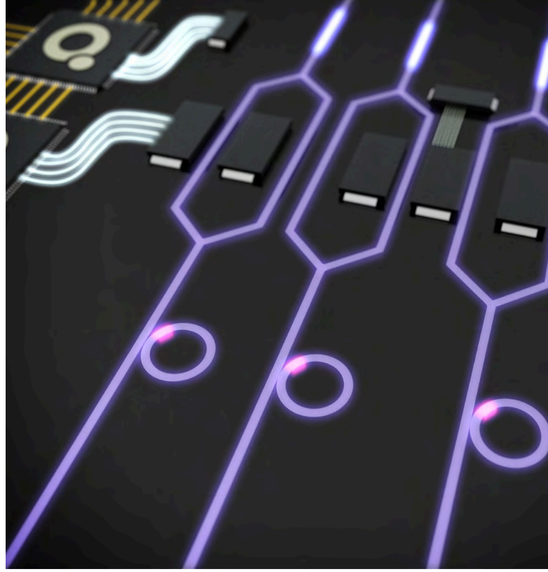
Project website FMD-QNC
QNC Space

Photonisc quantum computer

The photonic approach, which uses light particles (photons) as qubits, offers enormous advantages when it comes to the necessary scaling of qubits. This is because the functions required for the computing operations can be produced on a single chip using sophisticated semiconductor manufacturing processes. Fraunhofer IPMS is therefore working with partners on a photonic quantum computer with up to 100 qubits.

Fraunhofer IPMS is developing the integrated, monolithic control of the optoelectronic components of the photonic quantum computer as well as the assembly and connection technology. In two and a half years, the project partners want to present an initial prototype, and in five years at the latest, a quantum computer chip capable of performing large-scale calculations is to be created.

Project website PhoQuant



Graphic representation of a photonic quantum computer

Video "Introducing Project QSolid – Quantum computer in the solid state"

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Federal Ministry of Education and Research

You can find more information on our projects and technologies in the field of quantum computing **here**.

For a quick and easy overview, watch our **Webinar "Advanced Technology and Hardware for Next Generation Computing".**

Chip-based quantum random device

Random numbers are of enormous importance in IT security, as they are used for cryptographic processes such as key generation and thus ensure the security of data in terms of confidentiality, integrity and authenticity.

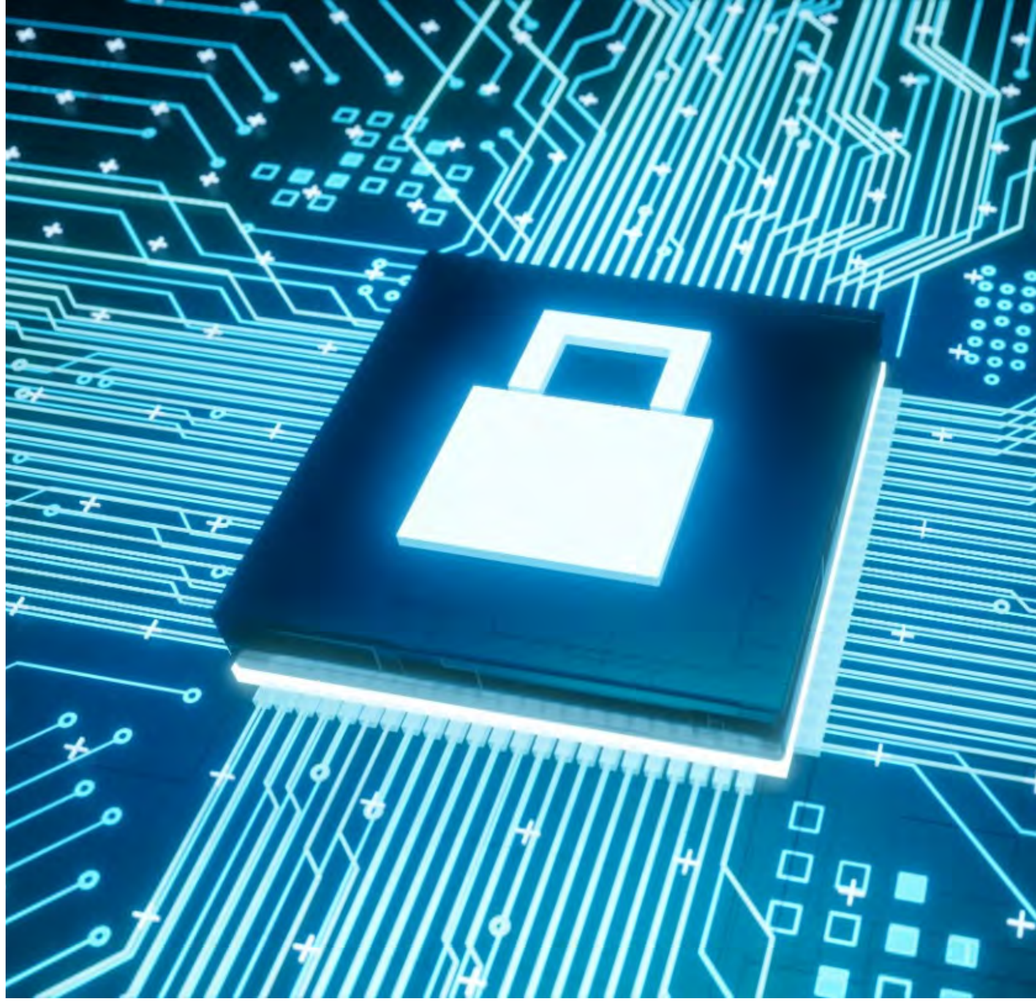
In the "CBQD" project funded by the BMBF, a chip is being developed that generates random numbers at high speed on the basis of quantum photonic effects. The aim is to combine a high speed of random number generation with a compact design. At the same time, the chip should meet the requirements of Common Criteria AIS 20/31 PTG.3, a standard for security requirements for IT products from the German Federal Office for Information Security (BSI).

The chip is to become the basis for numerous communication systems for authorities, banks, critical infrastructure and the Internet of Things.

The interdisciplinary team brings extensive expertise ranging from quantum theory to security proofs, security-by-design experience for random number generators, silicon photonics and QKD systems and their integration into applications. Fraunhofer IPMS is responsible for project coordination and QNRG chip integration.

Press release "Photonic quantum chip for fast and reliable random number generation"

Project website CBQD – Chip-based quantum random device



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Secure optical data communication by means of quantum cryptography and LiFi

Modern quantum technology opens up many new areas of application. But it also harbors risks. For example, thanks to their enormous computing power, quantum computers could be able to undermine state-of-the-art data encryption methods. To prevent this scenario, several partners led by KEEQuant GmbH are developing a new approach to secure optical data transmission in wireless networks using light and quantum keys. The "QuINSiDa" project is funded by the German Federal Ministry of Education and Research.

- **Press release "Secure optical data communication by means of quantum cryptography and LiFi"**
- **Project website QuINSiDa**

Quantum-secure identities for a digital future

Access to online services and network databases is regulated by means of digital identities. Asymmetric encryption methods are used to transmit these securely over the network. In the future, however, quantum computers will be able to crack these classic encryption methods. The BMBF-funded "Quant-ID" project aims to research end-to-end solutions for reliable digital identities using post-quantum cryptography.

- **Projec website Quant-ID**
- **Press release "Quantum-secure identities for a digital future"**

Quantum-secure information exchange between authorities

Communication between national authorities must be particularly secure. To this end, the "QuNET&FUNK" project is developing optical communication systems that use quantum cryptography as well as data transmission via free-space optical links and satellite radio. The aim of the development is to create compact and robust communication nodes that are easy to use at a low price. The project is funded by BMBF.

- **Project website QuNET+FuNK**

Compact modules for quantum communication

The "MIQUE" project is developing compact modules for quantum key distribution (QKD) that are suitable for mobile applications and secure communication over short distances. The project includes the development of modules for generating QKD keys, detecting the signals and integrating them into VPN environments. The project offers great potential for innovation and is intended to strengthen Germany's technological sovereignty in the field of quantum communication.

- **Project website MiQuE**

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Federal Ministry of Education and Research

All our projects and technologies in the field of quantum communication can be found **here**.

Technology platform for neuromorphic chips

Neuromorphic computers are based on the structure of a biological nervous system. Neuromorphic systems for edge AI applications show enormous potential in pattern recognition, analysis and prediction and have great potential in areas such as medical diagnostics or the recognition of speech patterns and promise to enable these extraordinary performances with the lowest possible energy requirements compared to today's architectures.

In order for industry to transfer these technologies into commercial products and innovations as quickly as possible, they must be developed from basic research towards commercial applicability, and the necessary development and pilot production infrastructure must be established. The aim of the PREVAIL project ("Partnership for Realization and Validation of AI hardware Leadership") is to offer a technological platform that is capable of designing, manufacturing and testing prototypes for advanced neuromorphic chips for edge AI applications.

In the project, four Fraunhofer institutes – in addition to the coordinator Fraunhofer IPMS, these are the institutes IZM, IIS and EMFT – are contributing their advanced 300 mm manufacturing, design and testing capabilities. The aim is to create a "Hardware for Edge AI" platform for 300 mm technology. This is to be expanded in the long term in collaboration with CEA-Leti, imec and VTT, the leading European research organizations (RTOs).

The PREVAIL project is co-financed by the European Union and the German Federal Ministry of Education and Research (BMBF) under the funding code 16ME0834.

Project website PREVAIL
Webinar "Neuromorphic Computing for Edge AI"

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Federal Ministry of Education and Research

»Not only computing power, but also **energy efficiency** is a major issue with chips for next generation computing.«

Dr. Wenke Weinreich

Sensors learn to think

Autonomous robots are equipped with sensors and electronics in order to perceive their surroundings and to cope with unforeseen situations independently. This is accompanied by a significant increase in energy consumption. That is why in the NeurOSmart project, Fraunhofer IPMS is working with four other institutes to develop a neuromorphic in-memory accelerator that is tailored to the respective sensor. The human brain serves as a model here.

Project website NeurOSmart

Novel materials for Neuromorphic Computing

Various hardware approaches are being discussed for the implementation of neuromorphic computing. In the ANDANTE project, we are using ferroelectric field-effect transistors (FeFETs) as the ideal synapse. These are characterized by a very high dynamic range as well as very low propagation delay. This means that the signals from the pre-neuron can be transmitted quickly and with very low loss and collected in the post-neuron. In addition, these can be installed in a chip alongside standard logic transistors, which enables a scalable edge AI accelerator.

Project website Andante

funded by

European Commission | Horizon 2020 European Union funding for Research & Innovation

Federal Ministry of Education and Research | Staatsministerium für Wirtschaft, Arbeit und Verkehr | Freistaat Sachsen

Sensor Edge Cloud for Federated Learning

In the SEC-Learn project, Fraunhofer IPMS and ten other Fraunhofer Institutes are researching the development of a neuromorphic computing architecture for federated learning. Federated learning refers to an approach in which AI algorithms are trained in such a way that data is stored in a distributed manner on multiple devices or servers. In contrast to classic cloud-based machine learning, the advantage is that sensitive data remains in local systems. The platform developed in the SEC-Learn project will also use neuromorphic hardware accelerators that consume several orders of magnitude less power.

Project website SEC-Learn

Memristive transistors for neuromorphic computer architectures

The most important basic elements of a neuromorphic computing system are electronic synapses. Neuromorphic architectures based on resistive memories (RRAM) are considered to be particularly promising. Significantly higher information densities can be achieved here thanks to the multi-level switching properties. In the MEMION project, Fraunhofer IPMS is producing and characterizing a lithium-based synaptic transistor using semiconductor technology processes.

Project website MEMION

funded by

SAB SÄCHSISCHE AUFBAUBANK

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All our projects and technologies in the field of Neuromorphic Computing can be found **here**.

For a quick and easy overview, watch our **Webinar "Neuromorphic Computing for Edge AI"**.

Annual report 2023/2024

Bio & Health

Early detection of deep vein thrombosis with ultrasound

Deep vein thrombosis (DVT) and its fatal complication, pulmonary embolism, affect millions of people worldwide and account for a large percentage of acute hospitalizations. In DVT, a blood clot forms in the deep veins, usually in the lower limbs, which obstructs blood flow. In 50% of people with deep vein thrombosis, the clot eventually detaches from the vein wall and travels to the lungs, where it causes a pulmonary embolism. Around 25% of people who suffer a pulmonary embolism die as a result. This makes pulmonary embolism the third most common cause of cardiovascular death worldwide after stroke and heart attack. The clinical diagnosis of DVT has so far been very unreliable, as up to two thirds of DVT episodes are clinically inconspicuous and those affected are symptom-free even if a pulmonary embolism has developed.

Early diagnosis of DVT is crucial and has been shown to prevent life-threatening complications, minimize the risk of long-term complications (post-thrombotic syndrome, recurrent DVT), improve treatment outcomes and reduce healthcare costs. The ThrombUS+ project brings together an interdisciplinary team of experts from industry, technology, social sciences and clinical trials to develop a novel wearable device for continuous, user-independent monitoring of people at high risk of thrombosis.

Together with VERMON, Fraunhofer IPMS is developing the ultrasonic transducer array for portable, continuous monitoring of deep vein thrombosis directly on site. We are focusing on our CMUTs (Capacitive Micromachined Ultrasonic Transducers), MEMS-based ultrasonic transducers, which are considered the next generation of medical ultrasound sensors. CMUTs can be manufactured at low cost due to high volume production. In addition, the advantages such as miniaturization with a high number of channels, high bandwidth in combination with high sensitivity enable the development of a completely new system.

The ThrombUS+ project is Funded by the European Union under the funding code HORIZON-HLTH-2023-TOOL-05-101137227.

- **Project website ThrombUS+**
- **Video „How Do Micromachined Ultrasound Transducers (MUT) Work?“**
- **Capacitive micromachaned ultrasound transducers (CMUT)**
- **Webinar: Capacitive micromachined ultrasonic transducer (CMUT) – from concept to device**

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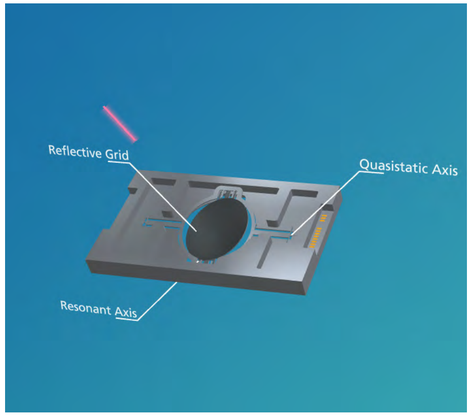
Qualified microscanners for customer-specific applications in medicine

The potential of microscanners in medical technology is immense. They impress with their low volume and weight as well as their high energy efficiency, which enables mobile use. In order to meet customer-specific requirements, more than 200 different microscanner designs have already been developed at Fraunhofer IPMS. The range of services extends along the entire value chain, from design and prototype development through to pilot production in our own clean room on 8" wafers.

Fraunhofer IPMS is continuously expanding the range of applications for scanner mirror technology with innovative and patented design solutions and technology modules, as well as the integration of artificial intelligence (AI).



Virtual Showroom „MEMS Mirror Technologies“

Press release "Qualified microscanners for customer-specific applications in medicine"

MEMS scanners website

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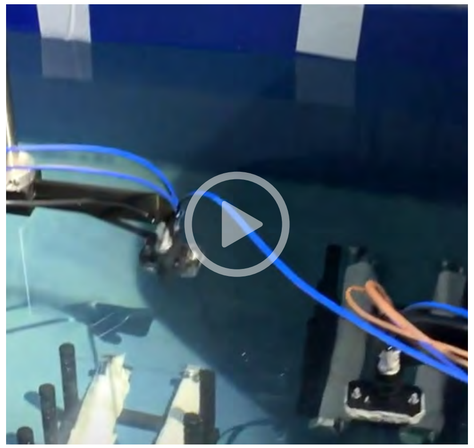
Else Kröner Fresenius Center for Digital Health: Promoting research. Helping people.

The Else Kröner-Fresenius Center for Digital Health (EKFZ) is a joint cross-faculty initiative of TU Dresden, the University Hospital Carl Gustav Carus Dresden, five Fraunhofer Institutes – including Fraunhofer IPMS – as well as the Leibnitz Institute for Polymer Research and the Helmholtz-Zentrum Dresden-Rossendorf. The aim is to bring innovative, digital medical technologies from the laboratory to patients. In the HybridEcho project, Fraunhofer IPMS is researching how to drastically improve medical imaging thanks to the use of highly sensitive MEMS-based ultrasound transducers.

In the project, capacitive ultrasonic transducers, so-called CMUTs – which offer high sensitivity and thus good resolution – are to be coupled with modern transmission and reception technologies, as known from 5G mobile communications. Integration into an overall system has the potential to drastically increase image quality, enabling novel applications such as transcranial ultrasound of cerebral hemorrhages or efficient tumor screening of the smallest lesions.



Video: Innovation Project "HybridEcho"

Capacitive micromachined ultrasound transducers (CMUT) website

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Early disease detection in body fluids with photonic biosensors

Standard medical procedures are time-consuming and often do not take into account individual differences between patients, leading to potential consequences for treatment outcomes and quality of life. To address this problem, Fraunhofer IPMS, in collaboration with partner institutes Fraunhofer IZI and Fraunhofer IOF at the Fraunhofer Center Erfurt, is developing disposable biosensors with extensive multiplexing capabilities that deliver rapid results. These biosensors enable early disease detection, personalized medicine and precision medicine, which has the potential to significantly improve healthcare outcomes.

The photonic biosensor chips are developed at Fraunhofer IPMS on a silicon nitride waveguide platform technology. These biosensors consist of specially developed, scalable on-chip multi-channel microring resonator architectures of currently up to 16 sensors operating at a wavelength of 1550 nm. Further designs are currently being developed towards the visible range based on microring resonators and Mach-Zehnder interferometers. The detection method is based on special bioassays developed by the partner institute Fraunhofer IZI, in which antigen molecules bind specifically to functionalized sensor surfaces. If binding is successful, a resonance wavelength shift is read out in the transmission spectra of the device. These biosensors are highly sensitive in detecting biomolecules in liquids, which makes them useful for the early detection of diseases in body fluids.

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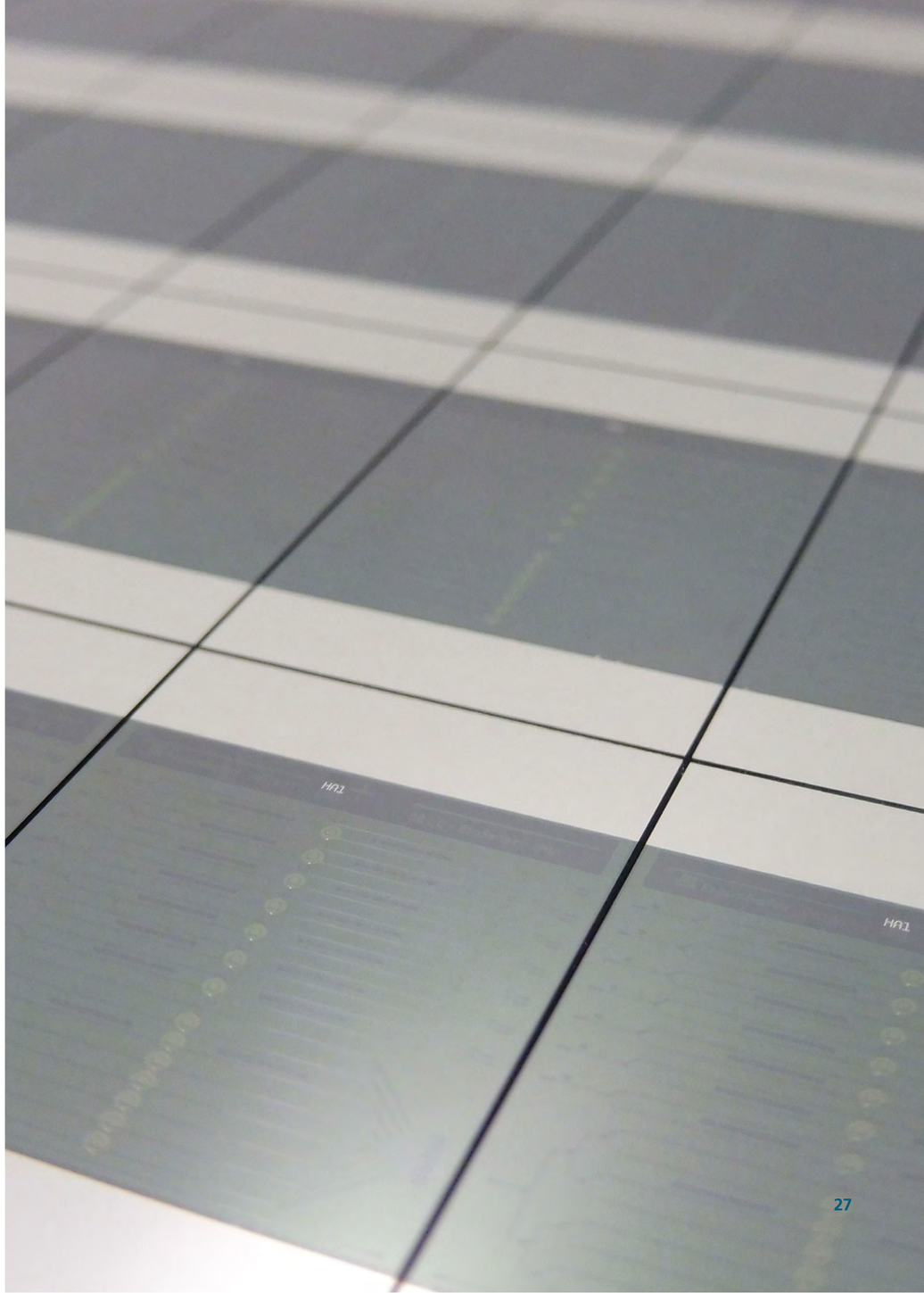
The research team's approach is multidisciplinary. This approach includes the development of sensor chips, bioassays, biocomponents, surface functionalization, microfluidics and system integration. By considering all these aspects, the team strives for optimal performance and reliability of the biosensor system.

The research team has successfully developed a demonstrator based on a multi-channel silicon nitride microring resonator biosensor system. This system enables the multiplex detection of specific miRNA biomarkers associated with neurodegenerative diseases in liquids. The detection is performed via DNA-based capture molecules immobilized on the sensor surface. The developed sensors and the integrated system are versatile and can be adapted for the detection of nucleic acids, various pathogenic biomarkers, viruses or bacteria in different liquids.

The next development phase involves collaboration with diagnostics companies and clinics to further advance the development of biosensors for relevant biomedical applications. The aim is to realize the practical implementation of these biosensors in healthcare facilities.

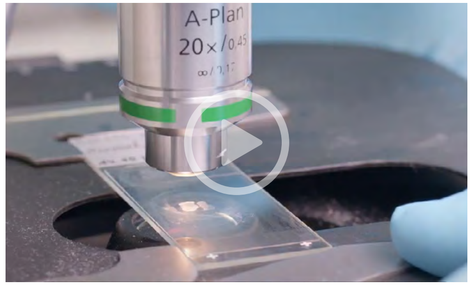
Biosensors website
Webinar „Optical and Electrical Microsystems for Advanced Biomedical Imaging and Diagnosis“



Research projects

LSC Onco: Laser scanning microscope improves detection of tumor cells

Distinguishing between tumors and healthy tissue during a surgical procedure is of great importance, but can be a challenge. As part of the Fraunhofer Center Erfurt, we have developed a novel, MEMS-based confocal laser scanning microscope for this purpose together with Fraunhofer IZI.



Video: MEMS-based laser scanning microscopy for improved cancer cell detection

Medical imaging website

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Spirometer: Early detection of diseases using ultrasound breath analysis

Early detection of severe disease progression, for example in respiratory diseases, strongly improves the chances of recovery. By recording physical parameters such as respiratory rate and volume, signs of illness can be detected earlier than usual and, above all, non-invasively and therefore particularly gently. Fraunhofer IPMS has developed an ultrasound-based spirometer for exactly this purpose.

Video: How Do Micromachined Ultrasound Transducers (MUT) Work?

Capacitive micromachaned ultrasound transducers (CMUT)

Webinar: Capacitive micromachined ultrasonic transducer (CMUT) – from concept to device

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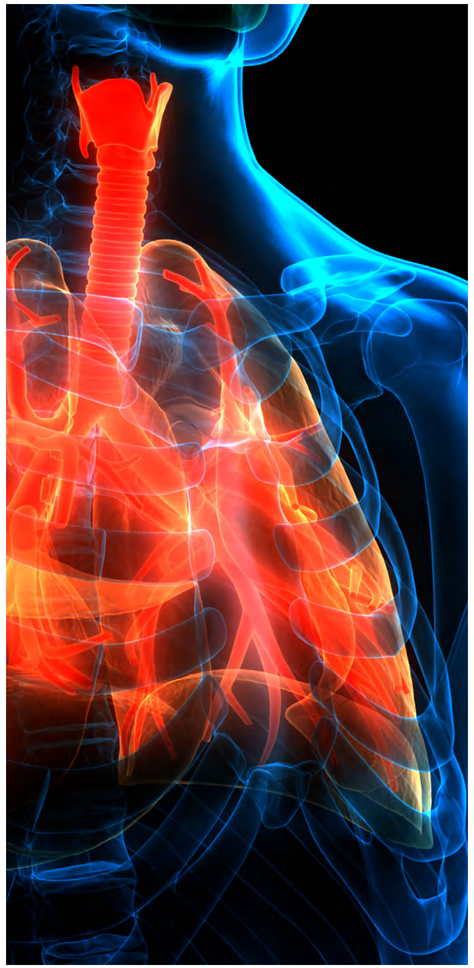
You can find all our projects and technologies in the field of medical technology **here**.

Our **Webinar "Smart Systems for Medical and Health"** will give you a quick overview of our research.

IMS respiratory gas analysis – detecting diseases in the air we breathe

Various diseases change the metabolism in the body. This can often be detected by volatile organic compounds (VOCs) in the air we breathe. The Fraunhofer Center Erfurt is developing a silicon-based chip as the basis for an ion mobility spectrometer that can detect typical VOCs for the early detection of diseases.

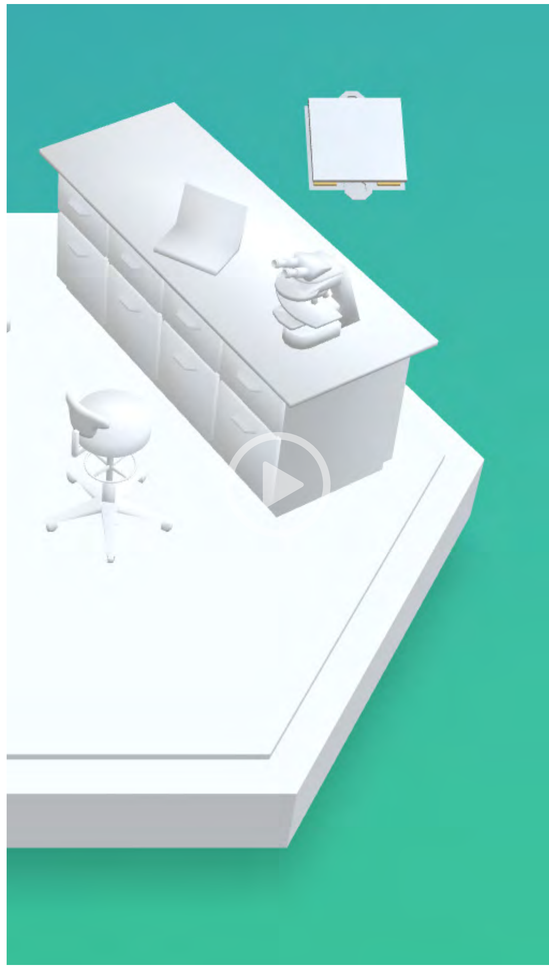
- **Website: Respiratory air analysis – applications for biotechnology and medical technology**
- **Webinar: Multimodal, Modular and Mobile Sensor System for Improved Patient Monitoring**



Targeted illumination of biomedical samples to reduce light-induced damage

In light microscopy, permanent illumination with a relatively high brightness causes damage to biomedical samples due to the light radiation. In order to reduce this phototoxic effect, the illumination must be selective and limited to the area to be examined. The Fraunhofer Center Erfurt is developing optical modules for high-resolution microscopy that can selectively control the incident light.

- **Webinar: Optical and Electrical Microsystems for Advanced Biomedical Imaging and Diagnosis**
- **Website: Structured illumination for microscopy: targeted illumination of biomedical samples to reduce light-induced damage**
- **Video: Structured Illumination for Microscopy**



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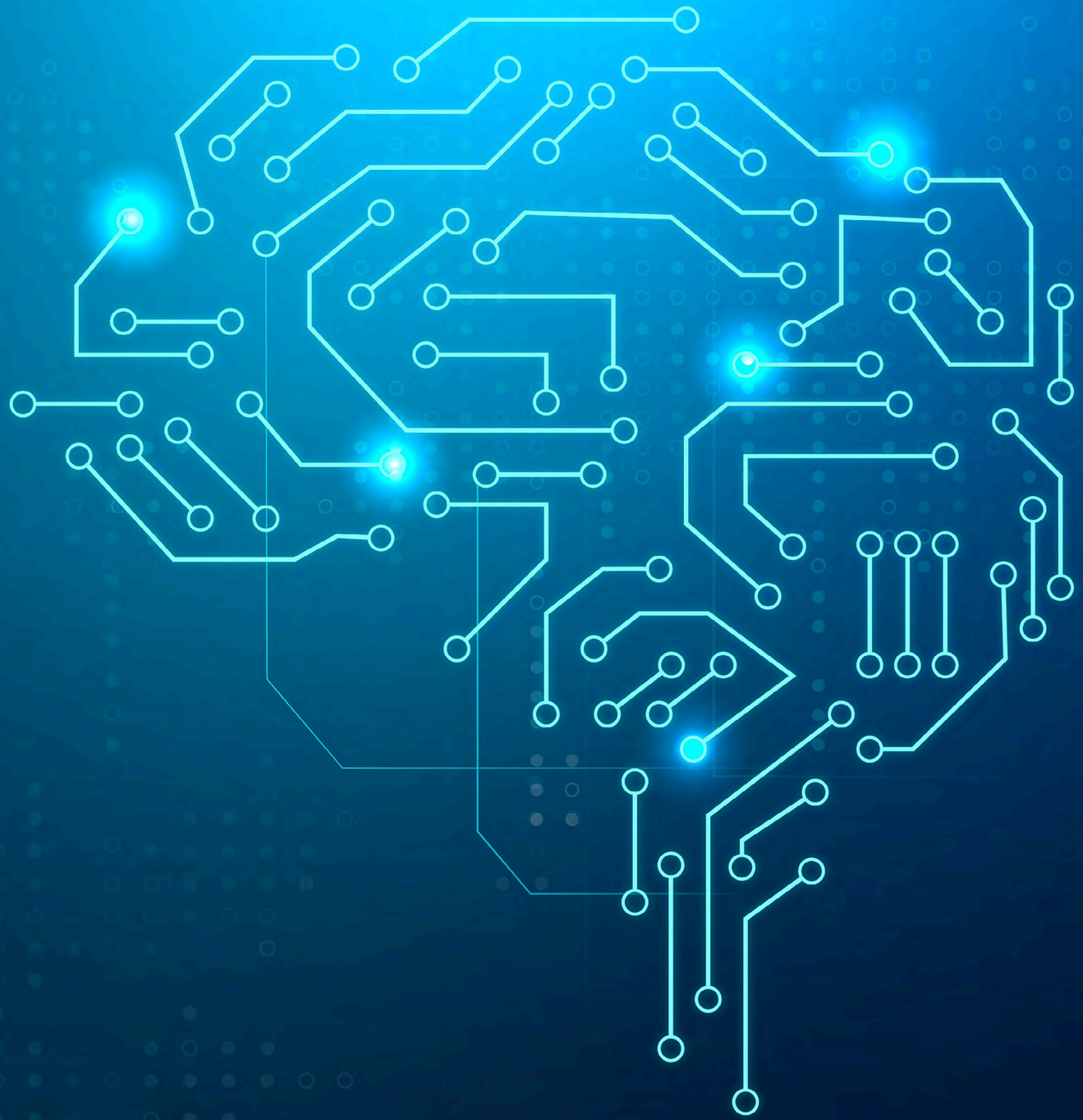
Annual Report 2023/2024

Sensors & AI



OASYS – Optoelectronic sensors for application-oriented systems for life sciences and intelligent manufacturing

As the sensory organs of digitalization, sensors form the basis for smart solutions in the commercial and private sectors – from the optimization of agricultural and industrial production, the intelligent design of mobility concepts and urban planning to home automation and the personalization and decentralization of medical care.

The OASYS project is researching the (further) development of MEMS-based technologies for imaging processes that not only offer new possibilities and functionalities for image acquisition compared to previously available solutions, but are also compact, mobile and extremely energy-efficient and deliver reliable results even under challenging environmental conditions.

At the kick-off in December 2023, Manja Schüle, Minister of Science, Research and Culture (MWFK) of the State of Brandenburg, said: "The research consortium pools the expertise of several scientific institutions, works together across state borders and cooperates with regional companies. The best conditions for a strong innovation ecosystem in Lusatia: the solutions and ideas developed here should help small and medium-sized companies on their way into the digital future and create more highly qualified jobs in Lusatia. There were already many good reasons to settle in Lusatia before. As of today, there is one more."

In addition to Fraunhofer IPMS, the project consortium includes BTU Cottbus-Senftenberg and the Leibniz Institutes FBH and IHP. The BMBF is funding the project over a period of five years with 12.5 million euros as part of the Coal Structural Strengthening Act.

Dr. Andreas Berns (VDI/VDE Innovation + Technik GmbH), Prof. Dr. Günther Tränkle (Leibniz FBH), Prof. Dr. Gerhard Kahmen (Leibniz IHP), Dr. Manja Schüle (MfWK Brandenburg), Prof. Dr. Harald Schenk (Fraunhofer IPMS), Prof. Dr. Michael Hübner (Vice President for Research at BTU Cottbus-Senftenberg), Prof. Dr. Matthias Beller (Vice President of the Leibniz-Gemeinschaft, Director of LIKAT), Gerhard Kast (CEO of UP Umweltanalytische Produkte GmbH; OASYS praxis partner)

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Federal Ministry of Education and Research

Checking items of clothing using a smartphone, AI and infrared spectroscopy

Fraunhofer IPMS has developed an ultra-compact near-infrared spectrometer that is suitable for analyzing and identifying textiles. The combination of imaging, special AI algorithms (artificial intelligence) and spectroscopy means that even mixed fabrics can be reliably identified. The technology could optimize the recycling of used clothing and enable used clothing to be separated by type. An extremely miniaturized version of the system even fits into smartphones. This could open up numerous new applications for consumers in everyday life – from checking clothes when shopping to checking for counterfeits.

The first step is to take a picture of the item of clothing using a conventional camera module. From the image information of the textile fabric, the AI selects a concise point to be examined by the spectral analysis module. The spectrometric profile of the textile fabric is compared with a reference database to determine which fibers are involved. The optical resolution is 10 nanometers. Thanks to the high resolution, the NIR spectrometer can also determine mixed fabrics such as polyester and cotton garments with the help of AI. With a surface area of 10 x 10 and a height of 6.5 millimetres, the system is so compact that it could easily be integrated into a standard smartphone.

Press release "Checking clothes with a smartphone, AI and infrared spectroscopy"

Website: Near-infrared spectrometers

Video: How Does NIR Spectroscopy Work?

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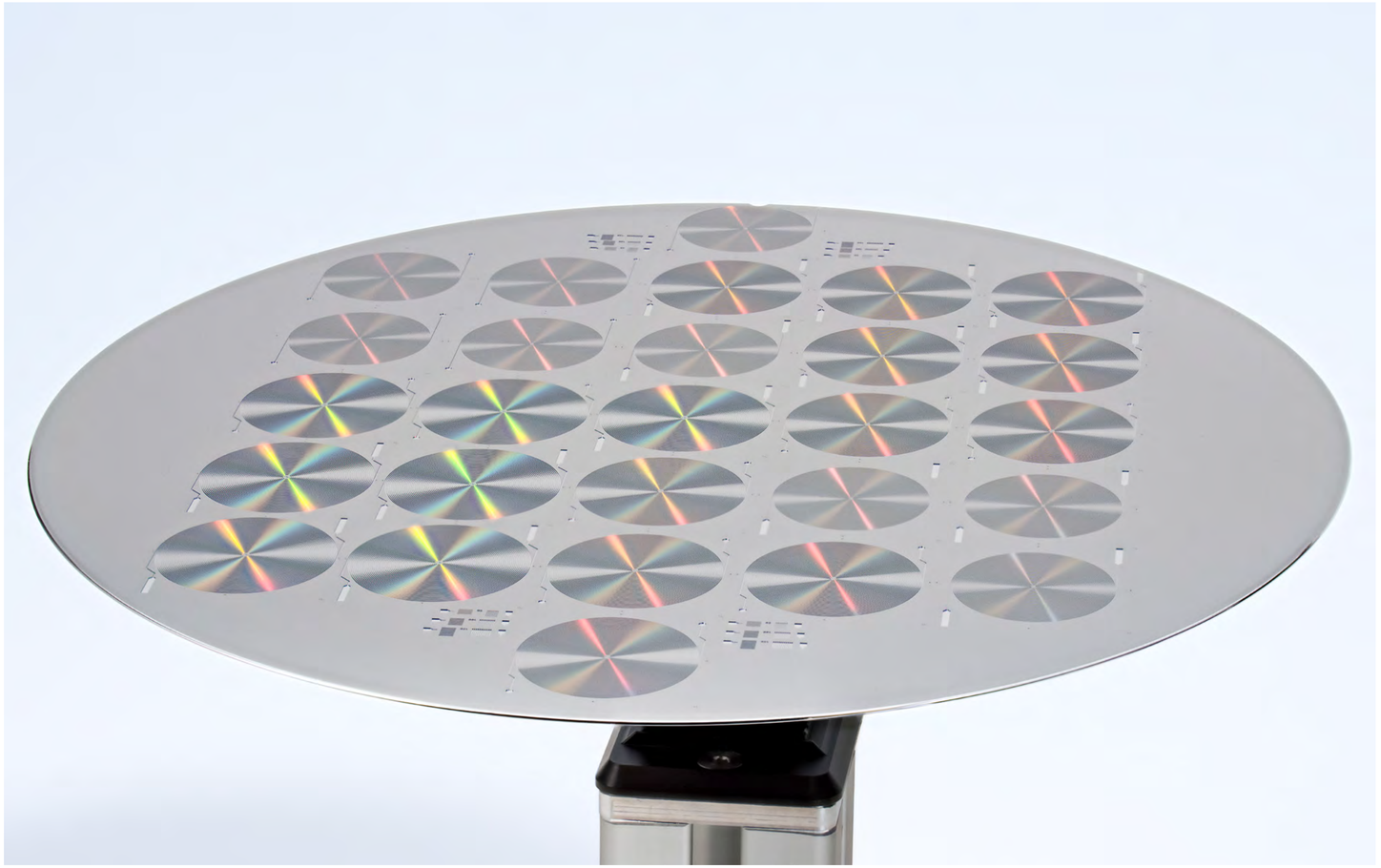
Chemical sensor technology for food analysis

Damage to health could be avoided and inferior product quality detected if sensitive, selective on-site analysis adapted to the application was available. With the technologies available today, this is not yet available with the required speed, precision and user-friendliness. Fraunhofer IPMS is therefore researching a mobile gas chromatography (GC) system that is fast, easy to use, robust and inexpensive.

It is used to analyze so-called VOCs – volatile organic compounds. VOCs are chemical compounds that are characteristic of a certain composition or health hazard. The detection, identification and quantification of VOCs is of great importance in many areas. These include, for example, food quality / safety, medical markers, civil security, agriculture, etc.

In the project, two application-specific demonstrators for VOC detection are being developed and demonstrated in two industry-relevant key applications. One is the identification of counterfeit food, for example olive oil. The second application is plastics recycling.

Project: Pummel – Point of Use Micro-Multichannel-Gas-Chromatograph



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Research projects

You can find all of our projects and technologies in the field of sensing on our **website**.

Why not find out mor about our ultrasound sensors? Watch our **Webinar „Low frequency MEMS ultrasound transducers“**.

AI-powered microsensors and actuators for gesture recognition

Digital helpers – such as smart apps or smart cars – are already firmly integrated into everyday life. However, Data is currently mostly processed on large, external servers. Embedded artificial intelligence (edge AI) aims to change this and enable Data and algorithms to be processed directly on the end device. Fraunhofer IPMS is therefore researching innovative solutions to integrate machine learning algorithms into everyday devices.

Sensor- and actuator-based signal pre-processing using AI

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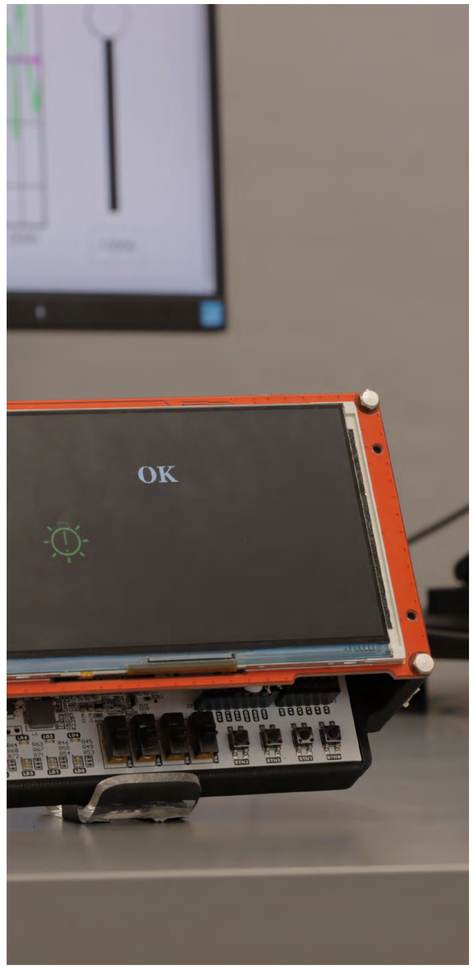
Predictive maintenance using AI-powered sensors

Machine damage and breakdowns are often associated with high costs and usually lead to considerable economic losses. Conventional methods of machine monitoring are limited to the detection of damage that has already occurred and the prevention of consequential damage based on a few measured variables and simple characteristics.

Predictive sensor technology that detects damage before it occurs would be desirable. Fraunhofer IPMS is therefore researching smart, MEMS-based sensors with AI-powered Data evaluation for predictive maintenance.

Press release: RISC-V processor core from Fraunhofer IPMS now Edge AI-ready

Video: Edge AI solutions for predictive maintenance



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Annual Report 2023/2024

Digitalization & Data Communication

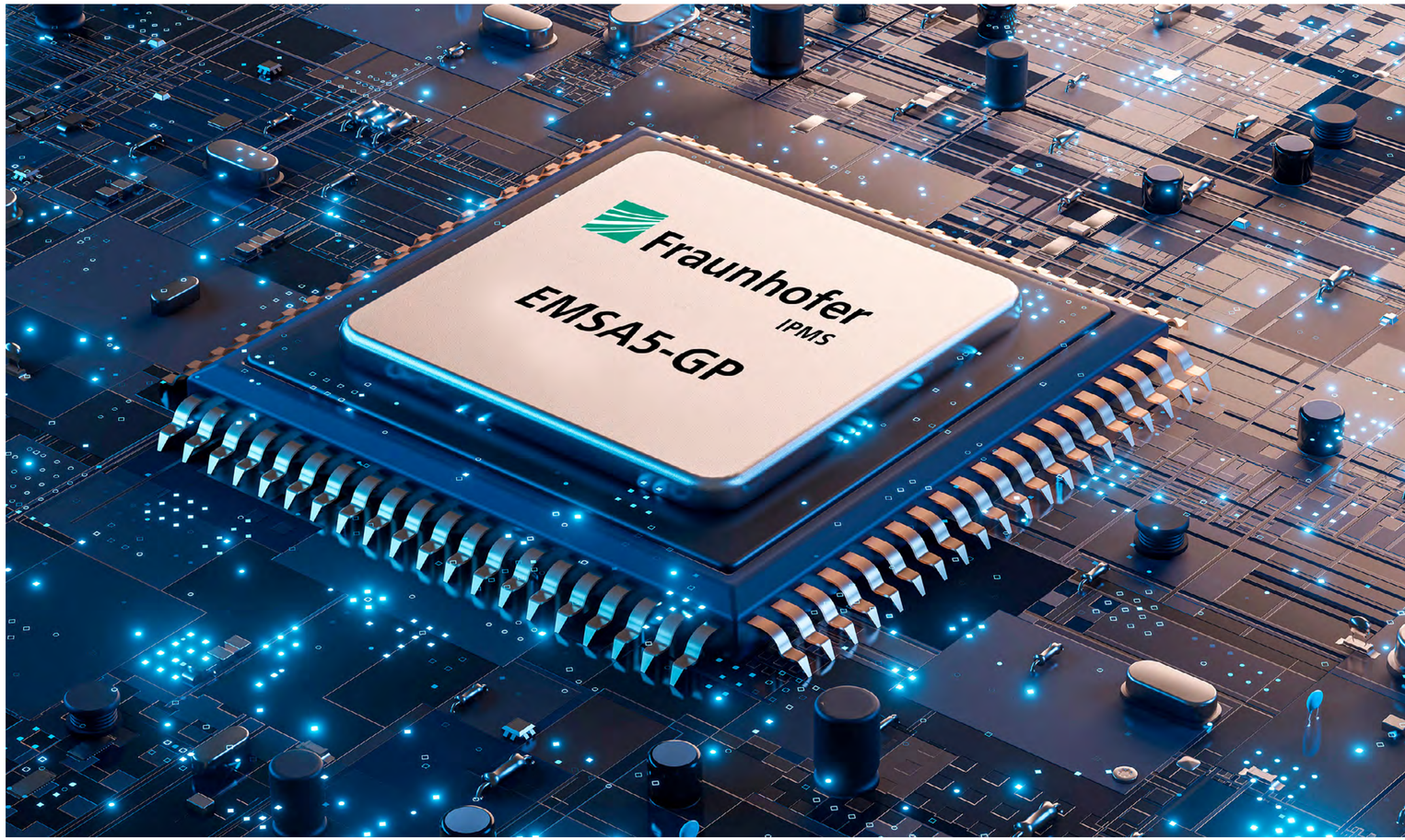
Flexibility, longevity and security – RISC-V conquers the processor market

The open-source instruction architecture called "Reduced Instruction Set Computer V" (RISC-V) was designed with the aim of focusing on energy efficiency as well as computing power for new designs. This enables small, energy-efficient and high-performance processors.

The accessibility of RISC-V has triggered a revolution and, thanks to its open architecture, enables developers to design processors that are tailored to specific requirements. Fraunhofer IPMS also offers a processor IP based on the RISC-V instruction architecture.

The EMSA5 is a 32-bit processor with a five-stage pipeline that is used both in embedded systems and in functional safety applications such as in the automotive sector. For the latter, the IP core has ASIL D ready certification in accordance with ISO 26262.

Whitepaper



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New controller IP-Core for enhanced data security

Data security is one of the most important issues in today's digital age. Increasing system attacks and cybercrime make it necessary to secure data in new ways. Fraunhofer IPMS has therefore developed the MACsec Controller IP-Core, which implements the latest Ethernet security standards. It ensures the authentication, integrity and encryption of data between different nodes of a Local Area Network (LAN).

The latest controller IP-Core Media Access Control Security (MACsec) implements the Layer 2 security standard specified in IEEE 802.1AE. MACsec protects Ethernet connections at the second layer of the OSI model by using a combination of authentication, encryption and integrity protection to ensure that only authorized nodes communicate on the network, traffic remains confidential and data integrity is maintained.

MACsec can be used with the Fraunhofer IPMS LLEMAC IP core, any other Ethernet MAC IP core and in standalone mode. Thanks to its platform independence, simple system integration is possible so that the MACsec can be integrated into any FGPA or ASIC.

Press release
Whitepaper

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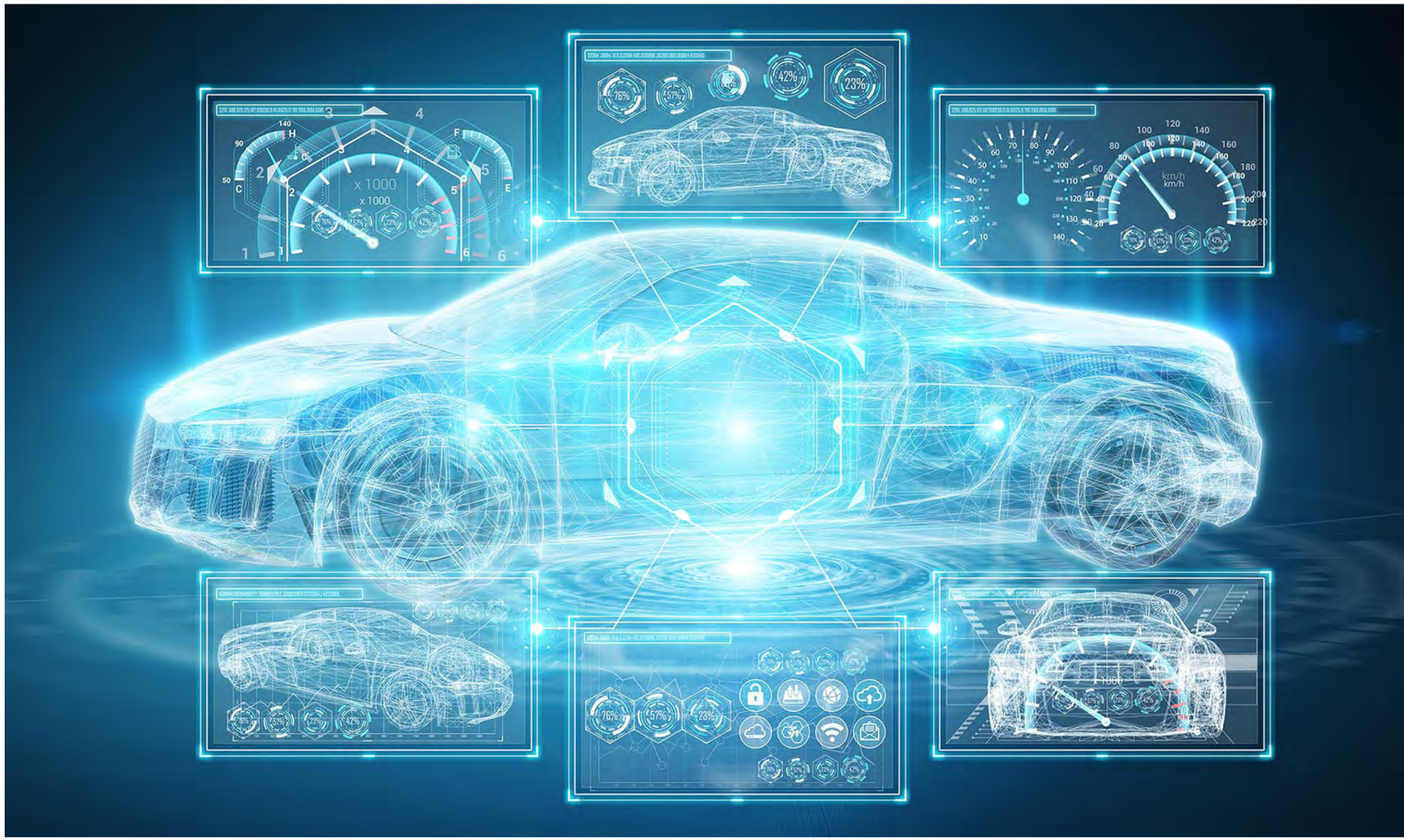
Fraunhofer IPMS is driving the revolution in vehicle architecture

The vehicles of the future will be automated and connected in order to move autonomously in road traffic and relieve the burden on drivers. This requires new vehicle architectures and high-performance components. With its expertise in Automotive Ethernet TSN, Fraunhofer IPMS is supporting various research projects in which TSN components are being developed to meet future requirements.

In the "Verano" project, the focus is on the development of distributed and efficient data processing using AI methods. The aim is to optimally distribute the computing load and develop an AI-controlled radar sensor network using sustainable communication technologies.

The "CECAS" research project is developing an automotive supercomputing platform for automated driving. The consortium is designing processors, interfaces and system architectures for this purpose.

Whitepaper
Press release



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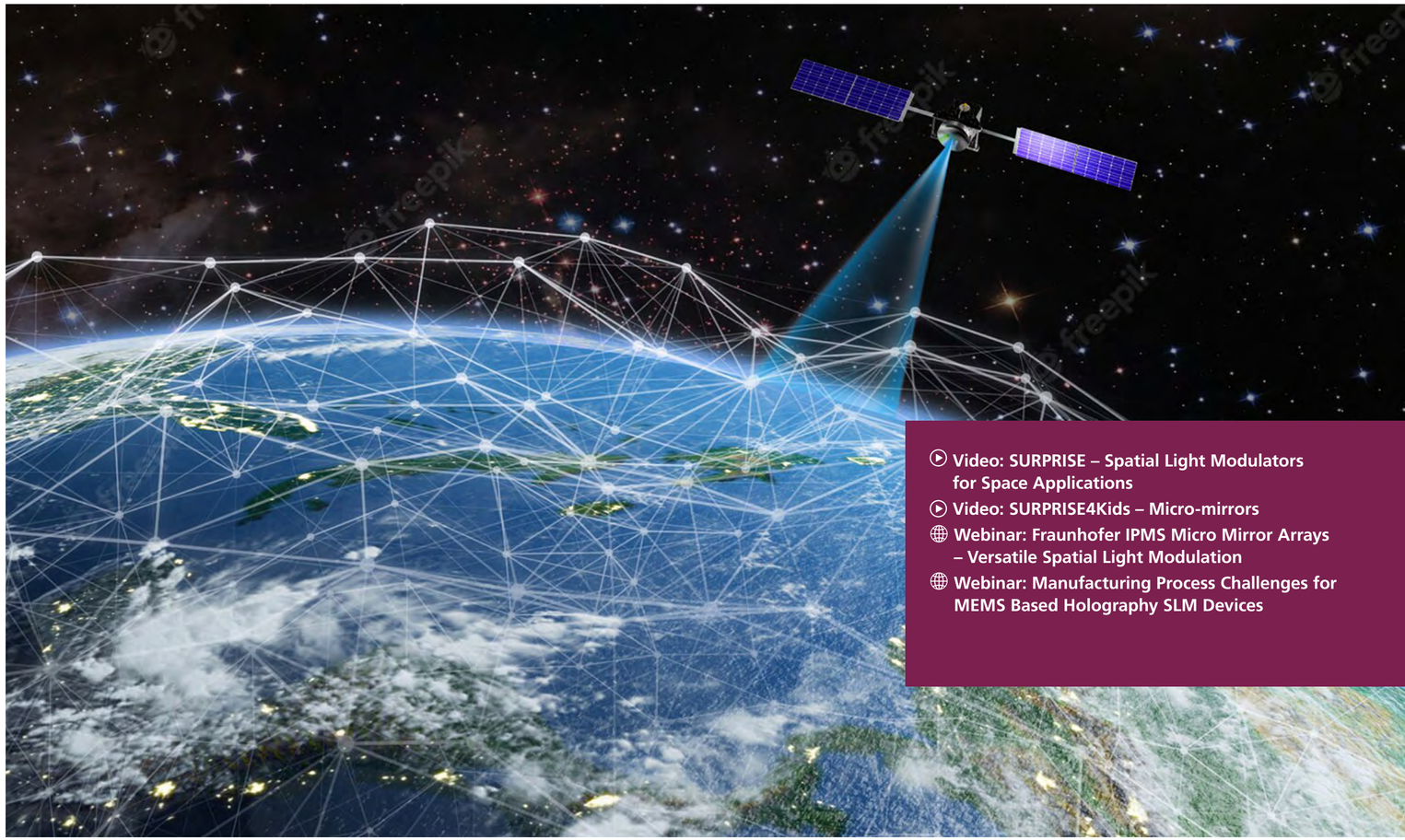
Microtechnology conquers space for more precise earth observation

Earth observations are becoming increasingly important for a better understanding of our planet. However, the collection and processing of data from space still face obstacles. It takes a long time, sometimes even several days, to obtain information. Additionally, the images only provide rough details of about one kilometer in size. Capturing the invisible part of light is very challenging with current technologies.

A solution is provided by new optical systems with spatial light modulators (SLM). They capture data from space with high resolution and have been developed and tested in the EU project SURPRISE.

In the three-and-a-half-year project, which was completed in June 2023, an SLM of the current technology generation from Fraunhofer IPMS successfully underwent a test under space conditions. The 256 x 256 pixel device was evaluated for temperature (from -40 °C to 80 °C), vacuum (< 10^{-5} mbar), and vibrations in the X, Y, and Z axes. Not a single pixel failed.

These experimental findings, together with the simulation results, confirm the robustness of the spatial light modulators from Fraunhofer IPMS and encourage further activities for the development of SLM technology for space.



- Video: SURPRISE – Spatial Light Modulators for Space Applications
- Video: SURPRISE4Kids – Micro-mirrors
- Webinar: Fraunhofer IPMS Micro Mirror Arrays – Versatile Spatial Light Modulation
- Webinar: Manufacturing Process Challenges for MEMS Based Holography SLM Devices

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Novel devices for increased hardware security

To ensure that electronic products have not undergone any unauthorized modifications, it is desirable to incorporate encrypted identifications (IDs) or encrypted operation logs into the electronic circuits. For example, to ensure the mileage of vehicles or to verify/secure payment transfers using credit cards. However, the challenge is increasingly arising that these security elements can be bypassed either through software-based methods or hardware reverse engineering.

The goal is therefore to create a solution that is reliable, secure, and cost-effective. The two currently established approaches, databases and security chips (HSM chips), can be manipulated or hacked. Therefore, Fraunhofer IPMS is researching novel components that enable more secure hardware obfuscation.

These components can selectively change their ferroelectric behavior through a process called Field-Induced Nucleation of Crystals (FINK). Unlike electrons in flash devices, the ferroelectric polarization cannot be read out, allowing for multidimensional concealment.

Contact person

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Emerging Memory Solutions
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DNA as a future mass data storage device

DNA is known as the fundamental medium for storing genomic information. However, DNA can also be used for storing (binary) data – a future technology that is currently being explored in basic research in Europe.

Within the project "Modular high-throughput micro-platform for future mass data storage based on synthetic biology," funded by an internal program of the Fraunhofer-Gesellschaft, a novel microchip platform for efficient cell-free and digitally controllable biosynthesis is being developed.

Fraunhofer IPMS, along with three other institutes, is conducting research on the foundations for future mass data storage with extremely high storage density. The microchip platform to be developed for writing software-defined nucleotide sequences (e.g., DNA, RNA, or peptides) aims to enable the high-throughput production of mass data storage through replication in the microelectronics industry's mass production processes. By miniaturizing the current space-consuming synthesis devices into portable, energy-efficient, and cost-effective systems, the platform aims to enable commercial, biology-based data storage.

Contact person

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Acoustic Sensors and Systems
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sandro.koch@ipms.fraunhofer.de

Fraunhofer IPMS

Annual Report 2023/2024

Highlights

Awards

Dresden Excellence Award

Congratulations to Dr. Thomas Kämpfe for being awarded the Dresden Excellence Award on March 11, 2023, for his habilitation **"Electron Devices Based on Ferroelectric Hafnium Oxide Thin Films"**.

© Jürgen Männel

Alfred Kuhlenkamp Prize

Dr. Maximilian Lederer was awarded the Alfred Kuhlenkamp Prize by the VDE GMM (Society for Microelectronics, Microsystems, and Precision Engineering) for his work on **"Material Development of Doped Hafnium Oxide for Non-Volatile Ferroelectric Memory"**. This is the highest distinction awarded by the GMM to young scientists.

Best Paper Award

Hanying Wen received the Best Paper Award at the 46th International Spring Seminar on Electronics Technology (ISSE) for her paper **"Characterization of AlSiCu/TiN/p-Si Schottky Contacts with Nanophotonic Structures for Near-Infrared Photodetectors"**.

© Fraunhofer / Mark Müller

Joseph von Fraunhofer Prize 2023

In-ear headphones that are wirelessly inserted into the ear canal could potentially replace smartphones in the future. The foundation for this is being laid by a research team from Fraunhofer IPMS and Bosch Sensortec GmbH with a novel technology for integrated microspeakers – and they were awarded the Joseph-von-Fraunhofer Prize, which comes with a prize money of € 50,000.

Press release

© Fraunhofer / Mark Müller

Fairs & Events 2023

Photonics West
January 31 – February 2, San Francisco, USA

We presented our latest developments in areas such as microoptics, MEMS-based light modulators, and biophotonics.

Embedded World
March 14 – 16, Nuremberg

In Nuremberg, we showcased the latest developments from our extensive portfolio of IP cores for FPGAs and ASICs.

Sensor+Test
May 9 – 11, Nuremberg

We showcased our range of sensory technologies, including ultrasound, optical, and chemical sensing. The High Performance Center Micro/Nano and the iCampus were also represented.

OFC
March 5 – 9, San Diego, USA

At the joint booth of Berlin Partner at OFC in San Diego 2023, we presented optical actuators for fiber optic systems.

Girls' Day
April 27

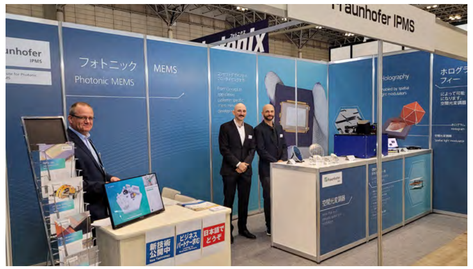
On Girls' Day, female students from the fifth grade onwards had the opportunity to immerse themselves in the world of microelectronics at Fraunhofer IPMS. We are looking forward to welcoming more visitors next year!

LASER World of Photonics
June 27 – 30, Munich

We presented the latest developments in the field of micro mirrors and spatial light modulators. The Fraunhofer Center Erfurt was also present, showcasing research results in the field of medical technology.

June 30, Dresden

Every year, it is a great pleasure for us to introduce the Dresden public to our research. In 2023, we showcased a selection of technologies in the foyer of the Technical University of Dresden. Our program was complemented by a series of exciting lectures and a career speed dating event.



Photonix

October 4 – 6, Tokyo

In Tokyo, everything revolved around our spatial light modulators for high-precision steering, control, and shaping of light.

Medica

November 13 – 16, Düsseldorf

At the Fraunhofer joint booth, we presented our latest developments in biosensors, medical imaging, and breath gas analysis.

Semicon EU

November 14 – 17, München

At the Silicon Saxony joint booth, there was a comprehensive display of the 200 and 300 mm technologies of Fraunhofer IPMS, with a particular focus on Green ICT in microelectronics manufacturing.

MST Congress

October 23 – 25, Dresden

In 2023, the MST Congress focused on sustainability and technological sovereignty. Prof. Hubert Lakner, Institute Director of Fraunhofer IPMS, served as the chair of the conference. In addition to numerous presentations and posters on current technology developments, we also organized a barcamp for the first time, allowing participants to exchange ideas and network on current topics in microelectronics. There was also a moderated panel discussion on best practices in talent recruitment.

At the joint booth of the Research Fab Microelectronics Germany (FMD), Fraunhofer IPMS presented a new demonstrator for two-photon lithography as well as ion mobility spectroscopy. The High Performance Center Micro/Nano and the iCampµs Cottbus were also present.

Guests

Sonotec
March 2023

During the visit, we discussed plans for joint public projects in the field of MEMS devices, and of course, a tour of the institute was an essential part of the visit.

A visit from down under
July 2023

Maria Antico from the Australian research institute CSIRO and Davide Fontanarosa from the Queensland University of Technology visited us to discuss collaboration in the field of MEMS.

Ascent+ Research Accelerator Day
October 2023

As part of the European project Ascent+, a group of international students and researchers had the opportunity to gain insights into our 300 mm research.

Brazilian delegation
November 2023

In November 2023, we had the pleasure of hosting a Brazilian delegation from the Ministry of Science, Technology, and Innovation, the Ministry of Industry, and the Eldorado Institute.

European delegation
June 2023

In June, we were delighted to welcome a 33-member delegation from Sweden, Austria, Poland, France, Belgium, Spain, and Lithuania as part of the Silicon Saxony Days & Excite Project in Dresden.

Wissenschaftsminister Sebastian Gemkow
September 2023

As part of the Spin2030 campaign, the Saxon Minister for Science visited our Center for Nanoelectronic Technologies, which is the largest German research center for applied microelectronics research based on 300 mm wafer industry-standard equipment.

Taiwanese delegation
November 2023

As part of the enhanced collaboration with Taiwan, we welcomed a Taiwanese delegation from the National Taiwan University of Science and Technology, led by the university's president, Prof. Jia-Yush Yen.

Belgian royal couple at X-FAB
December 2023

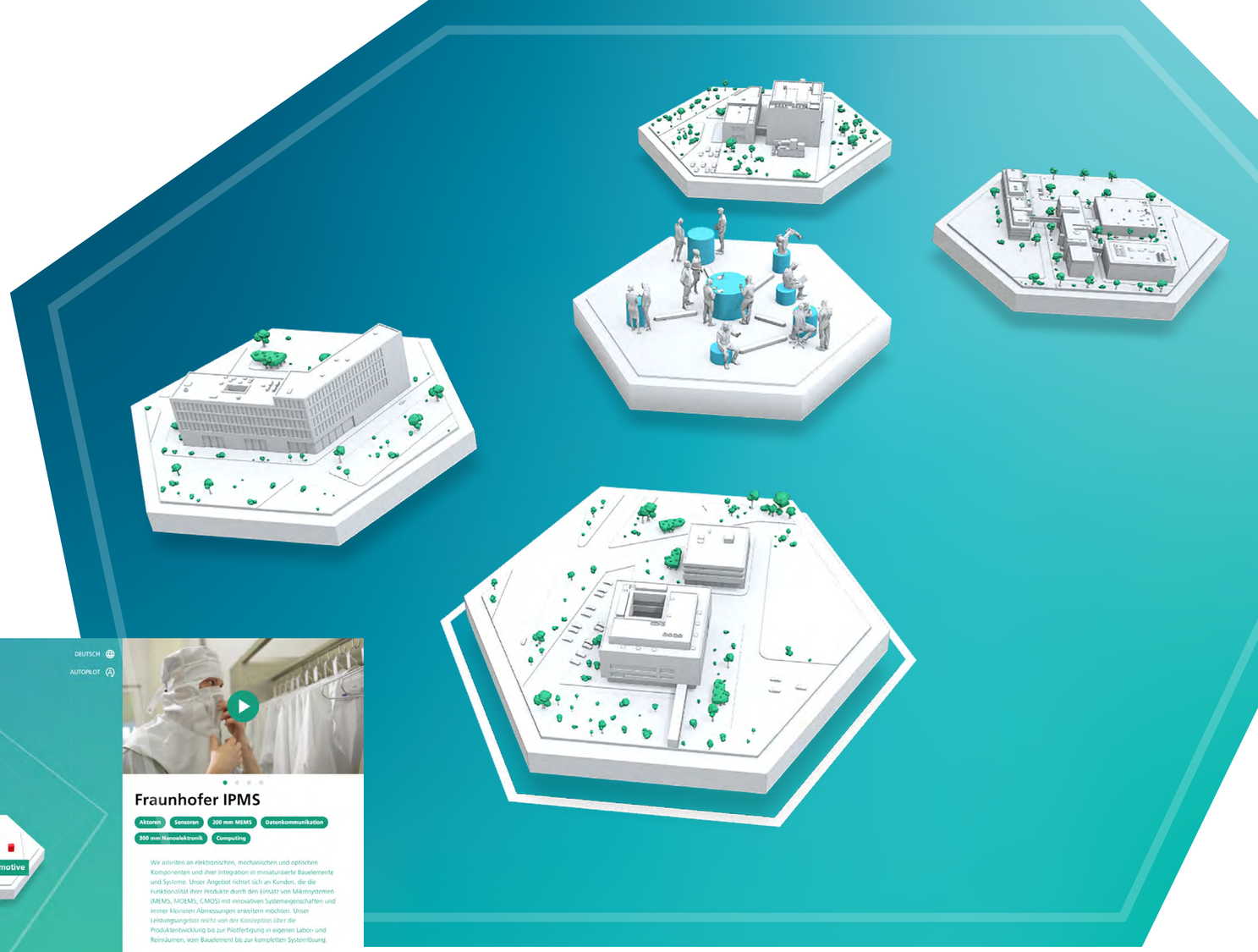
During the visit of the Belgian royal couple with President Steinmeier at X-FAB, our institute director Prof. Harald Schenk presented details about the German-Belgian collaboration in the semiconductor field and the ongoing research activities.

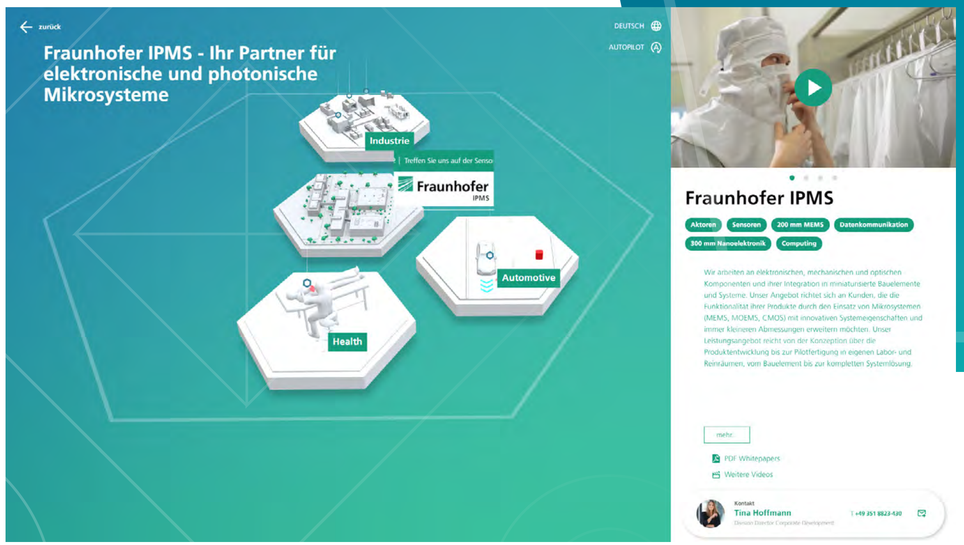
© Pawel Sosnowski
(Courtesy of Saxony State Chancellery)

Showroom

In the virtual showroom, you can experience our technologies interactively and in 3D. Take a look around and discover our demonstrators and application videos. Enjoy exploring!

www.showroom.leistungszentrum-mikronano.de





360° cleanroom tour

Many people have heard of a cleanroom, but far fewer have actually visited one. However, that can now change for all interested individuals with the virtual cleanroom tour offered by Fraunhofer IPMS. With just a click of the mouse, you can access the foyer, the changing room, and finally, the cleanroom, where you can explore the facilities and processes.

Why is it necessary to change clothes before entering the cleanroom? How does one pass through the airlock? What happens in the lithography area? And what kind of equipment does Fraunhofer IPMS have for 200 mm technology?

If you are curious, there is a quick and easy answer to these questions: Start the virtual cleanroom tour and find out! In the various areas, you will find plenty of information about the equipment and technologies of Fraunhofer IPMS. If you prefer to "dive in" for a more immersive experience, you may have the opportunity to participate in a physical cleanroom tour during a project meeting at Fraunhofer IPMS.

Virtual cleanroom tour

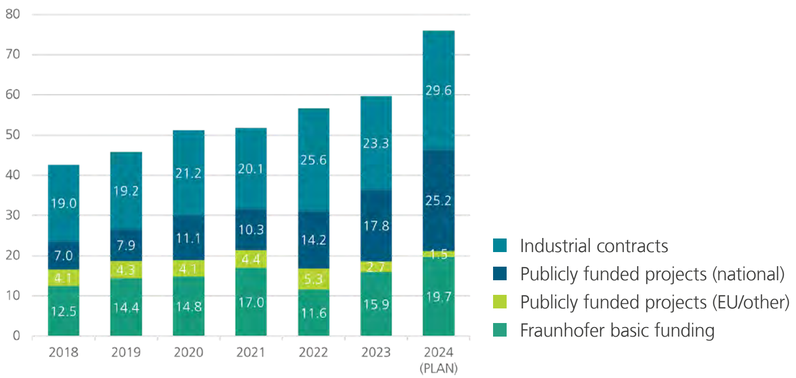
Fraunhofer IPMS

Annual Report 2023/2024

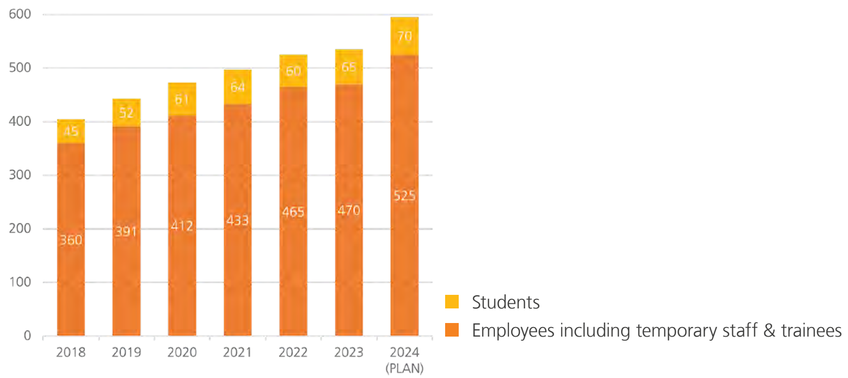
Fraunhofer IPMS at a glance

Figures

Budget (in million Euros)



Employees



At a glance

	2018	2019	2020	2021	2022	2023	2024
Industry in %	47.1	43.0	43.5	40.8	48.1	39.0	38.9
Public funds (national) in %	17.3	17.6	22.7	20.9	26.7	29.8	33.2
Public funds (EU/other) in %	4.9	3.0	2.0	3.1	5.0	4.6	2.0
Total revenue in %	74.7	70.2	74.6	70.7	84.8	73.3	61.1

Plan

Advisory Board 2023

Industry representatives

PD Dr. Ingeborg Hochmair-Desoyer
MED-EL Medical Electronics, CEO

Björn Sass
GlobalFoundries Dresden, Module One LLC & Co. KG, Principal Member Of Technical Staff

Dr. Ronald Schnabel
VDE/VDI Gesellschaft Mikroelektronik, Mikrosystem- und Feinwerktechnik (GMM), Managing Director

Prof. Dr. Frank Schönefeld
T-Systems Multimedia Solutions GmbH, Member of the Board

Dr. Johannes Schumm
Sensirion AG, Vice President Research & Development

Scientific Representatives

Prof. Dr.-Ing. Karlheinz Bock
TU Dresden, Faculty of Electrical and Computer Engineering

Prof. Dr.-Ing. Jürgen Czarske
TU Dresden, Chair of Measurement and Sensor System Technique, Director of Institute of Circuits and Systems

Jörg Doblaski
X-FAB Global Services GmbH, CTO

Prof. Dr. Gesine Grande
Brandenburg University of Technology (BTU) Cottbus-Senftenberg, President

Prof. Dr. Wolfgang Osten
University of Stuttgart

Prof. Dr. Katja Schenke-Layland
University of Tübingen, Director Natural and Medical Sciences Institute

Prof. Dr. Ulrike Wallrabe
University of Freiburg, Department for Microsystems Engineering

Public Sector Representatives

Dr. Lutz Bryja
State Ministry for Higher Education, Research and the Arts, Head of Division

Dirk Hilbert
State Capital of Dresden, Mayor

Sts. Barbara Meyer
Saxon State Ministry for Regional Development, State Secretary

Dr. Inge Schlotzhauer
Brandenburg Ministry of Sciences, Research and Cultural Affairs, Head of Division

Dr. Eike-Christian Spitzner
VDI/VDE Innovation + Technik GmbH, Head of Department Electronics and Microsystems

Dr. Tina Züchner
German Federal Ministry of Education and Research, Advisor

Participants in the Advisory Board meeting in 2023.

Strategy audit

In May 2023, Fraunhofer IPMS successfully had its strategy audited by external experts from science and industry. The strategy process is a methodology that has been anchored in the Fraunhofer-Gesellschaft for over 15 years. Strategy development serves to position the institute for the future in a competitive environment. On this page, we give you an insight into the feedback from our auditors.


Auditors in the strategy process of Fraunhofer IPMS.

Fraunhofer IPMS has a very good reputation and is closely linked to industry.«

"The trend topics presented, such as medical/health, Green ICT, AI and edge sensor technology are, in my view, the right choice, also in terms of view of strengthening microelectronics in Europe."

"The ability to produce microelectronic structures on the basis of 200 and 300 mm wafers is an absolutely unique selling point. Fraunhofer IPMS thus occupies an excellent position and is able to accompany new products through to pilot production. This capability is also linked to the special position in the Research Fab Microelectronics Germany (FMD)."

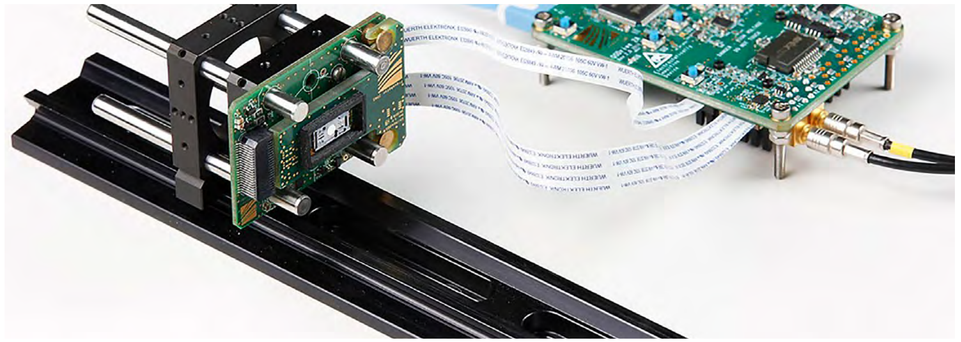
Fraunhofer IPMS plays an indispensable role in the research infrastructure of the federal states (especially Saxony).«

A coherent vision was presented, which is in line with the content presented from the individual divisions and provides clear guidelines for the further development of the institute in the coming years.«

In the cleanroom strategy, it is noticeable that small series production/ pilot production is also increasingly being sought for optimal capacity utilization. In addition to the SME target group, this offer could also be of interest to industrial sectors with long test and market development phases and the associated smaller quantities and longer start-up curves (e.g. medical technology).«

Evaluation kits

With our evaluation kits you get a fully functional experimental setup and can immediately test our technology for your application.



MEMS scanners for quasi-static or resonant operation

The evaluation kits "QSDrive Scan Kit" (for quasi-static scanners) and "Simple MEMS Driver" (for resonant scanners) allow especially small and medium sized companies to operate MEMS scanners of Fraunhofer IPMS according to specification without the complex in-house development of drive electronics.

The evaluation kit for quasi-static scanners consists of a ResoLin device – a gimbal MEMS scanner with a linear axis and an optional, orthogonally oriented resonant axis – as well as control electronics that enable operation of the devices with a supplied optimized trajectory. Depending on the design of the MEMS device, closed-loop operation of the device and synchronized operation of the resonant axis are also possible. Function control is performed by software that communicates with the electronics via USB.

The resonant scanner kit contains a 1D or 2D resonant device – a cardanic MEMS scanner with one or optionally with two orthogonally oriented resonant axes – as well as the Simple MEMS drive electronics, which enables the operation of both axes with the respective resonant frequency. Depending on the design of the MEMS component, synchronized operation of the resonant axes is also possible. Function control is provided by software that communicates with the electronics via USB.

Both evaluation kits include a scan head that holds the device. Thus, thanks to its special design, the evaluation kit can be easily integrated into common optical experimental setups.

MEMS evaluation kit

LiFi Hotspot & Gigadock

In the LiFi area, we offer two evaluation kits with different focuses. LiFi GigaDock® is suitable for an optical, wireless, bidirectional point-to-point data link in full duplex mode over short distances in the cm range. Different versions offer data rates from 1 to 5 Gbit/s. For medium distances in the meter range, our evaluation kit LiFi Hotspot is a good choice. It supports data rates up to 1 GB/s at a distance of up to 5 m.

LiFi Hotspot evaluation kit
LiFi Gigadock® evaluation kit

Ethernet Time Sensitive Networking (TSN)

The evaluation kit consists of either a Smartzync board (Xilinx) or a Netleap board (Intel/Altera) with an optionally implemented IPMS TSN-IP core for endpoint applications (TSN-EP), switched endpoint applications (TSN-SE), or switch applications (TSN-SW). Linux drivers with application examples as well as RTOS test applications and TSN network configuration examples are also available

TSN evaluation kit

CMUT

The "CEK CMUT" evaluation kit offers interested developers and users of ultrasonic sensors the possibility to build a fully functional experimental setup for evaluating miniaturized capacitive micromachined ultrasonic transducers (CMUT). It consists of either one or two CMUT sensor modules, adapted control electronics, and software as a web application that controls the CMUT via plug-and-play.

CMUT evaluation kit
Video of the CMUT evaluation kit

RISC-V Prozessor IP-Core

Our EMSA5 demo platform is an ideal tool for evaluating the RISC-V processor IP core EMSA5. It includes an Artix®-7 35T FPGA arty evaluation board with implemented EMSA5 IP core.

RISC-V evaluation kit

Find all of our evaluation kits on our **website**

Whitepapers & webinars

Whitepapers

#1
Time Sensitive Networking – An Introduction to TSN

#2
TSN implementation on the basis of Intel FPGAs

#3
TSN-Ethernet Switched Endpoint Controller

#4
Latency-Optimized TSN Networks

#5
RISC-V processor core for functional safety

#6
Smart Catheter Pilot Line - A European Benchmark

#7
CAN IP core design

#8
Zone-based E / E architecture: CAN XL and Automotive Ethernet

#9
CANsec - Security for the third Generation of the CAN Bus

#10
Rotating Innovation: Contactless High-Speed Data Transmission

#11
MACsec,a basis for secure Ethernet networks

Webinars

#2
Li-Fi – Communication at the Speed of Light

#4
Automotive LIDAR Technologies

#6
Capacitive Micromachined Ultrasonic Transducer (CMUT) – From Concept to Device

#8
MEMS Technologies for Vehicle Environment Detection

#11
Optical and Electrical Microsystems for Advanced Biomedical Imaging and Diagnosis

#16
Meet our experts: Leveraging Semiconductor Manufacturing for large-scale Quantum Computing Technology

#17
Advanced Technology and Harware for Next Generation Computing

#20
Neuromorphic Computing for Edge AI

#26
300 mm Semiconductor Analytics: XPS/HAXPES Scanning Microprobe

Watch all of our webinars on our **website**

Networks and scientific collaboration

iCampus

The innovation campus electronics and microsensors Cottbus – iCampµs – is a research cooperation aimed at developing innovative sensors to introduce small and medium-sized companies in the region to high-tech topics such as microsensor technology, AI-based algorithms, and 5G data transmission.

As a member of iCampµs, Fraunhofer IPMS, with its Cottbus branch, conducts research on technologies in the field of environmental sensing, Industry 4.0, and smart health. This includes Schottky photodiodes for automated processes, sensors for near-infrared (NIR) in Industry 4.0, as well as MEMS HF varactors for 5G mobile communication.

iCampus Cottbus
Video: iCampus Cottbus – the innovation campus electronics and microsensors in the Lusatia region

Lausitz Science Network

Fraunhofer IPMS is a member of the Lausitz Science Network e.V. (LSN). The LSN is an alliance of research institutions that aim to further develop the strengths of the Cottbus-Senftenberg research location and increase its visibility. The participants organize joint conferences, support young researchers, initiate collaborative research projects, and invest in attracting skilled professionals and marketing the science location.

Lausitz Science Network

Lausitz Science Park

The Lausitz Science Park is one of the outstanding projects in structural development. Under the leadership of BTU Cottbus-Senftenberg, an innovation landscape with international appeal is set to emerge in Cottbus in the coming years, combining excellent basic and applied research with innovative start-ups and numerous company settlements.

As a partner in the Lausitz Science Park, Fraunhofer IPMS actively participates in shaping the initiative. In the summer of 2023, Federal President Frank-Walter Steinmeier visited BTU and received on-site information about the development of the Lausitz Science Park.

Lausitz Science Park
Image film

Dresden University of Technology (TU Dresden)

Since its foundation, Fraunhofer IPMS has maintained a close partnership with TU Dresden. This applies in particular to the Faculty of Electrical Engineering and Information Technology, whose deans traditionally advise Fraunhofer IPMS in the Advisory Board. Through the professorship for Optoelectronic Devices and Systems of Prof. Dr. Hubert Lakner, there is an intensive exchange with students. The joint research work is reflected in regular joint public project proposals, publications, trade fair participations and patent applications.

Cooperation in the field of developing innovative components and manufacturing technologies was further intensified with the High Performance Center Micro / Nano.

TU Dresden and Fraunhofer IPMS also present themselves jointly to the outside world. Under the brand "DRESDENconcept", TU Dresden has joined forces with partners from science and culture, among them Fraunhofer IPMS, to make the excellence of Dresden's research visible and to coordinate its science strategy.

HTW Dresden – University for Applied Sciences

To strengthen cooperation, joint workshops have been held since 2021 to exchange research topics and project ideas. From sensor technology, human-machine interaction, edge AI to modern manufacturing processes, there is a range of topics that can be jointly shaped.

In the future, Fraunhofer IPMS will also offer guest lectures and enable students of the HTW Dresden to gain practical insights at the institute through excursions.

Brandenburg University of Technology Cottbus-Senftenberg (BTU)

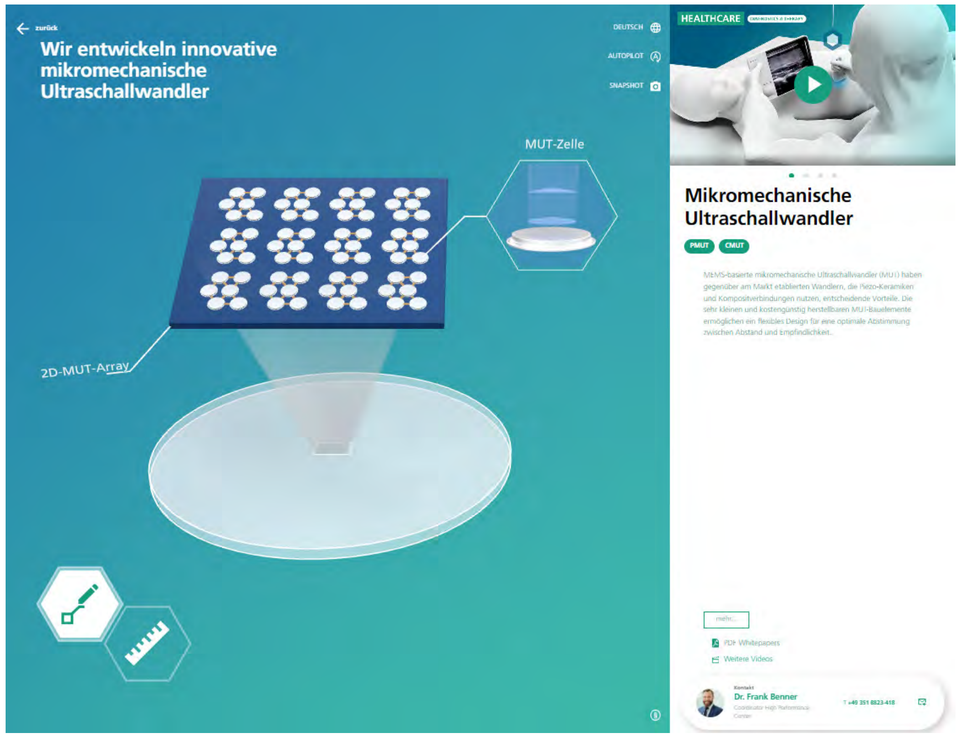
Through the professorship for micro- and nanosystems of Prof. Dr. Harald Schenk on the one hand and the institute's branch "Integrated Silicon Systems" on the other hand, Fraunhofer IPMS is particularly closely linked to the Brandenburg University of Technology (BTU) Cottbus-Senftenberg. The cooperation ranges from the joint use of laboratories and premises to the provision of attractive study focuses in graduate education and further education in the field of photonic microsystems to joint research and development work. You can also virtually visit our laboratories at BTU (in German):

Lab tour
Video "Science Gallery"

In addition, the research activities of BTU Cottbus-Senftenberg, Fraunhofer IPMS and other non-university research institutions are combined in the "iCampµs Cottbus" project (p. 55).

Like Fraunhofer IPMS, BTU Cottbus also focuses on transfer. This is how the "Science Gallery" came into being, which offers a vivid and entertaining presentation of technological innovations in a showroom. The Science Gallery is open to the public and also presents two exhibits of Fraunhofer IPMS, an ultrasonic sensor and a micropositioning system (in German).

Science Gallery



High Performance Center "Functional integration for micro/nanoelectronics"

The High Performance Center Micro/Nano brings together the expertise of four Fraunhofer institutes in Saxony – IPMS, ENAS, IIS/EAS, and IZM-ASSID – as well as the Technical University of Dresden, Chemnitz University of Technology, and Dresden University of Applied Sciences.

Digital showroom
Image video

Fraunhofer IPMS collaborates with Fraunhofer ENAS on research projects such as the development of a sensor platform based on micromechanical ultrasound transducers.

Research Fab Microelectronics Germany (FMD)

Fraunhofer IPMS is one of the 13 institutes that since 2017 have been cooperating in the Research Fab Microelectronics Germany (FMD for its acronym in German). Across locations and technologies, the FMD collectively addresses current and future challenges in electronic research, providing crucial developmental impulses for tomorrow's technology. Around 4,600 employees from all 13 institutes bring together their expertise in the research and development of micro and nano systems.

The FMD bundles the expertise of 11 institutes from the Fraunhofer Group for Microelectronics with that of the Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik (FBH), as well as the Leibniz Institute for Innovative Microelectronics (IHP) under one virtual roof. FMD constitutes a central point of contact for all micro and nanoelectronics related issues in Germany and Europe.

Website
Showroom

Improving Sustainability in Digitalization via Microelectronic Research and Development for Information and Communication Technology

The FMD and the Federal Ministry of Education and Research (BMBF for its acronym in German) took a further step towards the implementation of the German government's climate protection program with the funding project Green ICT @ FMD launched in autumn 2022. Within the Green ICT @ FMD project, all participating institutes are setting-up a cross-location competence center for sustainable Information and Communication Technology (ICT) under the coordination of the FMD business office. This competence center provides a centralized approach to green ICT-specific issues as well as a comprehensive range of cross-technology ICT solutions.

Project website

Promoting New Hardware Solutions for Next Generation Computing

Currently, a large number of fundamental research projects are being carried out in Germany on quantum and neuromorphic computing. Nevertheless, there are still insufficient opportunities for the development and application-oriented hardware testing that is required for highly complex computing technologies, as well as for the rapid implementation of the results into prototypes and small series. This is precisely what the Research Fab Microelectronics Germany - Module Quantum and Neuromorphic Computing (FMD-QNC) project — launched on December 1, 2022 — aims to address. Within the scope of the FMD-QNC project, researchers and companies should be supported in developing customized microelectronics and scalable manufacturing as well as integration processes for new information technologies.

Project website

EU Chips Act: FMD Pilot Line for Advanced Heterogeneous System Integration

Over the coming years, the Research Fab Microelectronics Germany intends to build the most comprehensive and advanced pilot line dedicated to chip integration for innovative, robust and trustworthy heterogeneous systems as a contribution to the EU Chips Act. This pilot line comprises an unprecedented range of component technologies and materials that will enable state-of-the-art system design, interconnection and assembly technologies, along with characterization, testing, reliability, and security assessment. Moreover, this pilot line seeks to promote the innovative potential of the whole industrial spectrum in Europe.

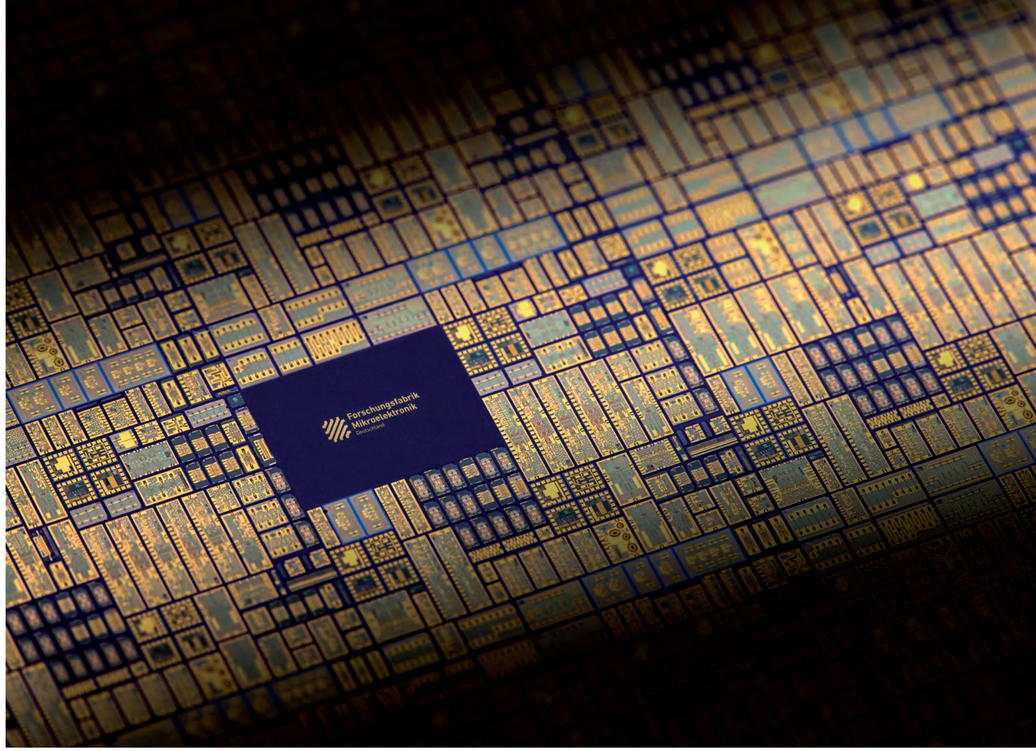
Ensuring Skilled Workers, Attracting Young Talent, Supporting Start-ups and SMEs

Along with the range of technological solutions, various cooperation opportunities, and the coordination of large collaborative projects, the FMD also runs special formats and programs for students, young professionals, start-ups, SMEs and research groups. For instance, the first Green ICT Award was presented in 2023. As part of the Green ICT @ FMD competence center, the award is granted to young talents writing their bachelor's and master's theses on resource-saving information and communication technology. Meanwhile, in 2024, the first Green ICT Camp will be held. The camp is a week-long student training program designed to inspire, raise awareness and promote networking among young students in the field of sustainable microelectronics.

Also last year, the funding programs Green ICT Space and QNC Space were launched. Both programs are open to small and medium-sized enterprises and start-ups (Research groups can also apply to QNC Space), enabling them to implement their ideas in collaboration with FMD institutes and project partners. On the one hand, the Green ICT Space is intended to promote companies and project ideas focusing on sustainability, low energy consumption and emissions reduction. On the other hand, in the QNC Space, applicants receive support to develop individual processes, process modules or subsystems in feasibility studies in the field of neuromorphic and quantum computing.

Both the design and production of microchips and microelectronics as a whole are key drivers of economic growth and progress. Accordingly, the FMD is working on a concept for a Germany-wide Microelectronics Academy aiming to improve the training of skilled workers in the field of microelectronics, e.g. for climate protection and sustainability, new computing technologies and trustworthiness in the semiconductor and chip sector.

Showroom
Video "Get to Know Us"



Patents and publications

Patents

Whether it's novel MEMS-based bending actuators, IP cores, or globally unique spatial light modulators with individually deflected tilt mirrors, Fraunhofer IPMS is synonymous with innovation in the field of optical sensors and actuators, ASICs, microsystems, and nanoelectronics.

Currently, Fraunhofer IPMS holds 297 granted patents, with 197 patent applications in the process of being granted.

Our patents

Publications

At Fraunhofer IPMS, excellent research is conducted, as evidenced by the numerous publications released by its scientists in 2023.

One highlight of the year was a publication on new materials for quantum computing. The paper titled **"300 mm CMOS-compatible superconducting HfN and ZrN thin films forquantum applications"** is available through Open Access at no cost.

Our publications

Theses

Bachelor

Heba Abu Al Aya
„Erkennung von Gesten durch ultraschallbasierte Dopplermessungen“
Koblenz University of Applied Sciences, RheinAhrCampus Remagen
Supervisors: Marcel Jongmanns, Prof. Dr. Marco Junglas

Pau York Brinkhaus Tort
„Konzept Testframework zur automatischen Verifikation von IP-Cores“
University of Leipzig
Supervisor: Prof. Dr. Danilo Beuche

Severin Schmidt
„Design, Aufbau und Charakterisierung eines Varaktordemonstrator“
BTU Cottbus-Senftenberg
Supervisors: Prof. Dr. Harald Schenk, Dr.-Ing. Klaus Schimmanz

Sophie Helene Von Der Sahle
„Evaluierung eines Mikroskopaufbaus zur Untersuchung von Flächenlichtmodulatoren – Eine Anwendung der Beugungskontrast-Mikroskopie“
Coburg University
Supervisor: Prof. Dr. Thorsten Uphues

Chaiwon Woo
„Defektanalyse von ferroelektrischen Feldeffekttransistoren“
Technical University Berlin
Supervisors: Yannick Raffel, Prof. Aleksander Gurlo

Master

Nithin Anujan Beena
„Assembly and Test technology for Thermally and Mechanically sensitive MEMS dies“
Technical University Dresden
Supervisors: Lukas Lorenz, Prof. Dr.-Ing. Thomas Zernaa, PD Dr.-Ing. habil. Martin Oppermann

Sajib Bhattacharjee
„Investigation and optimization of plasma etch processes of Titanium nitride (TiN) for hard mask applications“
Technical University Chemnitz
Supervisors: Prof. Dr. Stefan Schulz, Dr. Katharina Lilienthal

Sandra Bierhals
„Einfluss von kompetenzbasierten Assistenzsystemen in der manuellen Montage“
BTU Cottbus-Senftenberg
Supervisor: Prof. Ulrich Berger

Gunjankumar Gediya
„Characterization of the damping in MEMS components with low quality factors using impedance spectroscopy“
University of Applied Sciences Jena
Supervisors: Dr.-Ing. Anton Melnikov, Prof. Dr. rer. nat. Michael Rüb

Phyllis Graf
„Artificial Neural Network based Defect Analysis in Transistors – Leveraging Machine Learning to Predict Interface Trap Density“
Martin Luther University Halle-Wittenberg
Supervisors: Prof. Dr. Paul Molitor, Dr. Sandro Wefel

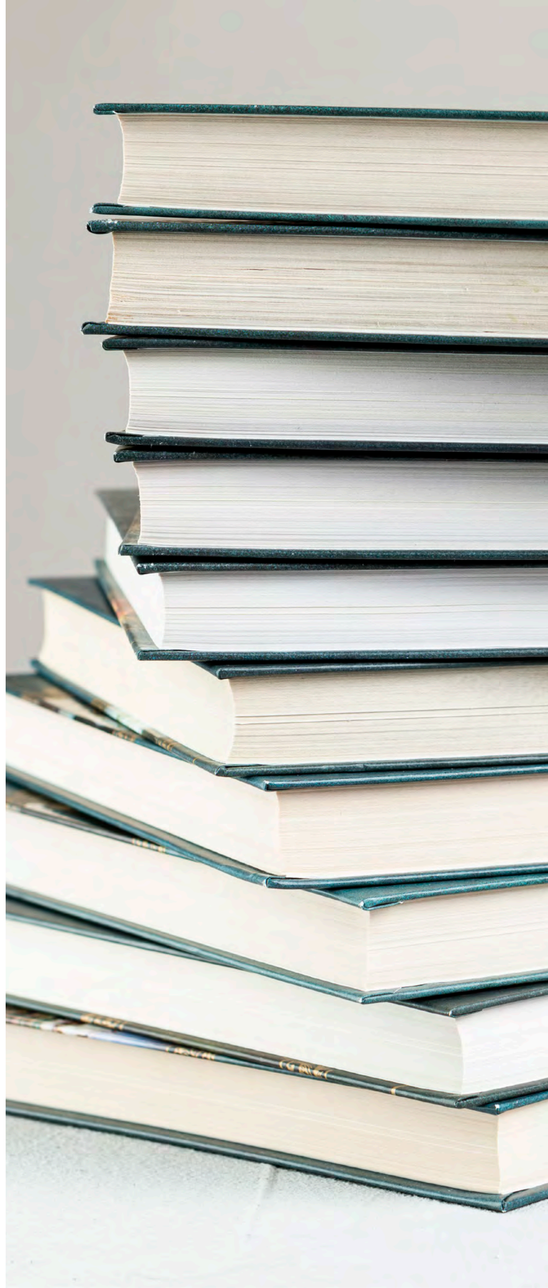
Anastasios Grammenos
„Integration of an in-memory accelerator with a RISC-V microprocessor“
Aristotle University of Thessaloniki
Supervisor: Vardar Alptekin

Prafulla Kumar Gupta
„PVD process development of ferroelectric HfxZr1-xO2 thin films“
Technical University Darmstadt
Supervisors: Dr. David Lehinger, Prof. Dr. Lambert Alff

Leander Hänsel
„Herausforderungen und Möglichkeiten der Vermarktung von F&E-Dienstleistungen – dargestellt am Beispiel des Marktes Holografie im Geschäftsfeld Spatial Light Modulators des Fraunhofer-Instituts für Photonische Mikrosysteme“
HTW Berlin - University of Applied Sciences
Supervisors: Prof. Dr. Annett Wolf, Fabian Lüdke

Fabienne Celine Hartlage
„Organisationsinternes Marketing für Social-Media-Kanäle“
Kiel University of Applied Sciences
Supervisors: Dr. Anne-Julie Zichner; Peter Felten, Prof. Dr. Bernd Vesper, Monika John

Daniel Hessler
„Charakterisierung von Feldeffekt-Transistoren mit ferroelektrischem Dielektrikum (FeFETs) hinsichtlich niederfrequenten Rauschanteilen“
Dresden University of Applied Sciences
Supervisors: Yannick Raffel, Ricardo Orlando Revello Olivo, Prof. Dr.-Ing. Tim Baldauf, M. Sc. Yannick Raffel
Bhavesh Arajanbhai Kachhadiya



„Simulation and Modeling of Acoustic Components of electrostatic MEMS transducer at ultrasonic frequency“
University of Rostock
Supervisors: M.Sc. Jorge Mario Monsalve, Prof. Dr.-Ing. Dennis Hohlfeld

Aravind Kappaganthula
„Design and Concept of a D-band Power Amplifier in 22nm FDSOI-Technology“
Technical University Dresden
Supervisors: M.Eng. Quang Huy Le, Prof. Dr. Hubert Lakner, Prof. Dr. Wolf-Joachim Fischer

Satya Swapna Kommisetti
„FPGA Application Development for SoC ACIM Accelerator“
Technical University Dresden
Supervisors: Prof. Dr. Hubert Lakner, Dr. Thomas Kämpfe, Vardar Alptekin

Rahul Kumar
„A Reconfigurable Hardware Processing Element for a RISCV-based SoC“
Technical University Dresden
Supervisors: Prof. Dr. Hubert Lakner, Prof. Dr. Wolf-Joachim Fischer, Dr. Marcus Bednara

Christopher Mai
„Anwendung maschineller Lernalgorithmen zur Klassifizierung von Montagegesten mit IMU-basierten Datenhandschuhen“
BTU Cottbus-Senftenberg
Supervisors: Prof. Ulrich Berger

Amal Nair
„Design and Implementation of a generic Cyclic-Redundancy-Check IP-Core for high-performance communication“
Technical University Dresden
Supervisors: Dipl.-Ing. Martin Knofel, Prof. Dr. Wolf-Joachim Fischer, Prof. Dr.-Ing. habil. Uwe Marschner

Pascal Pfeiffer
„Development of a Machine Learning Framework for Quantized Neural Networks on Embedded RISC-V Systems“
Technical University Mittelhessen
Supervisors: Dr. Andreas Weder, Markus Noack, Prof. Dr.-Ing. Dipl-Wirt. Ing. Diethelm Bienhaus, Prof. Dr.-Ing. Harmut Weber

Anant Rastogi
„Characterization of metal-ferroelectric-metal (MFM) capacitors with improved bias and temperature stress reliability“
Technical University Dresden
Supervisors: Dr. David Lehninger, Prof. Dr. Lukas M. Eng

Muni Reddy Singana
„Development of the Microcontroller firmware for the CMUT Evaluation kit“
Wismar University of Applied Sciences
Supervisor: Dr. Uwe Völz

Rujay Pawalu Soj
„Implementation and testing of an IP core for „Compact JTAG“ (cJTAG) on an FPGA system for a RISC-V processor“
Technical University Dresden
Supervisors: Martin Zimmerling Prof. Dr. Wolf-Joachim Fischer, Prof. Dr.-Ing. habil. Uwe Marschner

Steve Seemann
„Untersuchung von Fertigungsanomalien mittels Analyse von Prozess- und Metrologiedaten in der Halbleiterfertigung“
FernUniversität in Hagen (Germany's State Distance-Learning University)
Supervisors: Malte Czernowski, Sascha Bönhardt, Maximilian Everding, Prof. Dr. Uta Störl, Valerie Restat, Kevin Kramer
Athira Sunil

„Influence of interface material, scaling and operation temperature on FeFET devices and arrays“
Technical University Dresden
Supervisors: Franz Müller, Sourav De

Quoc Trung Trinh
„Development of magnetic tunnel junction sensors for racetrack memory application“
Technical University Darmstadt
Supervisors: Dr. Benjamin Lilienthal-Uhlig, MSc. Christoph Durner, Prof. Dr. Lambert Alff

Alina Thieme
„Zur Bedeutung sozialer Medien in Business-to-Business Märkten – Eine konzeptionelle Analyse“
Technical University Freiberg
Supervisors: Dr. Anne-Julie Zichner, Prof. Dr. Alexander Leischnig

Simon Elias Tschuck
„Implementierung einer automatischen optischen Inspektion zur quantitativen Fehlerkontrolle von Microscannern“
University of Applied Sciences Jena
Supervisors: Dr. Michael Wagner, Prof. Dr. habil. Jane Neumann

Vinya Vibhuti
„Development of integrated silicon nitride waveguides for applications in the visible and infrared wavelength ranges in a 300 mm CMOS clean room“
Technical University Dresden
Supervisors: Margarita Lapteva

Leonie Vieler
„Defektcharakterisierung von Gateoxiden für die Anwendung in Spin-Halbleiter-Qubits“
Technical University Dresden
Supervisors: Maximilian Lederer, Maik Simon, Dr. Manfred Helm, Dr. Johannes Heitmann

Wenjuan Wang
„Electrical Characterization for Schottky Carrier Near-infrared Photodetectors with Plasmonic Structures“
Technical University Braunschweig
Supervisors: Hanying Wen, Priv.-Doz. Dr. Christine Ruffert, Prof. Dr. Iordania Constantinou“

Zhihao Xian
„Investigation of coating dependent acoustic performance of CMUTs“
Technical University Braunschweig
Supervisors: Dr. Marcel Krenkel, Priv.-Doz. Dr. Christine Ruffert, Prof. Dr. Andreas Dietzel

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Diploma

Jian Chen
„Evaluierung AFM-Messkopf zur Kraftmessung an mikromechanischen Strukturen“
Technical University Dresden
Supervisors: Dipl.- Ing. FH Steffen Wolschke, Prof. Dr. Wolf-Joachim Fischer, Prof. Dr.-Ing. habil. U. Marschner

Robert Dunst
„Prozessdatenanalyse des tiefen reaktiven Ionen-ätzens (Bosch-Prozess) durch Data Mining und anschließende Modellbildung zur Optimierung der Herstellung von resonanten optischen Mikrospiegeln (MOEMS)“
University of Applied Sciences Zwickau
Supervisors: Christian Drabe, Elena Metzner, Prof. Dr. rer. pol. Christoph Laroque, Prof. Dr. rer. nat. Matthias Richter

Ruan Fang
„Simulation-based Evaluation of Photonic Nano-structure“
Technical University Dresden
Supervisors: Dr.-Ing. Lion Augel, Prof. Dr. Hubert Lakner, Prof. Dr. Wolf-Joachim Fischer

Max Haymann-Pohl
„Konzipierung und Umsetzung eines Low-Cost Hand-Held-Spektrometers für Anwendungen im NIR-Bereich“
Dresden University of Applied Sciences
Supervisors: Dr.-Ing. Andreas Weder, Prof. Dr.-Ing. Marc-Peter Schmidt

Salem Lakaw
„Modellierung und Entwicklung einer dezidierten Ansteuerung aktiver Funktionen auf einem LNOI-Wellenleiterchip für Gaussian Boson Sampling (GBS)“
Technical University Dresden
Supervisors: Dipl.-Ing. Matthias Landwehr, Prof. Dr. Wolf-Joachim Fischer

Zschalig, Anthony
„Evaluierung von Ansteuersequenzen zur Reduzierung der Einschwingzeit an elektrostatisch angetriebenen MEMS Array Strukturen“
Dresden University of Applied Sciences
Supervisors: Hanns Torlee, Dr. Andreas Neudert, Dr. Jan-Uwe Schmidt, Prof. Dr.-Ing. Tobias Zaiczek, Prof. Dr.-Ing. Marc-Peter Schmidt

Dissertation

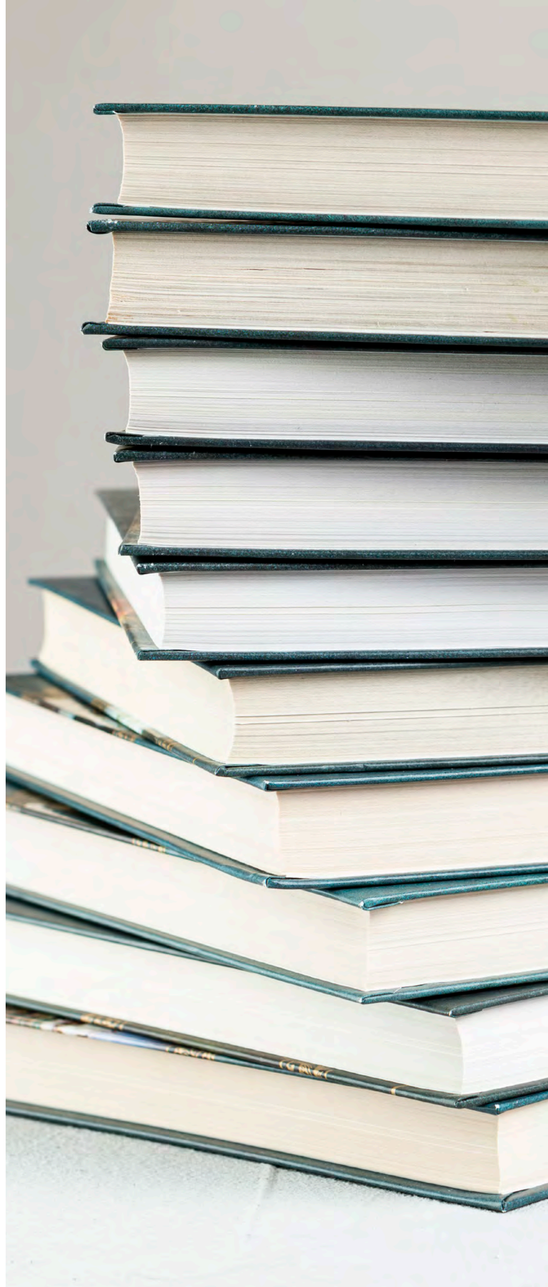
Wael Alsabbagh
„Investigating Security Issues in Programmable Logic Controllers and related Protocols“
BTU Cottbus-Senftenberg
Supervisor: Prof. Ulrich Berger

René Landgraf
„Polymeroptical Waveguides for Biosensing“
Technical University Dresden
Supervisors: Prof. Dr. Hubert Lakner, Prof. Dr. Wolf-Joachim Fischer

Michael Stolz
„Ermittlung und Beurteilung der Zuverlässigkeit von lateralen elektrostatischen Nanoaktoren und ihr Einfluss auf zukünftige Anwendungen“
BTU Cottbus-Senftenberg
Supervisor: Prof. Dr. Harald Schenk

Severin Schweiger
„Additive Manufacturing on Chip“
BTU Cottbus-Senftenberg
Supervisors: Prof. Dr. Harald Schenk, Dr. Sandro Koch, Dr. Sebastian Meyer, Prof. Dr. mont. Mario Kupnik

Eberhart Matthias Wissel
„Entwicklung eines Modells zur Optimierung der Teilhabe im Handlungsfeld der beruflichen Inklusion an industriellen Arbeitsplätzen“
BTU Cottbus-Senftenberg
Supervisor: Prof. Ulrich Berger



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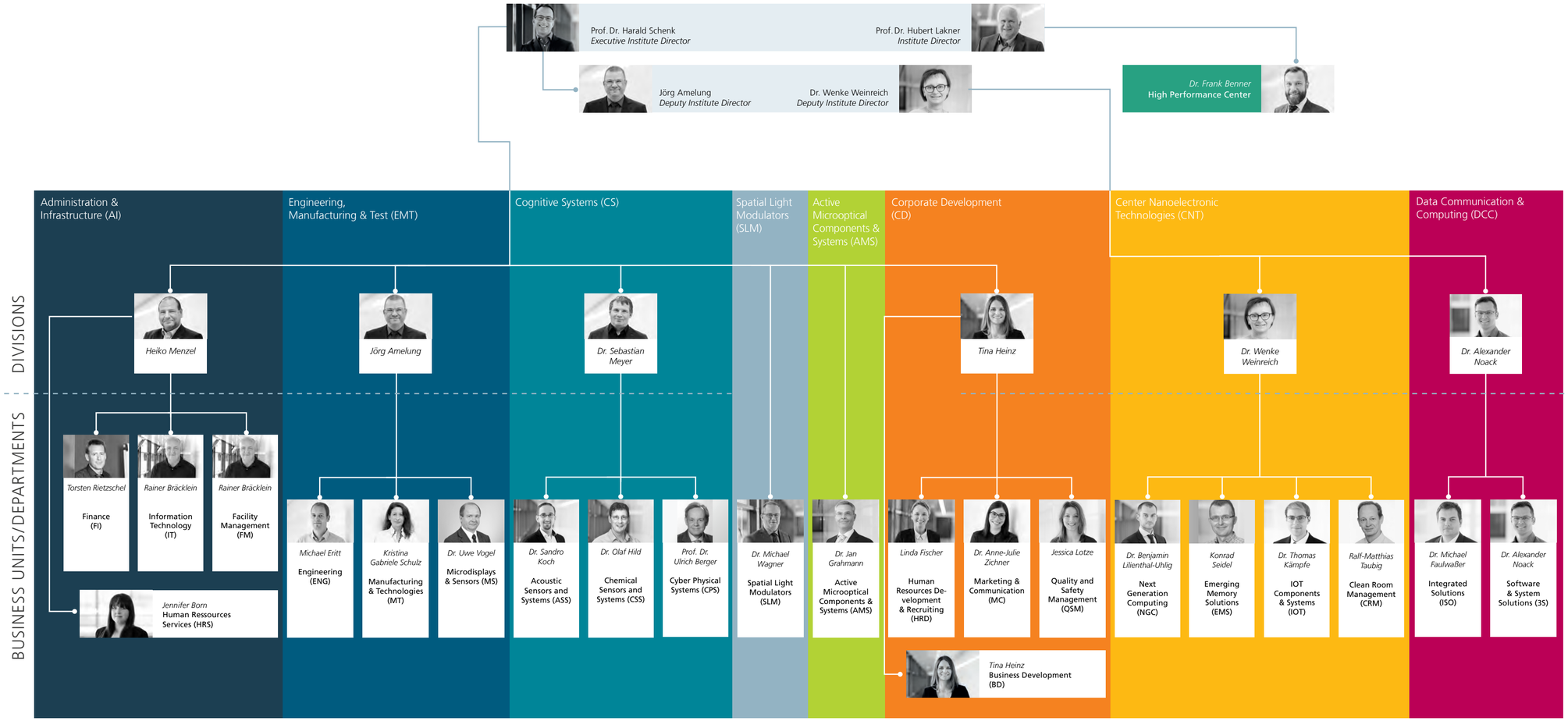

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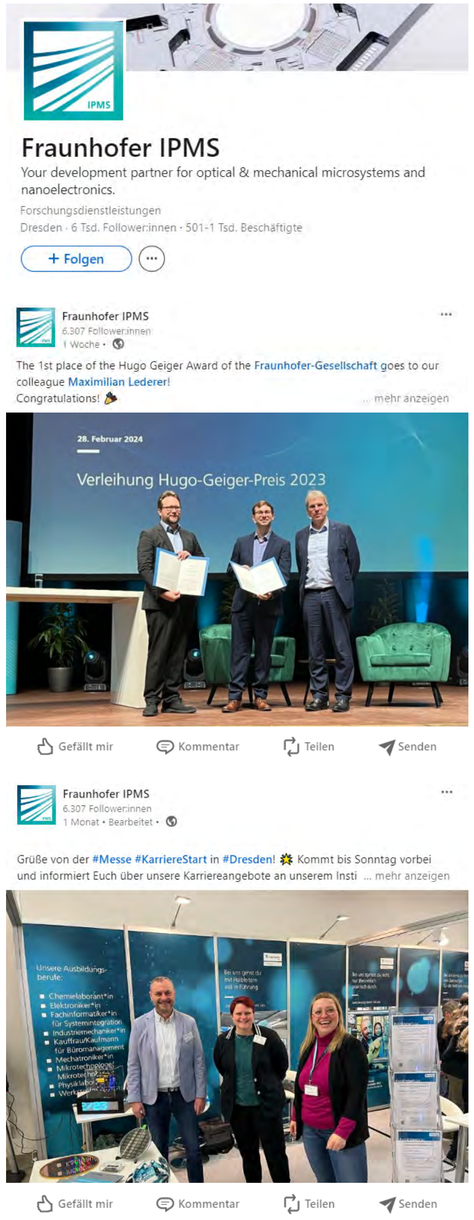

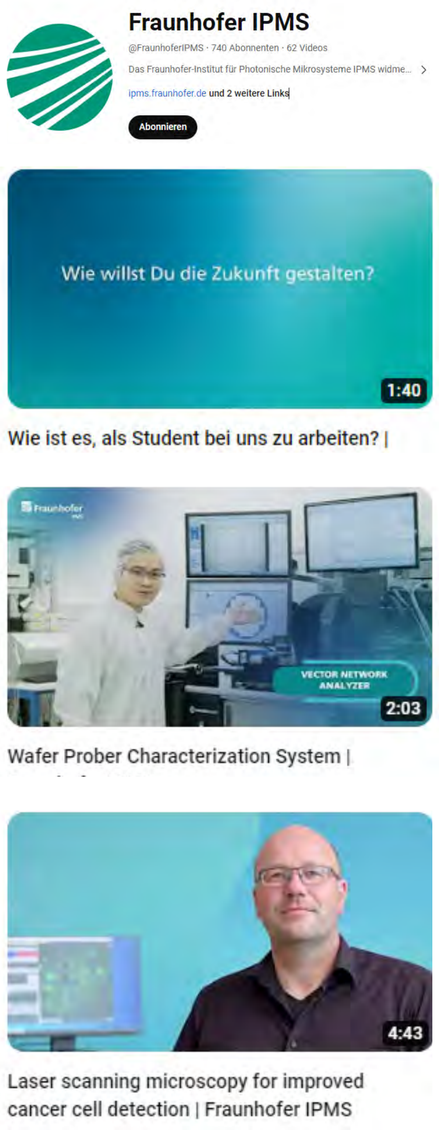

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