



2019

ANNUAL REPORT

Fraunhofer IPMS is one of the 74 currently existing independent institutes of the Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V., the leading European organization for industry-orientated research. Fraunhofer IPMS is DEKRA certified according to the DIN EN 9001:2015 Standard in order to meet out customers' high expectations.





WE RESEARCH FOR THE PEOPLE. APPLICATION-ORIENTATED, INNOVATIVE AND PROFESSIONAL.

With over 390 scientists, Fraunhofer IPMS develops innovative, customer-specific solutions in the fields of industrial manufacturing and automation, medical technology and improved quality of life at four sites in Dresden, Cottbus and Erfurt.

The focal points for our research are miniaturized sensors and actuators, integrated circuits and wireless data communication as well as customer- and application-specific micro-electro-mechanical systems (MEMS).

As a reliable, 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.

FOREWORD



DEAR FRIENDS AND PARTNERS OF THE FRAUNHOFER INSTITUTE FOR PHOTONIC MICROSYSTEMS,

Observing current technology trends proves to us once and for all: digital transformation is an unstoppable force and affects all areas of life. Digitalization and artificial intelligence have the potential to revolutionize our daily lives as well as industry and the economy, whether this is through smart homes, autonomous vehicles or fully-automated production and supply chains. Intelligent, networked technologies are enormously versatile; however, Internet-of-Things applications have one thing in common: there is always a sensor acting as a data provider at the interface between the virtual world and the real world, between people and machines, thereby forming the key component of the IoT. As a specialist in innovative sensor and actuator technology, new technologies for data communication and MEMS-based microsystems, we have been a reliable partner for our customers for many years. The focus of our work is developing solutions for several issues that can be used in industry in the fields of application for intelligent industrial solutions and improved quality of life as well as medical technology and health.

We look back on 2019 as an eventful year full of groundbreaking projects and successes, but also huge challenges. We are very proud to be combining our research activities with those being conducted by three other non-university research institutes in addition to the Brandenburg University of Technology Cottbus-Senftenberg at the newly founded "Innovation Campus Electronics and Microsensors Cottbus". The Innovation Campus's mission is to create synergies and work together to drive forward the transfer of research findings into the economy and society. This active participation makes an important contribution to the structural transformation of the Lusatia region and particularly supports small to medium enterprises with their power to compete.

Prof. Dr. Hubert Lakner
Executive Director

Prof. Dr. Harald Schenk
Director



Synergetic collaboration with other research institutes is the focus for the "Microelectronic and Optical Systems for Biomedicine" Project Hub located in Erfurt and founded in 2018. At this partner institute, Fraunhofer IPMS conducts interdisciplinary research with the Fraunhofer Institute for Applied Optics and Precision Engineering IOF and the Fraunhofer Institute for Cell Therapy and Immunology IZI in the fields of life sciences and microelectronics as well as optics and photonics. Solutions are developed together; problems and issues relating to medicine, biotechnology and the food industry are all addressed.

After spending 15 years in the facilities and cleanrooms owned by Infineon Dresden, our long-term research partners required these premises for their own growth, which posed a particular challenge for us last year in terms of finding a new home for our Center of Nanoelectronic Technologies (CNT). These efforts were successful thanks to the excellent support provided by the Free State of Saxony and the headquarters of the Fraunhofer-Gesellschaft. The new site offers excellent potential for the CNT, so we will also be able to conduct applied research on 300 mm wafers for microchip producers, suppliers, equipment manufacturers and R&D partners in the future. We are extremely grateful for all the support we received for this ambitious undertaking.

The creation of the spin-off company Arioso Systems GmbH is another highlight of our achievements over the past year. This spin-off company is enabling Fraunhofer IPMS to launch a completely new type of loudspeaker onto the market, which is used in hearing aids, hearables and headsets. The patented silicon-based technology has great advantages over conventional loudspeakers in terms of scalable production, scale of miniaturization and power consumption. We are filled with pride every time our

research results in a company being founded, meaning that we are making an important contribution to Germany's ability to compete.

2019 was also a special year for the Fraunhofer-Gesellschaft as it celebrated 70 years of existence under the motto: #Whatsnext? We posed the question and invited our employees to join together in developing visions for innovative solutions, future technologies and new applications as part of Fraunhofer IPMS's first "ideas workshop". Following an evaluation and potential analysis, the most promising of the ideas generated using this new interdisciplinary format are being further developed in 2020.

To conclude, let's take a look at our figures. Our consistent growth in recent years is reflected both in our operating budget of 44 million euros and in the fact that we have over 390 employees, who are now conducting research into solutions for the economy and society at three sites in Dresden, Cottbus and Erfurt. We are optimistic about Fraunhofer IPMS's prospects for the future and are looking forward to continuing our successful collaboration with you as customers, sponsors and partners for solving issues faced by industry and society and putting innovative ideas into practice.

Hubert Lakner

Harald Schenk

CONTENTS

- 2 About us
- 4 Foreword
- 6 Contents

HIGHLIGHTS 2019

- 8 70 years of Fraunhofer-Gesellschaft:
- 8 Fraunhofer IPMS Ideas Workshop
- 9 Industry Partner Day – Application-Orientated Research
- 9 New Site for the Center of Nanoelectronic Technologies
- 10 From Invention to Creation – the Arioso Spin-Off Company
- 12 Successful Launch of the Innovation Campus Electronics and Microsensors Cottbus
- 13 The High-Performance Center Enters a New Funding Phase
- 14 Successful Development of the Next Generation of “Made in Dresden” Chips
- 15 Extension of the MEOS Project Hub in Erfurt

FIELDS OF APPLICATION

- 16 Smart Industrial Solutions
- 22 Quality of Life
- 28 Medical and Health

SERVICES

- 36 From Technology Development to Pilot Production
- 38 Center of Nanoelectronic Technologies

FRAUNHOFER IPMS AT A GLANCE

- 42 Fraunhofer IPMS in Figures
- 43 Board of Trustees
- 44 The Fraunhofer-Gesellschaft
- 45 Networks
- 46 Patents and Publications
- 47 Cooperations
- 48 Completed Public Projects
- 49 New Public Projects
- 50 Contacts and Service



HIGHLIGHTS 2019



70 YEARS OF FRAUNHOFER-GESELLSCHAFT

The Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V. has been successfully shaping the future using innovative technologies and inventions for 70 years now. This is a good reason for Fraunhofer IPMS to sum up its achievements and cast an eye to the future.

The Fraunhofer-Gesellschaft takes its name from Joseph von Fraunhofer (1787-1826), a scholar from Munich. He succeeded in developing innovative products by combining science with practical applications. The Fraunhofer-Gesellschaft was founded in 1949 with the aim of continuing this pioneering spirit. Over the past 70 years, the Fraunhofer-Gesellschaft has significantly shaped the German research landscape and nowadays is Europe's leading organization for applied research. Without a doubt, one of its best known successes is the invention of the MP3 format, but countless inventions and intelligent solutions that we encounter in our daily lives are also "Made by Fraunhofer". The Fraunhofer-Gesellschaft still stands out for its application-orientated research for direct use by companies and society. This success is also reflected in the figures: over 28,000 employees at 74 research facilities conduct over 70% of the annual research volume, at a worth of 2.8 billion euros in the form of industrial contracts and publicly funded research projects.

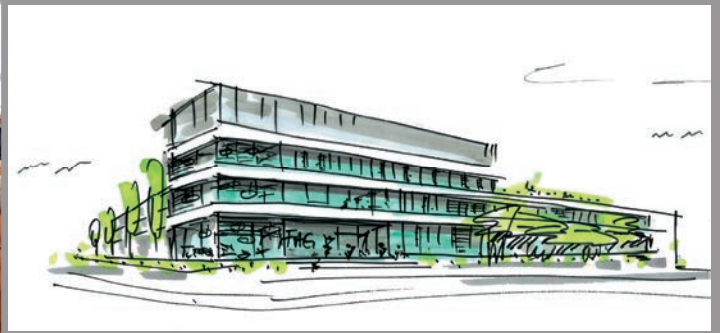
During our anniversary year in 2019, we at Fraunhofer IPMS particularly tasked ourselves with the question of "What's next?": Which technologies can contribute to improving people's quality of life in the future? And which issues can we address using our developments and expertise? In order to apply ourselves to these issues, we at Fraunhofer IPMS set up the Ideas Workshop as a new format for collaboration.

FRAUNHOFER IPMS IDEAS WORKSHOP

Robots as small as just one bit on a hard drive; vehicles that can drive themselves. These might sound like the stuff of science fiction, but they are already a reality. These inventions have one thing in common: at some point, they came into being as an idea in the head of a scientist. Every innovation starts with an idea, which can become a reality with courage, motivation and some investigative spirit. The aim of the first Fraunhofer IPMS Ideas Workshop, which took place on August 22, 2019, was to provide the right forum for this investigative spirit and to create an appropriate context for an interdisciplinary, creative exchange between our researchers.

In particular, interactions between employees outside of the usual research groups proved to be an idea booster. Over 30 substantive ideas were developed and discussed over the course of just one day. Driven by the question of future technologies, possibilities for the next generation of MEMS sensors were debated. Another exciting topic was the use of artificial intelligence, which will make our lives easier in the future, but creates high requirements for energy efficiency, memory systems and security. In the field of nano technologies, ideas relating to the use of so-called nanobots, i.e. molecule-sized robots, were discussed. As a next step, the approaches devised during the Ideas Workshop were evaluated and the most promising ideas are being further developed as part of research projects. The new format for generating novel ideas was very well received by the scientists and has established itself at the institute as a tool for encouraging innovations.

Find out more about our innovative technologies on our website: www.ipms.fraunhofer.de



Presentation:
Heinle, Wischer and partners (independent architects)

INDUSTRY PARTNER DAY – APPLICATION-ORIENTATED RESEARCH

Fraunhofer is synonymous with application-orientated research. Together with industrial and economical partners, individual solutions for very specific issues are developed, from the laboratory right up to their application.

Over the course of its 27-year existence, Fraunhofer IPMS has many examples of successful collaboration with industrial partners under its belt. The ambition for organizing Industry Partner Days was to give these collaborations an arena to thank our partners for their dedicated cooperation and, at the same time, to create a platform for jointly generating new project ideas.

Successful projects resulting from industrial collaborations have been presented in this format since 2017. The Industry Partner Days are thematic in terms of their content, and are just as varied as our technologies: from 200 mm MEMS technologies to innovative sensor technology for medical applications to the use of micro-mirror arrays in semiconductor manufacturing.

As part of the Industry Partner Day held in March 2019, we opened the doors of our Center of Nanoelectronic Technologies (CNT) in Dresden to an exclusive audience and presented the latest developments in the fields of energy devices, non-volatile memories and interconnects. In addition to insights into current projects and upcoming developments, our guests were given information on the possibilities for joint research on 300 mm wafers.

What's more, in 2019, we organized our first Industry Partner Day in California (USA). As an overview, representatives from our partner companies and leading scientists from Fraunhofer IPMS gave informative speeches on the findings of successful international collaborations, current research work and possibilities for joint projects in the future.

NEW SITE FOR THE CENTER OF NANO ELECTRONIC TECHNOLOGIES

The Center of Nanoelectronic Technologies (CNT) conducts applied research into microelectronics on 300 mm wafers for microchip producers, suppliers, equipment manufacturers and R&D partners. Previously, the 800 m² of cleanroom facilities owned by Infineon Technologies Dresden GmbH on Königsbrücker Landstraße were used for this purpose. Due to high economic demand, our long-term partner now requires these facilities itself to expand its production capacities. **Thanks to the excellent support from the Free State of Saxony and the headquarters of the Fraunhofer-Gesellschaft, a new home for the CNT was successfully found by working together. The move to the new site in northern Dresden to the property previously owned by Plastic Logic Germany GmbH is already planned for the start of 2021.** Until then, structural adjustments are being made to meet the CNT's requirements. The new site will not only provide optimal conditions for continuing 300 mm research activities, but also the potential for further growth.

The move and the required structural adjustments require a significant investment, which can only be achieved thanks to extensive support from the Free State of Saxony, the Fraunhofer-Gesellschaft and the German federal government. The property purchase by the Free State of Saxony safeguards the future of the Center Nanoelectronic Technologies in the long term and therefore the region's power to compete on an international level, creating over 70 jobs.

Further information:
<https://s.fhg.de/CenterNanoelectronic>



NED technology from Fraunhofer IPMS is expanding the fields of application for hearables.

FROM INVENTION TO CREATION – HOW FRAUNHOFER IPMS APPLIED AN INNOVATION BY FOUNDING THE ARIOSO SPIN-OFF COMPANY

Fraunhofer IPMS founded the spin-off company Arioso Systems GmbH in October 2019. The aim of founding this company was to launch an innovative sound transducer principle for miniaturized headphones (also known as ‘hearables’) onto the market. These voice-operated, multi-talented devices are worn in the ear and will even be able to completely take over Internet communication in the future thanks to their unique Nanoscopic Electrostatic Drive (NED) technology from Fraunhofer IPMS. We spoke to Dr. Hermann Schenk, Chief Operating Officer of the spin-off company, about the reasons behind this.

What aim is Fraunhofer IPMS pursuing by founding this spin-off company?

Entrepreneurial spirit is important for cutting-edge technology. With our spin-off company, we wanted to introduce

*Dr. Hermann Schenk,
Chief Operating Officer
Arioso Systems GmbH*



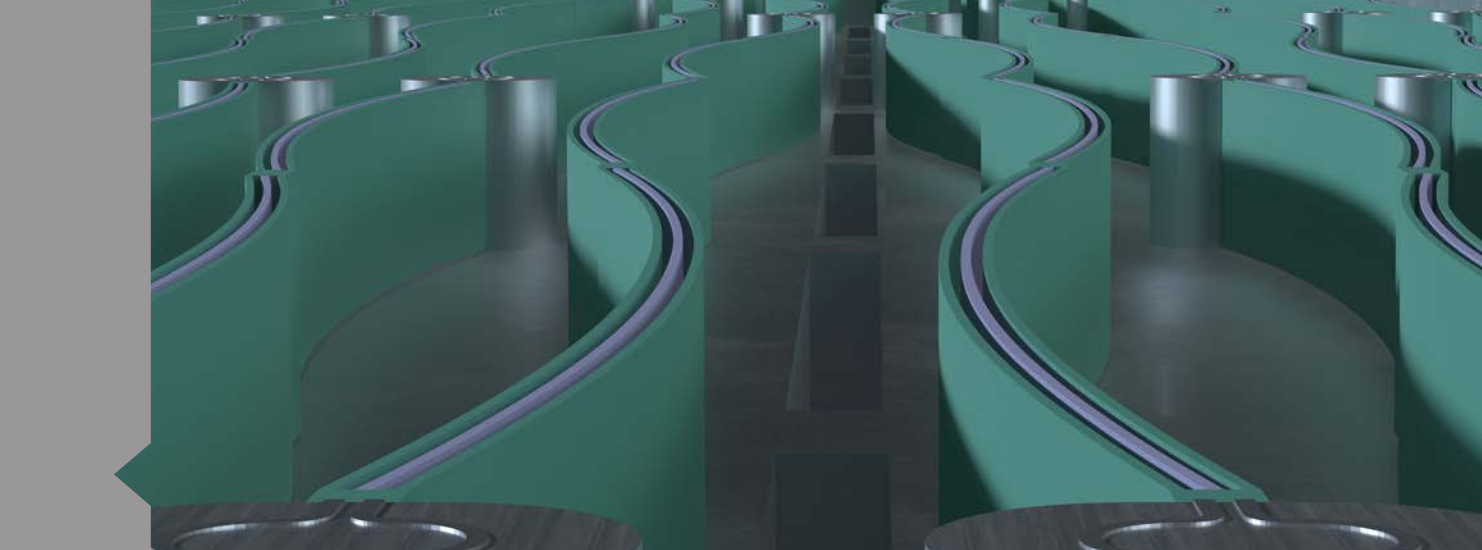
completely new audio technology to the market and thereby make our contribution to the competitiveness of Germany's industry. The business purpose of the IPMS spin-off company Arioso Systems GmbH is especially aimed at developing, manufacturing and marketing micromechanical transducers for audio applications using NED technology.

How did the idea for the innovation come about?

It all started with the invention of a new type of micro-electro-mechanical bending actuator. Actuators convert electrical signals into mechanical movements and are absolutely essential in electronics. Our expert Holger Conrad was given the task in his examination paper of converting electrical current on a semiconductor chip into movement. For this, he had to produce a micromirror made from piezo materials that bend under electrical load, which could be controlled electronically. As this did not work, Holger Conrad attempted to convert the electrical current into movement directly on the silicon chip. In this way, he developed the Nanoscopic Electrostatic Drive (NED) principle. The idea is spectacular: thanks to the NED principle, large displacements are already being achieved under currents of a lot less than 50 volts. By cleverly arranging the electrostatic cells, movement on the chip can occur continuously. This enables it to be used as a transducer, even producing high audio quality.

How does the NED actuator principle work specifically in a loudspeaker?

The new transducer principle no longer has a conventional membrane. Instead, the membrane is installed inside the body of a silicon chip, arranged to some extent as bands and in the form of a series of bending strips similar to the strings on a harp. With their integrated, electrostatic drive, the 20 µm thick bending strips form a completely new class of electrostatic bending actuators. The NED actuators are



energized into producing vibrations by applying an audio signal voltage. In order to prevent acoustic bypass on both sides of the strips, the development team led by Dr. Bert Kaiser and Dr. Sergiu Langa attached silicon wafer layers to the base and cover with cleverly arranged outlet and inlet slots on the upper and lower sides of the bending strips. This enables the micro loudspeaker to be produced completely using silicon technology.

How is the invention used in the ear?

The idea for applying in-ear NED technology came from our Institute Director Professor Dr. Harald Schenk. Sound sources generate pressure waves in the air, which cause our eardrums to vibrate. We perceive these as sounds. I seal off my ears with in-ear headphones, then the loudspeaker generates airwaves and my eardrum vibrates. In this way, the amount of air-moved influences the volume of the sounds, i.e. the sound pressure. The NED actuators function like vibrating strips, which displace the air with their movement, thereby stimulating the eardrum. The new technology facilitates sound pressures of up to 120 decibels; only around 0.5 mm³ of air has to be moved in the ear canal in order to produce such high sound pressures. The advantage of silicon technology is the NED loudspeaker's high scale of miniaturization, enabling the space created in the headphones to be used for further functionalities.

What applications are possible in addition to audio transmission into the ear?

The technology's high scale of miniaturization and energy efficiency open up completely new types of mobile applications. Just like having "Alexa in your ear", smart hearables enable numerous Internet applications such as payment services and translations, which are all voice-operated without any need to look at a smartphone. The

new transducer principle is also attractive for use in hearing aids.

How is Fraunhofer-Gesellschaft supporting the spin-off company?

The Fraunhofer principle is to enable knowledge to be applied. Fraunhofer-Gesellschaft initially provided 25 % of the company assets to the Arioso start-up and licensed NED technology for the "audio" field of application exclusively for Arioso. Furthermore, Fraunhofer IPMS has an excellent infrastructure for producing NED micro loudspeakers in small batches amounting to several tens of thousands every year. This capacity is indispensable for Arioso's successful market entry and will surely be requested by Arioso's customers.

What are the next steps for the spin-off company?

The start-up was initiated with a great promise of success thanks to the first-rate work by the scientists and clean-room engineers from Fraunhofer IPMS. The market is highly interested in MEMS-based micro loudspeakers. We are currently engaging in discussions with companies that would like to develop product perspectives for the different applications by working together with us. For Arioso, this means that we want to establish functions and produce pilot series. In doing so, Arioso has developed a very promising commercial basis. I am therefore highly optimistic and looking forward to seeing further developments from Arioso Systems GmbH.

Thank you very much for the interview!

Further information:
www.arioso-systems.com



Representatives from collaboration partners of the Innovation Campus Electronics and Microsensorics Cottbus: Project Coordinator Prof. Dr. Harald Schenk (IPMS, 4th from the right), Prof. Dr.-Ing. Ina Schieferdecker (BMBF, middle) and Dr. Martina Münch (MWFK Brandenburg, 4th from the left) and Prof. Dr. Christiane Hipp (BTU C-S, 3rd from the left).

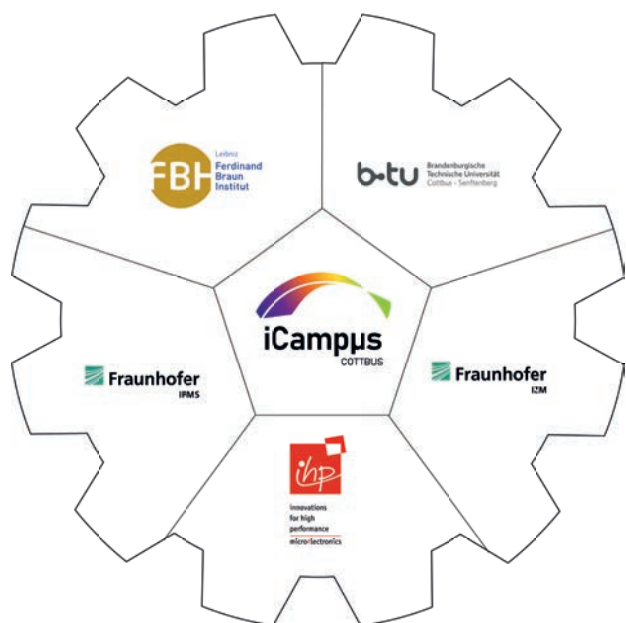
SUCCESSFUL LAUNCH OF THE INNOVATION CAMPUS ELECTRONICS AND MICROSENSORICS COTTBUS

Innovation and training are the engines for structural change. Research therefore provides a great opportunity for Lusatia, a region in a state of change. On November 19, 2019, the first research project on structural change began: the "Innovation Campus Electronics and Microsensorics Cottbus". Together with three other non-university partners and the Brandenburg University of Technology Cottbus-Senftenberg, Fraunhofer IPMS is conducting research on microsensors as the sensory organs for digitalization. The Leibniz Institute for Innovative Microelectronics (IHP), the Ferdinand-Braun-Institut Leibniz-Institut für Höchstfrequenztechnik (FBH), the Fraunhofer Institute for Reliability and Microintegration IZM and the Brandenburg University of Technology Cottbus-Senftenberg are excellent partners for Fraunhofer IPMS to collaborate with on synergetic research and testing of sensory systems.

The focus of this is applications in the fields of Industry 4.0, Agriculture 4.0 and Smart Health. Microsensors have diverse fields of application: MEMS sensors can provide information on whether arable soils need to be fertilized or whether it is a good time for the harvest. Smart sensors can monitor patients' cardiovascular systems, control automated industrial processes and forecast maintenance cycles for production facilities. In the future, 40 scientists at the Innovation Campus Electronics and Microsensorics Cottbus will further advance the development of this new type of sensor and drive forward the transfer of innovations into industrial applications.

The Innovation Campus is being funded with capital of 7.5 million euros up to the end of 2021 as part of the emergency program run by the German federal government for coal-mining regions, with the intention of opening up new opportunities for people and companies in the affected regions. By transferring R&D findings into the market, the Campus intends to make a contribution to increasing the ability to innovate and compete of the region's companies and therefore the Lusatia region as a whole.

Further information:
<https://s.fhg.de/2mc>



Launch event for the High-Performance Center
on 10/21/2019 at the
Dresden Technical University



THE HIGH-PERFORMANCE CENTER ENTERS A NEW FUNDING PHASE

Sensors that raise the alarm in the event of machine malfunctions; robots that can detect gestures and improved ultrasound-based diagnosis in medicine - these are all applications whose research and testing has been driven forward by the “Functional Integration for Micro-/Nanoelectronics” High-Performance Center. The aim of the close collaboration between research facilities and economic stakeholders is to combine competences in the field of micro- and nanoelectronics in order to put innovations into practice as applications as quickly as possible. The ENAS, IIS-EAS, IZM-ASSID and IPMS Fraunhofer Institutes are collaborating on this together with the Dresden Technical University, the Chemnitz Technical University and the Dresden University of Applied Sciences. This close collaboration ensures that new basic technologies and findings from fundamental research flow directly into application-orientated research and development. Industrial relevance is guaranteed through the participation of strong economic partners from the semiconductor industry, such as Globalfoundries.

The next funding phase for the High-Performance Center was officially started with a launch event on 10/21/2019. The focus of work carried out during the 2019/20 period has intensified in terms of transferring research findings into the economy. “We cannot tackle current challenges without the exchange between scientists and companies. The High-Performance Center combines the competences of the region’s best researchers and companies in the field of microelectronics,” explained State Secretary Uwe Gaul

from the Saxon State Ministry for Higher Education, Research and the Arts during the opening event. Professor Hubert Lakner, Coordinator for the High-Performance Center, presented the accomplishments achieved and the successes from the preceding pilot phase as well as an outlook for the key research areas announced for the period until the end of 2020.

The High-Performance Center is being funded during the 2019/2020 period with an amount of 5 million euros from the Free State of Saxony; furthermore, Fraunhofer-Gesellschaft is providing additional funds for the accompanying measures. This project is further reinforcing “Silicon Saxony” as the largest microelectronics network in Europe.

Further information:

<https://s.fhg.de/LeistungszentrumMikronano>





Center of Nanoelectronic Technologies CNT

SUCCESSFUL DEVELOPMENT OF THE NEXT GENERATION OF “MADE IN DRESDEN” CHIPS

Silicon chips are the nerve cells for artificial intelligence: millions of the smallest components are housed on their surfaces, which transmit important information and signals to devices that are becoming increasingly smarter. These semiconductor chips are installed in every smartphone and they are becoming increasingly more efficient and smaller. Energy efficiency is therefore especially important for chip architecture. This is decisive for implementing artificial intelligence applications that will preserve resources and the environment in the future.

As part of the EMMA IPCEI project, Fraunhofer IPMS Center Nanoelectronic Technologies and the Dresden-based chip manufacturer Globalfoundries are developing innovative materials, processes and components for FDX energy-saving technology. This equally energy-efficient, high-performance and cost-effective technology for manufacturing chips is in particular demand in the growing Internet-of-Things and automotive markets. At the same time, the EMMA project is also focused on the research area of sustainability: it includes a doctoral program for qualifying young scientists in this field. As a result, long-term support and safeguarding of expertise and thereby the region's power to compete are guaranteed.

In the meantime, 15 PhD students have been working on innovative process developments for FDX technology, among other things, as well as developing non-volatile embedded memory and characterizing high-frequency technologies (RF). In addition to this, numerous scientific publications, conference contributions and invention disclosures were generated during the previous project stage and the latest process and characterization systems were put into operation. Fraunhofer IPMS received support in this from the Federal Ministry of Education and Research (BMBF) as part of the funding for the Research Fab Microelectronics Germany (FMD).

The upcoming move of the CNT to the former Plastic Logic Germany GmbH site in northern Dresden in 2021 has been taken into account in the EMMA project plan. The project has been extended until the end of 2021 and can therefore be continued in the new facilities. Thanks to support from the Free State of Saxony and the headquarters of the Fraunhofer-Gesellschaft, it has already been possible to secure the funding for the significant aspects of the move upfront.



EXTENSION OF THE MEOS PROJECT HUB IN ERFURT

Timely disease detection and treatment using optical microsystems are the goals for the “Microelectronic and Optical Systems for Biomedicine” Project Hub located in Erfurt.

In the past year, the Project Hub has been further expanded, so that the researchers can carry out their work in two new laboratories and in the cleanroom.

The MEOS Project Hub is an interdisciplinary alliance of the Fraunhofer Institute for Photonic Microsystems IPMS, as the leading research provider in the field of microelectronics and microsystems, the Fraunhofer Institute for Applied Optics and Precision Engineering IOF, as the recognized center of excellence for optical and photonic technologies, and the Fraunhofer Institute for Cell Therapy and Immunology IZI, a key player in the field of life sciences.

The aim of the collaboration in Erfurt is the synergetic combination of different competences and expertise for developing and testing innovative solutions for biomedical applications.

In doing so, the work at the Project Hub will initially concentrate on three technology platforms. The **“Structured Illumination”** platform aims to develop optical modules for high-resolution microscopy with significantly reduced phototoxicity. The **“Advanced Imaging”** technology platform is intended for innovative solutions in the field of optical imaging. The third focus, **“Biofunctional Surfaces and Biosensors,”** relates to researching miniaturized solutions for diagnosing diseases based on fluid analysis. With an eye to the future, expansion of the MEOS activities into other fields of application is also possible. Development of ready-for-use systems and their transfer for industrial use in medical technology, diagnostics, biotechnology, pharmaceuticals and the food industry is a key mission for future MEOS work.

Further information:

<https://s.fhg.de/ProjektzentrumErfurt>

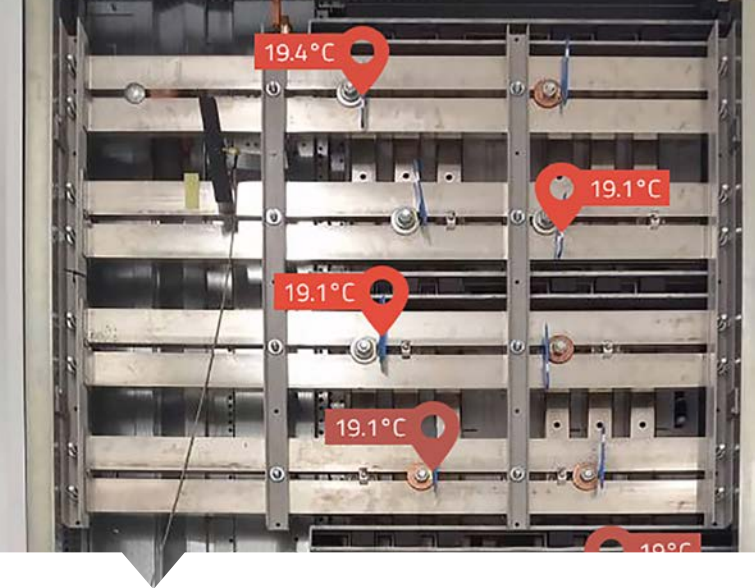


Application Area **SMART INDUSTRIAL SOLUTIONS**

Factories of the future are becoming increasingly more digitalized, efficient and automated. Machines, production and services are being intelligently networked together across a range of technologies. In the smart industrial solutions field of application, Fraunhofer IPMS is therefore developing innovative solutions in the areas of logistics, production and processes. This is due to the fact that, in the future, automated systems and robots will make work easier for people. In order to make this vision a reality, Fraunhofer IPMS is developing micro-electro-mechanical system-based sensors, optical components and actuator technology, which record the environment and secure interactions. In the process, sensor technology becomes the sensory organ for digitalization: it forms interfaces between machines and people. For the information transfer of the data collected by the sensors, Fraunhofer IPMS is also developing communication technologies and interfaces, which can transmit data securely in real time, using a high bandwidth.







RFID SENSOR TECHNOLOGY FOR INCREASED SAFETY IN THE CONTROL CABINET

Switchboards are the heart of every industrial system: they supply machines with electricity. Undetected overloads and faulty installations in control cabinets can lead to components overheating and even fires, which can in turn result in system failures and complete production shutdown. Warning of such outcomes is often given in advance due to warming of the screw connections on the power rails. Continuous temperature monitoring is therefore important.

Until now, permanent temperature monitoring in control cabinets was difficult, as cables or batteries could not be integrated directly onto the power rails due to high voltages. Usually, the temperature is therefore measured using infrared cameras, for which the systems must be frequently switched off. This means that continuous measuring is impossible.

As a solution to this problem, Fraunhofer IPMS has developed a battery-free RFID sensor system, which uses wireless data and energy transfer technology from the reading device to the sensor. The reading device supplies the sensor with energy in order to carry out the measurement and then transmit the measurement values. The new process from Fraunhofer IPMS records the temperature directly at the screw connection on the power rails, thereby enabling continuous, disruption-free monitoring. Using intelligent solutions, this can be easily integrated into existing production environments and connected to the controlled systems currently being used.

Further information:

<https://s.fhg.de/rfidsensorsystem>

WIRELESS DATA TRANSFER USING LIGHT FOR INDUSTRY 4.0

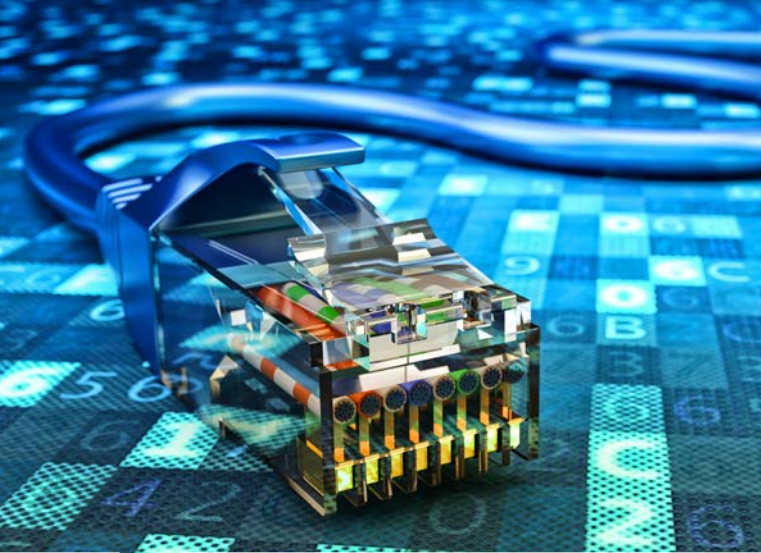
Machines, logistics and products are in direct communication with each other in modern, automated industrial systems. Fraunhofer IPMS is developing and implementing innovative solutions for wireless data transfer using light.

The term **Li-Fi**, i.e. **Light Fidelity**, is understood to be an optical and therefore wireless communication standard for the close-range area. The operating principle can be easily explained: An LED on the transmitter is modulated, i.e. switched on and off, so quickly that the timed sequence cannot be seen by the human eye. The signal emitted by the LED is absorbed by a photodiode on the receiver and converted into electrical impulses, which can be read. A prerequisite for this type of data transfer is direct visual contact between the transmitter and the receiver.

Li-Fi technology has many advantages. For example, it enables 360° rotary transmission as an application for rotating components. Li-Fi supports communication in real time and provides high data security due to the obligatory visual contact. This interference-free data transfer method also predestines the technology for use in interference-prone environments. With a size of up to 5 x 5 x 5 mm³ and a range of over 10 cm (GigaDock®) to 30 m (HotSpot), our Li-Fi technology enables high data transfer rates from 1 Gbps (HotSpot) to 12.5 Gbps (GigaDock®).

Further information:

<https://s.fhg.de/Li-Fi>



IP CORES FOR INDUSTRIAL COMMUNICATION

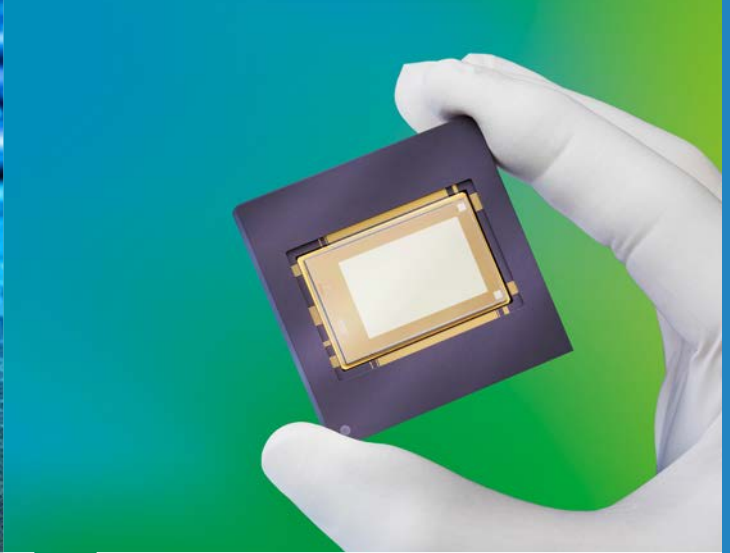
IP Cores are used to develop embedded systems. IP-based design is an approach that helps developers to save time and effort by using specific, tested IP Cores.

Fraunhofer IPMS is developing IP Cores for industrial communication which enable time-sensitive data transfer (TSN) from devices via Ethernet networks.

The IP Core product family from Fraunhofer IPMS also includes IP designs for CAN2.0, CAN-FD and CAN-XL as well as LIN fieldbus systems.

Fraunhofer IPMS is also developing IP Cores for the automotive sector, which is why the LLEMAC-1G, as an integral component of the TSN IP Core family, is classified as ASIL-D ready according to ISO standard 26262. The CAN controller core is also classified as ASIL-B ready. The standard ensures the operating safety of electrical and electronic components as well as systems in the automotive sector.

Further information:
<https://s.fhg.de/ipcores>



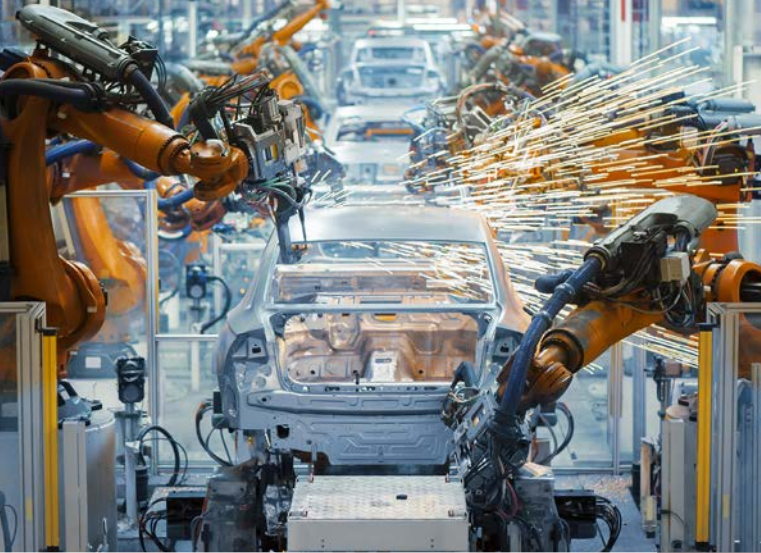
HIGH-RESOLUTION FAST LIGHT CONTROL FOR INDUSTRIAL MANUFACTURING

Optical microsystems are forging the path of light: photonic systems from Fraunhofer IPMS can modulate light using small movable mirrors and thereby generate images and structures in a unique way. The research institute is developing Spatial Light Modulators (SLM) for this with up to several million mirrors on one semiconductor chip.

Among other things, micromirror arrays are used in semiconductor production as well as in micro and laser projection. Fraunhofer IPMS is currently a worldwide leader in terms of its developments in this field. Its latest development is a CMOS-integrated micro-mirror array with two tilting axes per mirror and an associated technology platform.

The individual mirrors, which vary per chip in terms of number and size according to the specific application, can be individually tilted or vertically deflected, so that a surface pattern is created along different axes, for example to project defined structures. High-resolution tilting mirror arrays made from up to 2.2 million individual mirrors are used as highly dynamic programmable masks for optical micro-lithography in the ultraviolet spectral range. The mirror dimensions in this case are typically 10 µm or larger. By tilting the micromirrors, structural information is transferred to a high resolution photo-resist at high frame rates. Further fields of application are mask inspection and measurement technology for the semiconductor industry, as well as microscopy in laser printing, marking and material processing.

Further information:
<https://s.fhg.de/Flaechenlichtmodulator>



Microscanner mirrors from Fraunhofer IPMS enable multidimensional sensor technology for robots.

AUTOMATED EYE FOR QUALITY – MULTIDIMENSIONAL SENSOR TECHNOLOGY

Digitalized production requires the use of sensors which work as multidimensional perceptive sensory organs. Fraunhofer IPMS is developing microscanner mirrors, which are intended to enable robots to detect objects in their environment in the same way as human sight. This means that industrial robots would be capable of taking on even more challenging tasks and reacting appropriately to their environment. The research team at Fraunhofer IPMS is also working on the concept for a “scanning eye,” the aim of which is to enable three-dimensional machine vision. At the same time, the scanner mirror module acts as a scanning eye, which can capture high-resolution images on all three spatial axes.

Scientists are using the **LiDAR (Light Detection and Ranging) principle** for this: the scanner mirror modulates the light from a laser and detects the reflected signals; at the same time, a travel-time measurement of the light between the object and the detector takes place. The robust MEMS scanners can be integrated very well due to their high scale of miniaturization. In the field of automated industrial production, the small scanner mirror modules can be integrated into robot arms, for example, so that robots are capable of permanently recording their environment, detecting upcoming work steps and monitoring the quality of their work. The robotic eye therefore works in a way that is fully automated.

The robotic eye can also be used for further functionalities in addition to optical perception. This enables non-destructive material testing of products to be carried out using infrared spectroscopy or sensory recording of the environment to take place using **Quantum Cascade Laser (QCL) spectroscopy**. In doing so, the spectral fingerprint of substances is detected, meaning that this can be

identified exactly. Among other things, this type of sensor technology is used to monitor the quality of drinking water, test drugs produced by the pharmaceuticals industry, monitor industrial systems remotely, monitor pipelines for leakages and detect hazardous substances.

Another exciting technology in which microscanner mirrors from Fraunhofer IPMS are used is **Optical Coherence Technology (OCT)**. Thanks to OCT, the superficial and deep structures of objects can be analyzed using a resolution in the micrometer range, which can enable industrial robots used in automated production to carry out precise quality assurance of products independently.

Microscanner mirrors from Fraunhofer IPMS therefore enable environmental parameters to be recorded in a new way, thus enabling the automated monitoring of production quality as well as ensuring increased safety for employees, systems and processes.

Further information:

<https://s.fhg.de/Mikroscannerspiegel>

Fraunhofer IPMS is developing neuromorphic systems for semiconductor chips.



ENERGY-SAVING CHIPS FOR ARTIFICIAL INTELLIGENCE

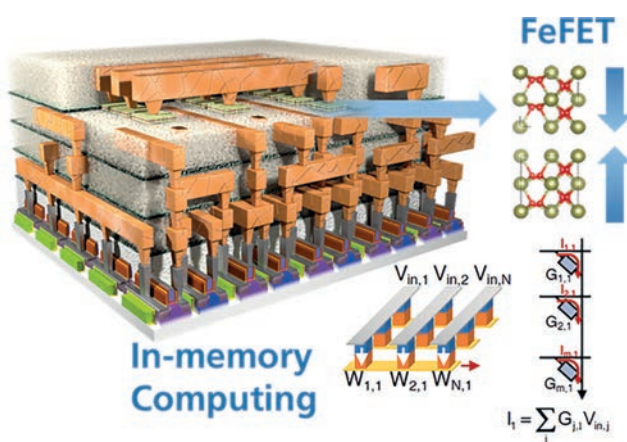
When we think, our brain processes a plethora of information. This facilitates extremely complex neuronal networking: millions of nerve cells are networked together using billions of synaptic connections. Neuromorphic computing imitates this unique form of networking and is a key technology for artificial intelligence. In the future, this will change our everyday life from autonomous driving to fully-automated production.

However, computers' complex thinking ability still uses a lot of electricity. **Fraunhofer IPMS is therefore developing new types of neuromorphic systems for semiconductor chips, which are capable of working in an energy-efficient way due to new integrated memory technologies. Similar to the human brain, the hardware architecture of the chip is designed in such a way that information is already stored in the system and is non-volatile.** There is no requirement for complicated data transfer between the processor and memory; the thinking processes take place right on the chip itself.

Fraunhofer IPMS is already working on developing and evaluating energy-saving neuromorphic computing chips in 22 nm FDSOI technology nodes. In the process, developers are applying new integrated memory technologies using ferroelectric hafnium dioxide in innovative concepts for implementing analog and digital neuromorphic circuits. In this case, memory and chip development is driven throughout the entire value added chain from applied research to IP generation to integrated systems. The chips designed and manufactured as part of the project are especially intended to be used for classification tasks in image recognition systems, such as autonomous driving, as well as for processing additional sensor data. This means that signal processing for existing mobile and portable sensor systems can be developed, which enables power consumption to be reduced by several orders of magnitude. In this way, energy consumption for complex computing capacities can be reduced and a new type of computer architecture for artificial intelligence applications can be implemented.

Further information:

<https://s.fhg.de/ValueAddedSolutions>



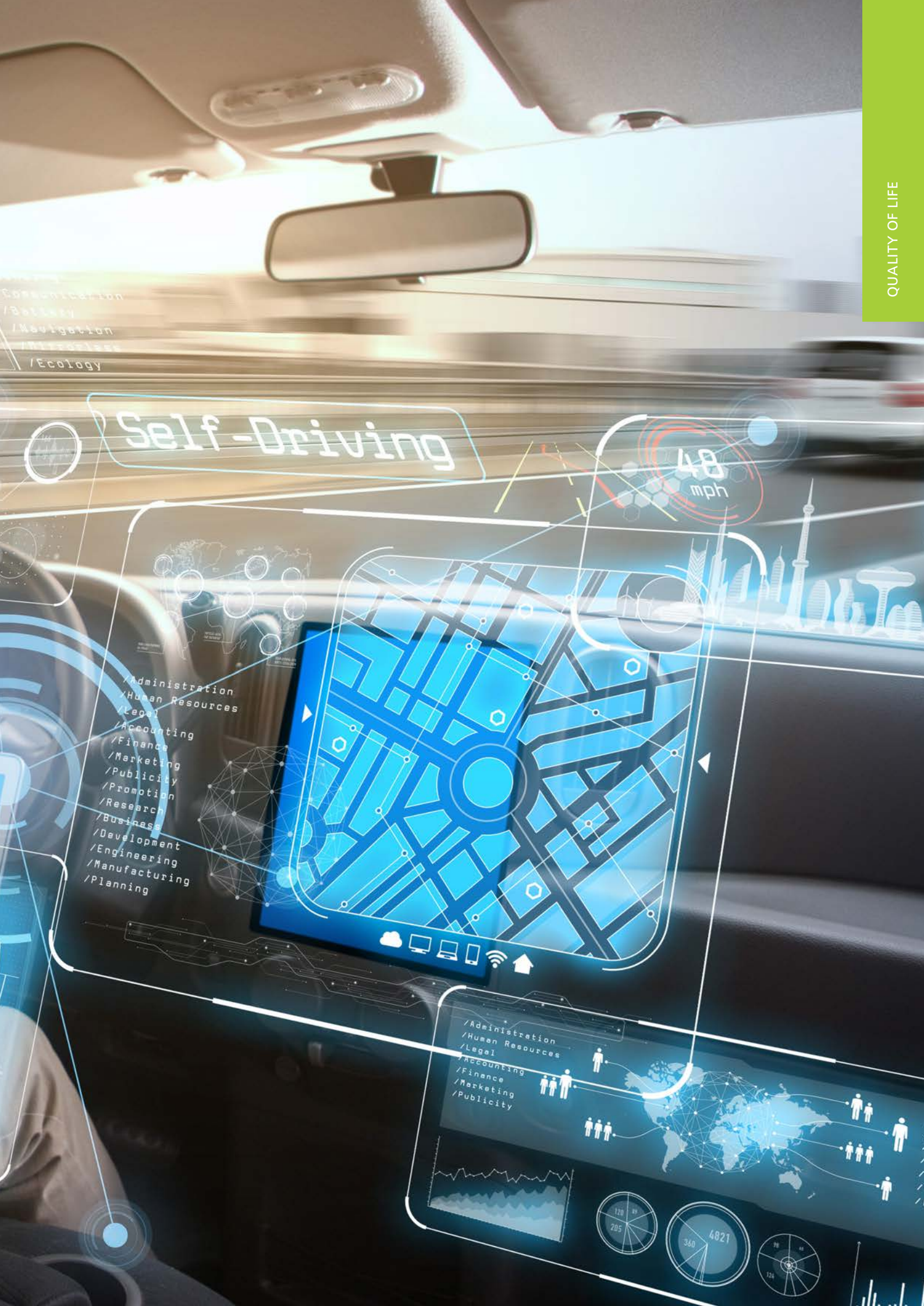
By using ferroelectric field effect transistors (FeFET) based on HfO₂ in 28 or 22 nm technology nodes, the weight values required for deep learning algorithms cannot only be stored directly in the chip, but these can also be calculated by the chips themselves (in-memory computing). In this way, matrix multiplications, which are required for artificial synapses, can be completed efficiently.



Application Area **QUALITY OF LIFE**

The world of tomorrow is already here today, whether this is in the development of autonomous driving for environmentally-friendly mobility or research into the Internet of Things, which is making our daily lives easier using artificial intelligence. Fraunhofer IPMS is developing sensory organs for these applications: optical sensors with micromirrors which enable multidimensional environment detection as well as innovative communication solutions for data transfer from the Internet of Things. The technologies form the interface between the digital world and the real world and will contribute to a better quality of life, energy efficiency and safety.





Self-Driving

48
mph

- /Administration
- /Human Resources
- /Legal
- /Accounting
- /Finance
- /Marketing
- /Publicity
- /Promotion
- /Research
- /Business
- /Development
- /Engineering
- /Manufacturing
- /Planning

- /Administration
- /Human Resources
- /Legal
- /Accounting
- /Finance
- /Marketing
- /Publicity





AUTOMOTIVE SENSORY ORGAN – SCANNING EYE FOR AUTONOMOUS DRIVING

A car drives round the corner, passengers are sleeping on the backseat and the driver's seat is empty. When a pedestrian suddenly crosses the street in front of the vehicle, it brakes automatically.

This is a scenario that can soon become a reality. In autonomous vehicles, people are nothing but passengers; the car controls itself autonomously and detects obstacles and hazards. **LiDAR sensors** are used, so that the vehicle can capture its environment, in principle replacing the driver's eyes. **LiDAR (Light Detection and Ranging)** enables the distance measurement between objects and the vehicle, and is based on emitting laser signals into the environment, with the reflected signals being detected and analyzed. **Fraunhofer IPMS is developing microscanner mirrors for this purpose which meet all the requirements for autonomous driving; at the same time they are small and can be integrated. This means that the vision of autonomous driving is nearly within reach.** The research team is also working on the concept for a "scanning eye", with the aim of making three-dimensional vision possible. A micromirror module captures the environment by means of the mirror spreading laser radiation in two dimensions. The third dimension is brought into play using the specific light reflected by the object. There are different processes for this, such as travel-time measurement, coded pulses and demodulation of FMCW signals.

Various LiDAR systems are being discussed for autonomous driving. Competing technologies often use large mirrors rotating around an axis and cannot be well integrated into vehicles due to their dimensions and weight. Further disadvantages are high manufacturing costs and sensitivity of the rotating parts to vibrations and knocks. Other alternatives are solid-state LiDAR systems, which work

without moving parts and can be integrated easily; however, objects that are further away cannot be adequately detected. For safe autonomous driving, measurements within just a few centimeters up to several hundred meters are required.

The MEMS mirrors from Fraunhofer IPMS can guarantee detection of the driving environment within this range. Due to their lightweight design and good capacity for integration, the modules are not sensitive to vibrations despite their mobility and can detect the environment without any measuring uncertainty. MEMS scanners, made from monocrystalline silicon, are extremely robust and reliable, and they fulfill requirements both in terms of their optical scanning range and their shock and vibration stability. This means that they fulfill the reliability requirements for a solid state LiDAR. Furthermore, CMOS-compatible silicon technology allows for scalable, cost-effective manufacturing of the modules, meaning they can be integrated into existing systems. The application of LiDAR technology for a MEMS scanner-based "eye" for vehicles is therefore a very promising step toward autonomous driving.

Further information:
<https://s.fhg.de/MEMSScanner>



GESTURE RECOGNITION USING ULTRASOUND

When we talk, we use our voices, facial expressions and gestures to communicate. However, we are increasingly also interacting with machines in our professional environments and our daily lives. This has given rise to the trend of contactless solutions for human-machine communication. Nowadays, voice-based assistance systems can be found everywhere, whether in cars, smartphones or living rooms.

However, voice control is unsuitable for public areas and only functions reliably in calm environments that are free from external interfering noises. **Fraunhofer IPMS has therefore developed an alternative approach for contactless, three-dimensional detection of distances, movements and gestures for communication with machines. The method enables machines from robots to smart household appliances to be controlled using gestures.** Scientists have developed a microchip architecture, which can generate and receive ultrasound up to 300 kHz. The reflected sound waves are then analyzed: for example, measurements are carried out of how long it has taken for the wave to travel between the sensor system and the reflecting object or how the frequencies have shifted due to the Doppler effect.

The ultrasound evaluation enables spatial resolution of natural movements and gestures in the sub-centimeter range over distances of up to half a meter. Compared to camera-based systems, our ultrasound systems enable significantly more cost-effective electronic and software systems to be built. They are not sensitive to stray light and enable reliable data collection even on optically transparent surfaces. In addition, the systems are CMOS-compatible and significantly more compact, and they can also be manufactured cost-effectively in large quantities. For this development, researchers are relying on a new class of electrostatic, microelectromechanical bending actuators,

which have been under constantly further development since 2016 for generating sound waves in micro-loudspeakers and for micropumps. This Nanoscopic Electrostatic Drive (NED) principle specific to Fraunhofer IPMS uses high forces from electrostatic fields in nanometer-sized electrode gaps in order to enable mechanical movements with displacements in the range of several micrometers. In the process, not just the chip surfaces, but the complete component volume are used to generate the wave. The use of the chip volume to generate the wave enables very small components to be manufactured. Possible fields of application for ultrasound-based, contactless movement detection can be found in automation and safety technology, medical technology and the automotive industry as well as in entertainment and household electronics.

Further information:

<https://s.fhg.de/Ultraschallwandler>



Thanks to MEMS technologies, hearables can independently carry out Internet communication.

THE INTERNET IN YOUR EAR – HEADPHONES BECOME ALL-ROUNDERS THANKS TO MEMS TECHNOLOGY

Hearables (miniaturized wireless headphones that are worn directly in your ear) will be able to become all-rounders in the future thanks to MEMS technology from Fraunhofer IPMS. They not only transmit speech and music, but will also be capable of independently carrying out Internet communication, i.e. on the edge.

In addition to audio technologies, the hearables of the future also include efficient processors for data processing and will be connected directly to the Internet via wireless interfaces. Similar to Graphics Processing Units (GPU) for smartphone displays, processors will dictate the energy requirement for future hearables and therefore their runtime. As space, size and battery capacity for an in-ear device are very restricted, all other components must function with a very small energy footprint in order to guarantee sufficient runtimes.

This has become possible thanks to the new type of miniaturized loudspeakers from Fraunhofer IPMS. These use a new, silicon-based transducer principle without a conventional membrane. Instead, sounds are generated using a series of bending strips, similar to the strings on a harp, inside the body of a silicon chip. New electrostatic actuators called Nanoscopic Electrostatic Drives (NED) are integrated inside the just 20 μm wide bending strips, which are energized by vibrations from the audio signal voltage. These vibrations are heard as sound.

In the laboratory, MEMS loudspeakers measuring a few square millimeters were able to generate a sound level of up to 100 dB with the same excellent sound quality and lower power consumption. Building on these laboratory findings, the first battery-operated demo system for in-ear reproduction has already been implemented. The focus of current work is further miniaturization of components for a relatively low unit price, thereby guaranteeing suitability for the mass market and further reduction of power consumption.

Electrostatic Bending Actuators (NED)



Further information:

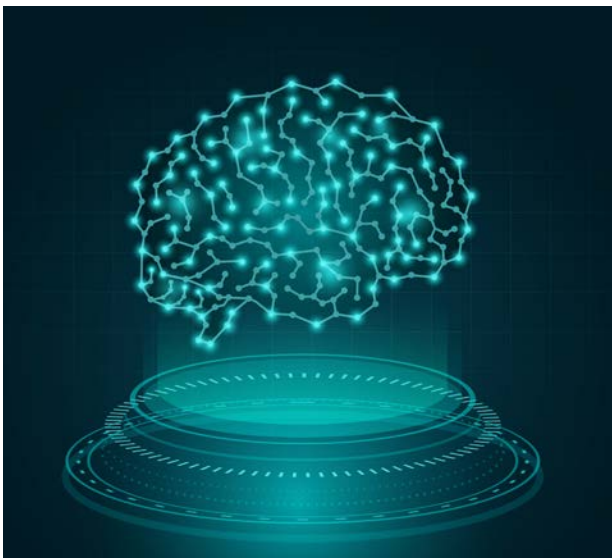
<https://s.fhg.de/Hearables>

Spatial Light Modulators (SLM) from Fraunhofer IPMS can bend light in such a way that this results in lifelike projections.



LIFELIKE HOLOGRAPHY USING SPATIAL LIGHT MODULATORS (SLM)

Virtual projections that are so lifelike you will want to touch them. Road signs displayed on your windshield, which are three-dimensional and realistic, embedded in the driver's field of vision. This is not just fiction, but should become a reality in the future with micromirror matrices from Fraunhofer IPMS. Millions of minuscule mirrors, which are assembled on a semiconductor chip, will bend light in such a way that realistic 3D images are generated as spatial projections. The individual mirrors, which vary per chip in terms of number and size according to the specific application, can be individually vertically deflected, so that a surface pattern is created to generate three-dimensional holographic images.



Holography uses the wave character of light to produce spatial representations.

The underlying holography process uses the wave character of light to produce spatial representations. The basis for this is perception by the human eye, which only detects the reflected light waves and not the object. On this basis, holographic projections enable spatial images of objects to be generated as holograms. However, these images are mostly static and are not capable of forming moving images. In contrast, the previous approaches for moving holography were not lifelike enough, as a sufficient quantity of light modulators was not available.

In the future, using the micromirror arrays from Fraunhofer IPMS, computer-animated holography should be possible, which reproduces such a realistic light field that the real world and the virtual world merge, producing moving images in real time. This makes the use of holography when driving a car in the form of augmented reality or in the field of multidimensional television possible.

Further information:

<https://s.fhg.de/Flaechenlichtmodulator>

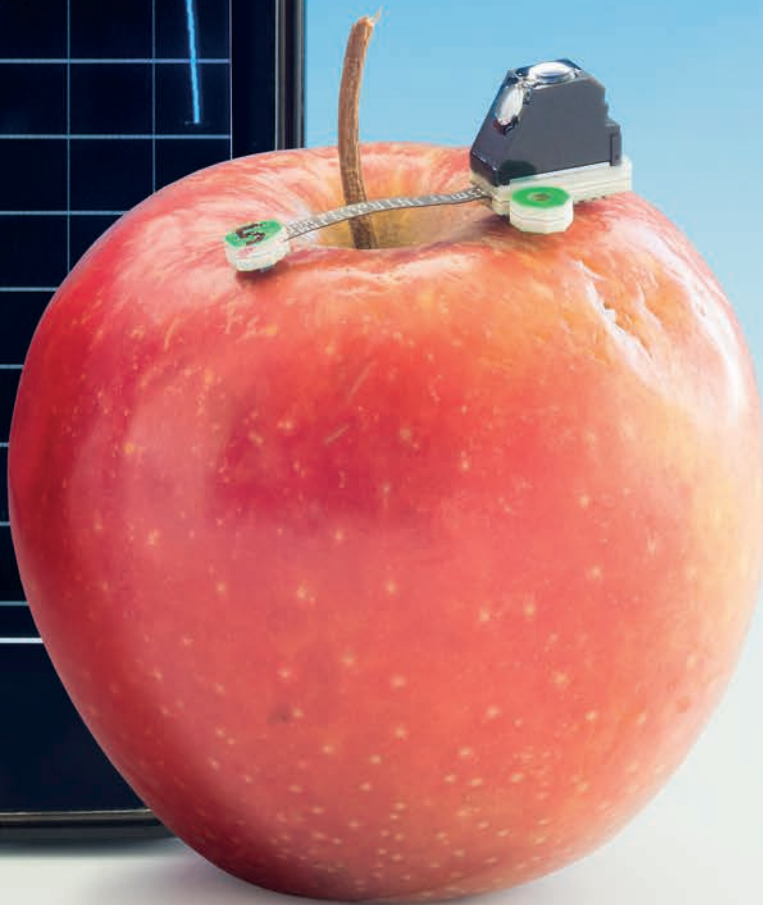
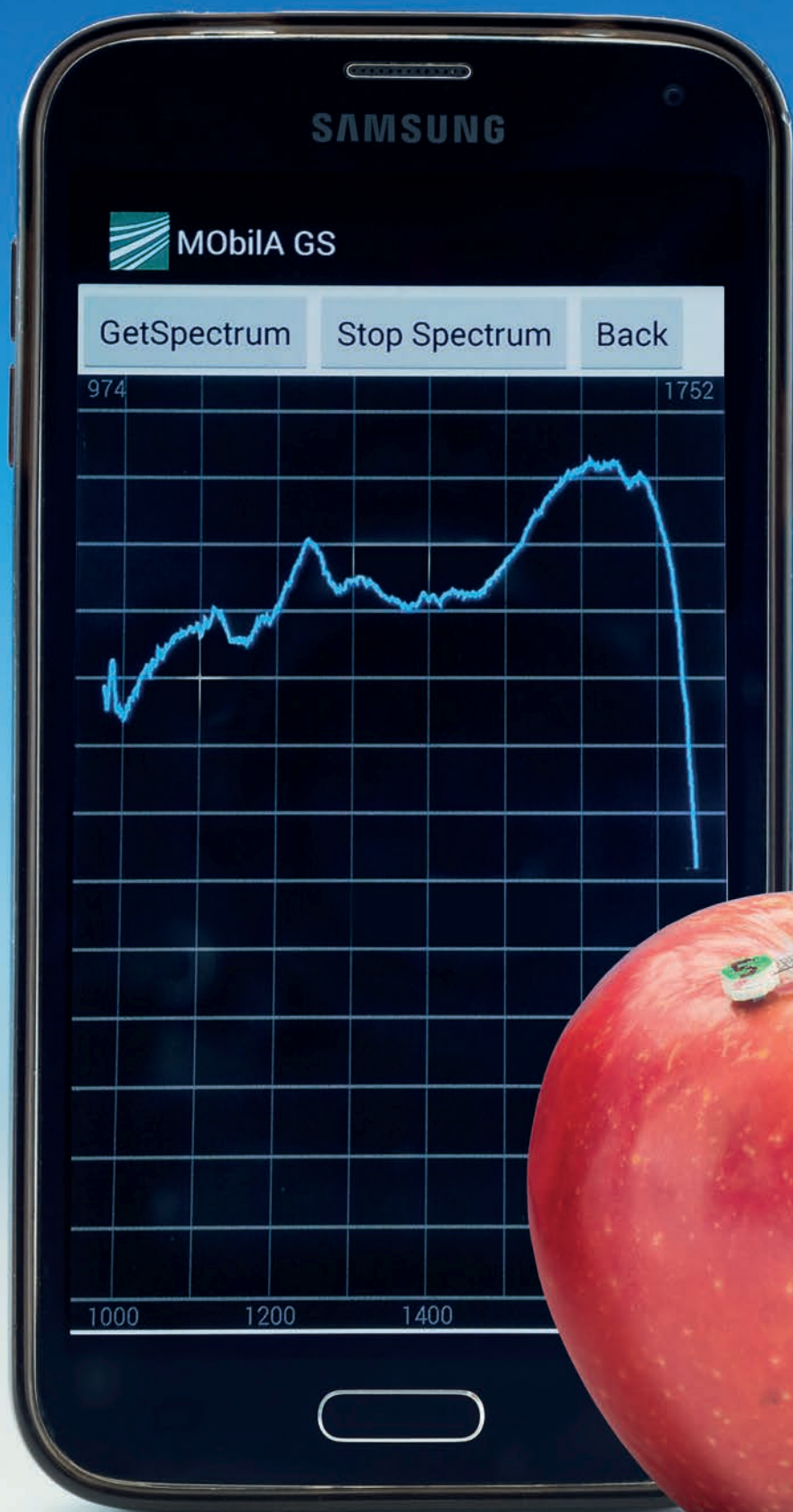


Application Area

MEDICAL AND HEALTH

Health is a precious asset - important fields of application for photonic microsystems from Fraunhofer IPMS are therefore technologies for improved prevention, diagnosis and treatment in the medical field. Life expectancy is increasing all over the world and with it the number of chronic diseases. Health awareness is also growing and so is the need for innovative prevention and diagnosis. MEMS technologies can be used in screening to detect some substances in food or to diagnose diseases that are already in the early stages thanks to the latest visual imaging processes.

Furthermore, micromechanical components enable new forms of treatment and targeted drug dosing.

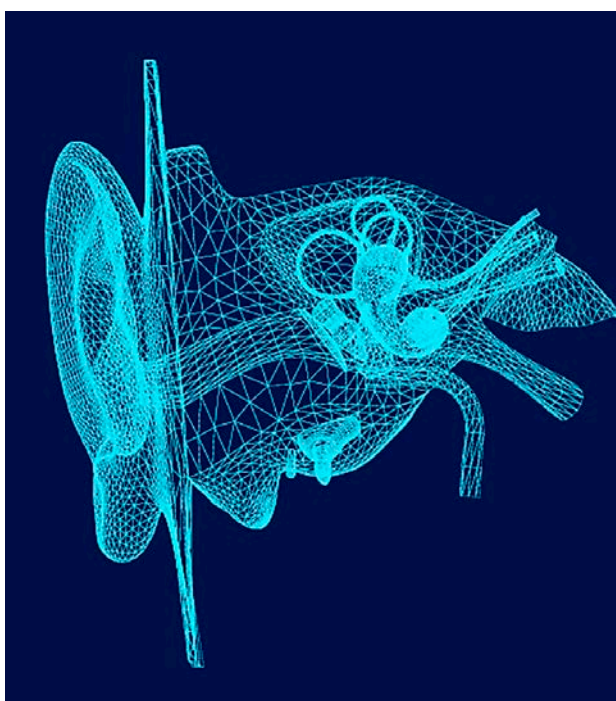




The ultrasound transducer from Fraunhofer IPMS enables precise diagnosis of middle ear infections.

ULTRASOUND DEVELOPMENT FOR IMPROVED DIAGNOSIS OF MIDDLE EAR INFECTIONS

Middle ear infections are often treated with antibiotics when these occur in babies and small children. Current medical devices for diagnosing otitis media are decades old; the average diagnostic error rates are at 50 percent, especially when it comes to the difference between bacterial and viral infections. Many children are therefore prescribed antibiotics unnecessarily, which contributes to the growing worldwide problem of antibiotic-resistant organisms in the long term. **A new type of ultrasonic transducer from Fraunhofer IPMS remedies this, as air-coupled ultrasonic technology enables precise diagnosis of middle ear infections.**



Using an otoscope developed by American start-up Oto-Nexus Medical Technologies, the area behind the eardrum can be analyzed in seconds. This makes it possible to establish whether the middle ear contains air or fluid; doctors are therefore able to differentiate between various stages of the illness, which enables targeted treatment. The key component of the intelligent otoscope is the integrated ultrasound transducer from Fraunhofer IPMS. The transducer transmits ultrasound impulses and detects the echo reflected from the eardrum. Based on analysis of these signals, the doctor receives a measurement result, which provides information on the scale of inflammation and helps to differentiate between viral and bacterial infections.

This unique technology from Fraunhofer IPMS uses condensers, which are arranged on the surface of a silicon wafer and have a movable electrode. This movable plate can be energized to produce vibrations in a wide frequency range as well as generating and receiving ultrasound signals. Components using this operating mode are called CMUTs (Capacitive Micromachined Ultrasonic Transducers).

Further information:

<https://s.fhg.de/mikromechanischerUltraschallwandler>

The area behind the eardrum can be analyzed in seconds using the new ultrasound development.



SPECTROSCOPY – A MINIATURIZED FOOD DETECTIVE

Bruised apples, and expired yogurts: all too often these foods end up in the trash. In Germany alone, every citizen throws away on average 85 kilograms of food every year. This is damaging to the environment and the climate, as resources like water, energy and agricultural land are used to produce every type of food. **Fraunhofer IPMS is working on a miniaturized spectrometer, which can help to improve food handling.** The microspectrometer is capable of determining the composition, ripeness and quality of foods. Furthermore, near-infrared analysis provides predictions on the degree of acidity and sugar content as well as information about whether the apple already has a bruise that will only become visible as a brown part the following day. In this way, the microspectrometer contributes to ensuring that food is consumed in a timely manner and does not end up in the trash.

In the meantime, research at Fraunhofer IPMS has succeeded in miniaturizing the developed spectrometer, so that it could be installed in smartphones. At just 0.6 cm³, i.e. around a fifth of the size of a standard sugar cube, the grating spectrometer is therefore currently one of the smallest near-infrared spectrometers in the world. Due to its compact assembly, light weight of less than a gram and low power consumption in the mW range, it is ideally suited for integration into mobile analysis devices. In its current form, it covers an NIR spectral range from 950 to 1900 nm with a spectral resolution of 10 nm.

Its operating principle is based on absorbing infrared radiation, which is not visible to the human eye. This penetrates deep into organic materials, such as food, and provides information on the chemical composition of the examined object. As a result, information can be obtained on important characteristics, such as the ripeness or freshness of fruit and vegetables, the water content in meat and the alcohol content of beer, wines and spirits. Further fields of application include, for example, analysis of the quality and authenticity of cosmetic products, drugs and textiles. The near-infrared spectrometer can also be deployed to produce benefits for food production. This means that, in agriculture, the nutritional requirements of soil can be determined using this technology. In this way, the soil can be optimally fertilized in a manner that takes care of the environment, and fertilizer use can be managed efficiently. Beyond that, miniaturized spectrometer systems from Fraunhofer IPMS are ideally suited for mobile use in the fields of pharmaceuticals, biotechnology and medicine as well as in the area of environmental protection and recycling.

Further information:

<https://s.fhg.de/photonischeSensorik>



OPTICAL MICROSYSTEMS ENABLE FAST DIAGNOSIS OF DISEASES

If a patient goes to the doctor with non-specific symptoms, the doctor requires a very high degree of diagnostic skill. Technical solutions based on microsystems can support doctors in searching for the cause of the illness using visual imaging as well as optical and chemical sensor technology. Fraunhofer IPMS is working at the MEOS “Microelectronic and Optical Systems for Biomedicine” Project Hub in Erfurt in an interdisciplinary collaboration with Fraunhofer IOF and Fraunhofer IZI on innovative systems enabling early disease detection.

Key components of the systems produced at the Project Hub are often the biosensors developed at Fraunhofer IPMS, which enable **diseases to be detected using fluid analysis**. For example, traces of special gases in exhaled breath are an early indication of different diseases, including cancer. Spectroscopic breath analysis can detect these gases, enabling timely diagnosis and therefore prompt treatment. Corresponding systems for chemical sensor technology that can be used in our daily lives using a MEMS ion mobility spectrometer can be made available as part of the rapid testing procedure. Miniaturized optical sensor technology is ideal for point-of-care diagnosis. This means that instead of a more time-consuming laboratory test, an analysis can take place directly on the spot. For this purpose, the sensor technology uses optimized components, such as micro-ring resonators with functionalized surfaces. The optical properties of these components are changed by docking antibodies on the surfaces, so that these can be detected with a high degree of sensitivity and a high throughput.

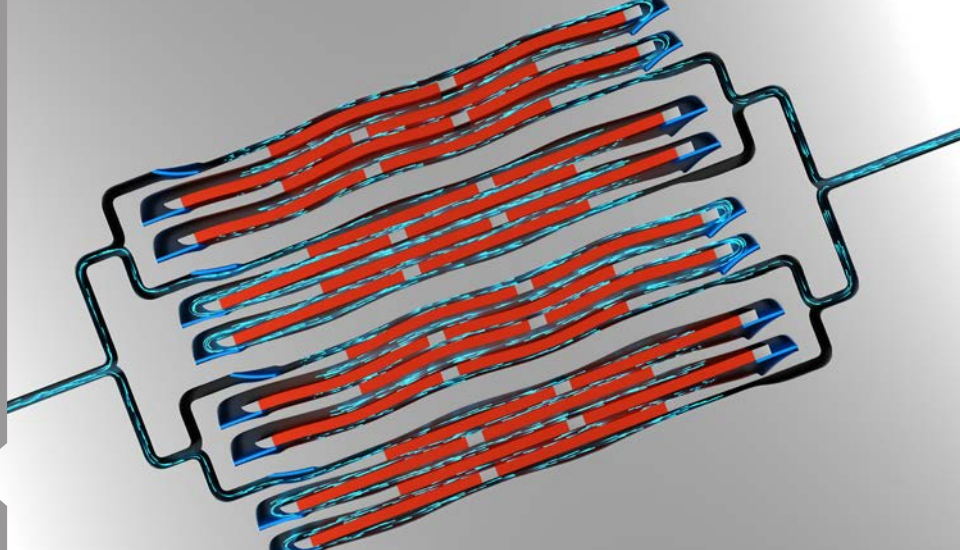
Optical microsystems from Fraunhofer IPMS can also help to differentiate between different types of cells easily and quickly. In this way, cancer cells, for example, are identified in a targeted manner using fluorescent markers. An optical system can differentiate between tumor tissue and healthy areas in real time and support doctors with surgical interventions across the entire tumor resection. In collaboration with the Helios-Kliniken Erfurt, Fraunhofer IPMS and Fraunhofer IZI are developing a fluorescence laser-scanning confocal microscope, for which a MEMS microscanner mirror is used to record images.

Furthermore, Fraunhofer IPMS is developing **optical modules for high-resolution microscopy with significantly reduced phototoxicity** together with partners in Erfurt. At the same time, optimized MEMS micromirror arrays from Fraunhofer IPMS that work as Spatial Light Modulators (SLM) operate in combination with special optics. By using two micromirror arrays in an extra engineered optical assembly, control of the light falling on the space as well as the angle and/or projection of defined patterns can be achieved. In this way, tissue samples can be examined as part of a very careful, high-resolution procedure.

Further information:

<https://s.fhg.de/ProjektzentrumErfurt>

Micropump



LAB ON A CHIP AND TARGETED DRUG DOSING THANKS TO MICROPUMPS

Targeted action, no side effects - these are the aims of optimal drug treatments. Examination and analysis of cells and test samples should also take place quickly and efficiently, and on the spot wherever possible. Micropumps from Fraunhofer IPMS offer innovative properties and parameters, which are pioneering both in terms of targeted drug administration as well as efficient, decentralized laboratory tests.

The micro-fluidic system integrated into the silicon chip can pump fluids through the smallest of channels, which are only as thick as a human hair. As with hearables and ultrasound gesture control, the operating principle for micropumps from Fraunhofer IPMS is based on Nanoscopic Electrostatic Drive technology. Under application of an electrostatic voltage, the shape of the bending actuators changes, so that a pump action can be achieved on the smallest quantities of gas and fluid.

Using this method, the smallest fluid molecules can be transported inside a chip. **A "lab on a chip" has the same functionality as a macroscopic laboratory and can be used directly on patients on the spot.** This therefore provides new, revolutionary potentials for point-of-care diagnosis as well as direct, decentralized laboratory tests and analysis. While pregnancy tests and blood sugar measurements have established themselves as the forerunners in this field, specific values from the samples can now be selected, analyzed and evaluated with a considerably higher degree of sensitivity. In the future, it should be possible to detect heart failure or sepsis, for example, immediately and react with life-saving measures.

In addition, micro-fluidic systems can also be used for optimal drug dosing. At a size of just 2.4 x 0.3 x 0.9 mm³, applications can now be targeted, which could not be implemented up to now due to the insufficient power densities of micropumps as well as a lack of integration concepts. **The minute pumps can administer drugs directly into the body, so that the possible side effects and interdependencies associated with oral administration can be avoided.** Therapeutics can also be administered without any invasive injections or infusions.

Dosing can be adjusted in each individual case, such that the micropumps make a patient-specific drug treatment possible. Due to the high biocompatibility of materials, the new micropump systems can be implanted without any health implications for patients and used as autonomous micro insulin pumps, for example. Beyond this, drainage of bodily fluids, such as lymph accumulations, can also be carried out via micro-fluidic systems.

Compared with commercial, mostly piezoelectric, membrane-based micropump systems, NED micropump systems are characterized by their low power consumption as well as their improved capacity for miniaturization and integration.

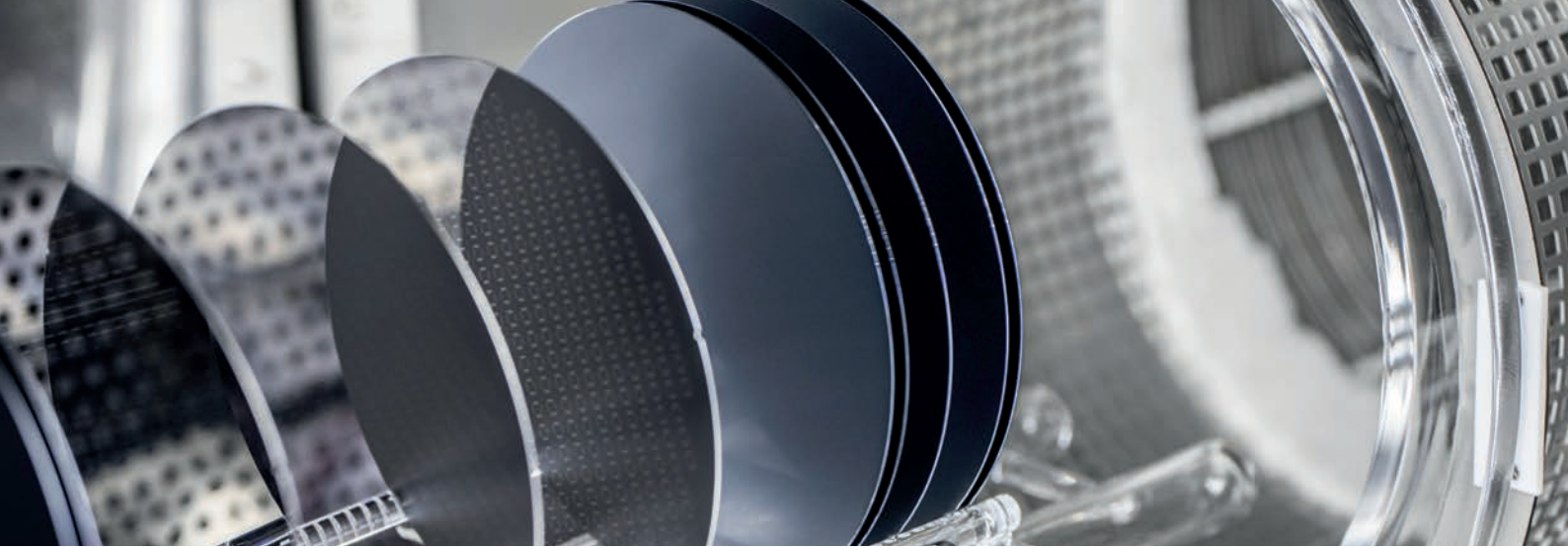
Further information:

<https://s.fhg.de/Mikropumpe>

An aerial photograph of a city at night, showing a grid of streets and illuminated buildings. The lights are blurred, creating a bokeh effect. A large, semi-transparent yellow callout box is overlaid on the left side of the image, containing the word "SERVICES" in white, bold, uppercase letters.

SERVICES





FROM TECHNOLOGY DEVELOPMENT TO PILOT PRODUCTION

Fraunhofer IPMS offers its customers complete services for the development of micro-electro-mechanical systems (MEMS) and micro-opto-electro-mechanical systems (MOEMS) on 200 mm wafers. Technological development and support of our MEMS technologies, from individual processes and technology modules up to complete technologies and cleanroom services, are supported by our team of almost 50 engineers, physicists and chemists. On customer request, we provide pilot production after successful development or support technology transfer, whereby Fraunhofer IPMS covers the Technological Readiness Levels (TRL) from three to seven. In the process, Fraunhofer IPMS will make a DUV scanner for high-precision lithograph structures (130 nm) available in the future as well as a CMOS-compatible grinder for thinning BSOI wafers. For this purpose, Fraunhofer IPMS has recently equipped BSOI wafers with new functions, such as cavities, buried pathways and multi SOI structures.

MICROMECHANICAL SURFACES

Fraunhofer IPMS is able to produce actuators and sensors, such as Spatial Light Modulators (SLM) and Capacitive Micromachined Ultrasonic Transducers (CMUT), using sacrificial layer technology. The processes and technology modules available to Fraunhofer IPMS for these highly complex components are:

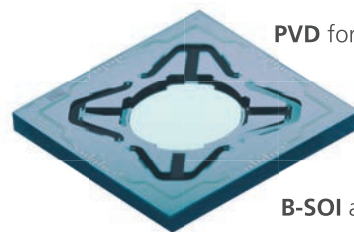
PE-CVD for **sacrificial layers** (TEOS + HDP + a:Si)

PVD for **hinges** and **mirrors** with stress tuning

MICROMECHANICAL VOLUME

Whether used in high-precision mirrors or the unique Nanoscopic Electrostatic Drive (NED) principle developed by Fraunhofer IPMS, these actuators are based on deep-etched silicon structures with large aspect ratios (>40). In addition to surface micromachining competences, the following modules are also available:

Deep silicon etching for comb drives



PVD for highly reflective layers

Trench filling
for insulation

B-SOI as a raw material for wafers

TMAH etching for rear side opening

Wafer bonding for quasi-static deflections



HF + XeF2 GPE release

ALD for **barrier layers**

Anti-stick layer
for **extremely high reliability**

Five-zone CMP for **high surface flatness**



ACTIVE SILICON

Fraunhofer IPMS produces components at the wafer level, which use the chemical and physical properties of functional layers, for example in the case of ion-sensitive field effect transistors for measuring pH values.

MONOLITHIC INTEGRATION OF MEMS AND CMOS

Monolithic integration of MEMS on CMOS is an integration technology for manufacturing integrated systems at the wafer level. Fraunhofer IPMS is developing and producing monolithic integrated MEMS for minimizing parasitic effects. This technology enables specially sized components with a high integration density to be produced reliably. Examples of this are SLMs, thermopile and CMUT arrays.

CLEANROOM & PILOT PRODUCTION

The CMOS-compatible MEMS cleanroom at Fraunhofer IPMS is operated in 24x5 mode by 3-shift teams. In addition, almost 50 operators, maintenance technicians and equipment engineers as well as production planners and process controllers are available.

Further characteristics of the cleanroom are:

- R&D and pilot production (low volume & high mix)
- 365 nm i-line (structure widths of up to 400 nm)
- ~1,000 wafer starts per month
- Cleanliness class 10 (ISO 4) over 1,500 m²
- Certified to ISO 9001:2015
- PPS-/MES software for planning, control, traceability and documentation

Integrated contamination management enables wafers and substrates to be exchanged between different collaboration partners in the MEMS cleanroom while simultaneously ensuring CMOS compatibility.

The quality standards in our high-mix / low-volume fabrication environment are guaranteed by quality management integrated within a production planning and control system. The Manufacturing Execution System (MES) enables Fraunhofer IPMS to combine tight process monitoring and documentation with active cycle-time control, thereby achieving a high level of reliability and delivery dependability.

ELECTRICAL CHARACTERIZATION

Fraunhofer IPMS is able to take the following measurements (in-/ex-situ) both at the wafer level and on the individual component for characterizing complex components and technologies:

- Mixed-signal testing
- Parametric test system
- Electro-optical test system for micro displays and sensors
- Sensor-actuator test system
- Non-electric test
- Optical inspection
- CV analysis
- Characterization of isolator integrity and reliability

Further information:

<https://s.fhg.de/MEMSTechnologie>

Contact:

Fritz Herrmann, Technical Sales Manager
 E-mail: fritz.herrmann@ipms.fraunhofer.de
 Phone: +49 351 8823 46 12



The CNT provides comprehensive services for semiconductor development and analysis.

CENTER NANOELECTRONIC TECHNOLOGIES

The CNT operates an infrastructure for process and material development on 300 mm wafers at its Königsbrücker Street site. The working environment complies with industrial standards and makes contamination-free input and output of wafers possible for customers. Developments and new processes can be integrated into customer processing sequences rapidly and without risk in order to save production costs and time. The range of services extends from technology development and electrical characterization to reliability testing, evaluation of equipment right through to comprehensive nanoanalytics. Local proximity to production lines and close cooperation with industrial partners make CNT an ideal cooperation partner. More than 40 processing and analysis tools are available for processing customer orders on 800 m² of cleanroom space (ISO 14644-1 class 6) and 200 m² of laboratory space. The equipment includes deposition and etching systems as well as inspection and analysis tools to determine defects and measure layer properties.

In 2018, the cleanroom at CNT was expanded to include important facilities, such as a complex system for PVD processes (Physical Vapor Deposition) from Applied Materials, with a multi-target design to handle a variety of technologies. One focus is the deposition of high-K dielectrics and titanium nitride-based electrode layers, which are necessary for the CNT activities in the area of FeFET (Ferroelectric Field Effect Transistors) and also for MIM (Metal Insulator Metal) components. In addition, the system offers new possibilities for applications in the field of spintronics, such as magnetic memory or spin-based sensors.

SCREENING FAB

The Fraunhofer IPMS Screening Fab offers semiconductor screening and assessments for materials, processes, chemicals and consumables from the laboratory to the production scale for Ultra Large Scale Integration (ULSI) for IC manufacturers and suppliers. We provide our customers with experienced scientists, professional wafer handling (ISO 9001) and the most modern equipment for 200/300 mm wafers with short cycle times in order to reduce costs and the time-to-market-launch period.

Fraunhofer Screening Fab for:

- Consumable evaluation
- Development of processes
- Ultra Large Scale Integration (ULSI),
- Pilot production
- Equipment assessment
- Wafer services

Further information:

<https://www.screening-fab.com/>



300 MM DEVICES AND VALUE ADDED SOLUTIONS

Fraunhofer IPMS is developing components and their integration in order to obtain expanded chip functionalities. Thanks to intense miniaturization due to the efficient use of wiring levels, semiconductor chips consume less energy and are more cost-effective. The focus of this lies on embedding memory as well as active and passive components. For this purpose, non-volatile memory is produced using ferroelectrics, MIM condensers, varactors, energy harvesters and memory as well as RF components. Development of individual components is carried out on 300 mm wafers. Furthermore, we provide services for developing the necessary integration, which can be applied in a modular way to a wide variety of technologies.

Further information:

<https://s.fhg.de/ValueAddedSolutions>

Contact:

Dr. Wenke Weinreich
Director of IoT Components & Systems
Phone: +49 351 2607 30 53
E-mail: wenke.weinreich@ipms.fraunhofer.de

ANALYTICS FOR NANOELECTRONICS

At the CNT, Fraunhofer IPMS provides comprehensive analysis of the surfaces of semiconductor chips and analysis experiments at the nanolevel. This means that processes for manufacturing semiconductor chips can be better understood and their resulting characteristics optimized. At the same time, Fraunhofer IPMS offers companies collaboration possibilities as part of industry-orientated research.

Analysis services:

- Scanning Electron Microscopy (SEM) and related methods (EDX, EBSD, TKD)
- Photoemission spectroscopy
- Atomic force microscopy (AFM, PFM)
- Flight time secondary ion mass spectrometry
- Transmission Electron Microscopy (TEM) and related methods (EDX, EELS, EFTEM)
- X-ray diffraction
- Confocal microscopy
- Porosimetry

Further information:

<https://s.fhg.de/AnalyticalServices>

Contact:

Dr. Benjamin Uhlig
Director of Next Generation Computing NGC
Phone: +49 351 2607 30 64
E-mail: benjamin.uhlig@ipms.fraunhofer.de

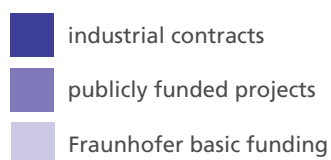
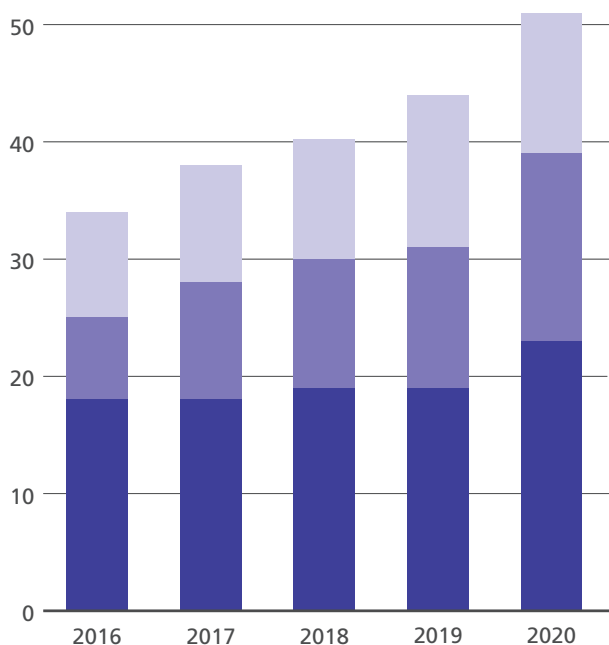
A photograph of two scientists in a laboratory. They are wearing white full-body protective suits, including hoods and face shields. The scientist in the foreground has a blue face shield and is reaching towards a piece of equipment. The scientist in the background has a red face shield. The laboratory environment is clean and brightly lit, with various pieces of scientific equipment visible.

FRAUNHOFER IPMS AT A GLANCE

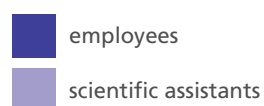
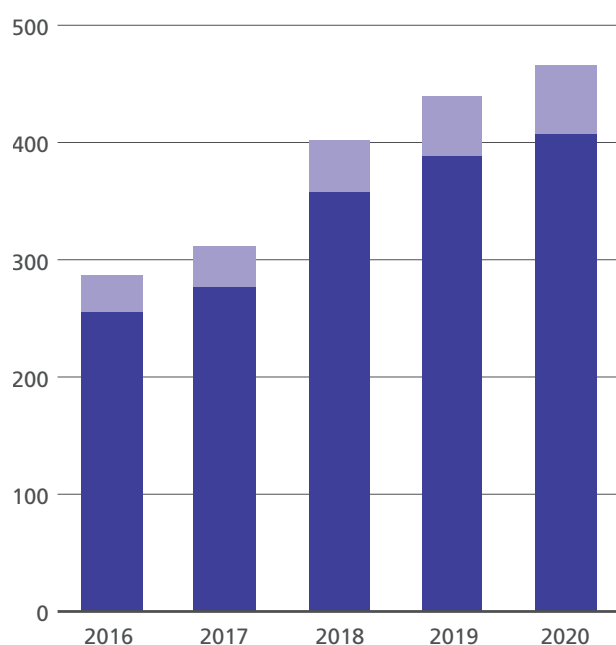


FRAUNHOFER IPMS IN FIGURES

BUDGET (IN MILLION EUROS)



EMPLOYEES



OPERATING REVENUES

	2016	2017	2018	2019	2020
Industry	51.0 %	48.6 %	47.0 %	42.7 %	45.0 %
Public Funds	22.1 %	24.6 %	27.3 %	27.1 %	31.4 %
Total Revenue	73.1 %	73.2 %	74.3 %	69.8 %	76.4 %
Employees	289	314	405	443	470



BOARD OF TRUSTEES

ECONOMIC REPRESENTATIVES

Konrad Herre

Chairman of the Board of Trustees,
Organic Electronics Saxony,
Chairman

Prof. Dr. Jörg-Uwe Meyer

MT2IT GmbH & Co.KG,
General Manager

Prof. Dr. Thomas Mikolajick

NaMLab,
Scientific Director

Dr. Axel Preuße

Globalfoundries Dresden
Module One LLC & Co. KG,
GF Fellow

Dr. Jürgen Rüstig

Independent Consultant

Dr. Hermann Schenk

Schenk Industry Consulting,
Managing Director

Prof. Dr. Frank Schönefeld

T-Systems Multimedia Solutions
GmbH,
Member of the Board

SCIENTIFIC REPRESENTATIVES

Prof. Dr. Alex Dommann

EMPA Swiss Federal Laboratories for
Materials Science and Technology,
Head of Department "Materials
meet Life"

Prof. Dr. Gerald Gerlach

TU Dresden, Institute of Solid State
Electronics,
Director

Prof. Dr. Wilfried Mokwa

RWTH Aachen, Institute of Materials
in Electrical Engineering,
Director

Prof. Dr. Ronald Tetzlaff

TU Dresden, Faculty of Electrical and
Computer Engineering,
Dean

PUBLIC SECTOR REPRESENTATIVES

MRin Dr. Annerose Beck

Saxon State Ministry for Higher
Education, Research and the Arts,
Head of Division

Jürgen Berger

VDI/VDE Innovation+Technik GmbH,
Division Manager

Dr. Claudia Herok

Brandenburg Ministry of Science,
Research and Culture,
Head of Division

Dirk Hilbert

State capital of Dresden, Mayor

MDgin Barbara Meyer

Saxon State Ministry for Economic
Affairs, Labour and Transport,
Head of Division

MR Peter G. Nothnagel

Saxony Economic Development
Corporation (WFS), Managing
Director

Dr. Ronald Schnabel

VDE/VDI Gesellschaft Mikroelek-
tronik, Mikrosystem- und Feinwerk-
technik (GMM), Managing Director

Dr. Tina Züchner

German Federal Ministry of
Education and Research, Advisor

FRAUNHOFER-GESELLSCHAFT

The Fraunhofer-Gesellschaft is the world's leading applied research organization. With its focus on developing key technologies that are vital for the future and enabling the commercial exploitation of this work by business and industry, Fraunhofer plays a central role in the innovation process. Based in Germany, Fraunhofer is an innovator and catalyst for groundbreaking developments and a model of scientific excellence. By generating inspirational ideas and spearheading sustainable scientific and technological solutions, Fraunhofer provides science and industry with a vital base and helps shape society now and in the future.

At the Fraunhofer-Gesellschaft, interdisciplinary research teams work together with partners from industry and government in order to transform novel ideas into innovative technologies, to coordinate and realize key research projects with a systematic relevance, and to strengthen the German and the European economy with a commitment to creating value that is based on human values. International collaboration with outstanding research partners and companies from around the world brings Fraunhofer into direct contact with the key regions that drive scientific progress and economic development.

Founded in 1949, the Fraunhofer-Gesellschaft currently operates 74 institutes and research institutions. The majority of our 28,000 staff are qualified scientists and engineers, who work with an annual research budget of 2.8 billion euros. Of this sum, 2.3 billion euros is generated through contract research. Around 70 percent of Fraunhofer's contract research revenue is derived from contracts with industry and publicly funded research projects. The remaining 30 percent comes from the German federal and state

governments in the form of base funding. This enables the institutes to work on solutions to problems that are likely to become crucial for industry and society within the not-too-distant future.

Applied research also has a knock-on effect that is felt way beyond the direct benefits experienced by the customer: our institutes boost industry's performance and efficiency, promote the acceptance of new technologies within society, and help train the future generation of scientists and engineers the economy so urgently requires.

Our highly motivated staff, working at the cutting edge of research, are the key factor in our success as a scientific organization. Fraunhofer offers researchers the opportunity for independent, creative and, at the same time, targeted work. We therefore provide our employees with the chance to develop the professional and personal skills that will enable them to take up positions of responsibility at Fraunhofer, at universities, in industry and within society. Students who work on projects at Fraunhofer Institutes have excellent career prospects in industry by virtue of the practical training they enjoy and the early experience they acquire of dealing with contract partners.

The Fraunhofer-Gesellschaft is a recognized non-profit organization that takes its name from Joseph von Fraunhofer (1787–1826), the illustrious Munich researcher, inventor and entrepreneur.

Furter information:
www.fraunhofer.de

NETWORKS

Fraunhofer IPMS is involved in several networks in order to facilitate knowledge transfer and skills sharing within the field of microsystems technology. Fraunhofer IPMS is also active in various inter-trade organizations.

www.ipms.fraunhofer.de/netzwerke

FRAUNHOFER GROUP FOR MICROELECTRONICS

Founded in 1996, the Fraunhofer Group for Microelectronics is the largest European service provider for Smart Systems research and development. As part of Fraunhofer-Gesellschaft, the largest organization for application-orientated research in Europe, the group combines years of experience with the expertise of over 3000 employees from the current eleven Fraunhofer Institutes plus five guest institutes from other Fraunhofer-Groups.

The group works together to transform networked cutting-edge research into micro- and nanoelectronics as well as into microsystem and communication technology. With a diversity of competences that is unique on an international scale, the Fraunhofer Group For Microelectronics bridges the gap between basic research and product development in order to significantly advance innovative strength in Germany and Europe.

Further information:

<https://www.mikroelektronik.fraunhofer.de/>



RESEARCH FAB MICROELECTRONICS GERMANY

Fraunhofer IPMS has been a part of the nationally coordinated Research Fab Microelectronics Germany (FMD) since April 2017. With 13 members and over 2,000 scientists, this research network is the largest R&D collaborative project for micro- and nanoelectronics in Europe.

Within the last two and a half years, successful project ventures have been established and numerous contracts completed in cooperation with the FMD. In 2019, projects with a combined volume of € 66.8 million were made possible as a result of investments into the FMD. Pure industry projects accounted for more than €17 million in 2019, underlining the importance of this unique cooperation in German microelectronics research.

The FMD vision of successful research and development work happening collaboratively at locations across Germany is supported by Germany's Federal Ministry of Education and Research, with approx. €350 million in funding set aside until late 2020. This investment into the FMD fuels the future viability of applied microelectronics research in Germany. Practically, this primarily takes the form of updated and modernized research facilities at the 13 participating institutes from the Fraunhofer-Gesellschaft and Leibniz Association. By the end of 2019, 157 new pieces of equipment have already been delivered and are, in the main, already up and running – a great step forward in substantially expanding the institutes' technological capabilities.

Further information:

<https://www.forschungsfabrik-mikroelektronik.de>



PATENTS AND PUBLICATIONS

PATENTS

Whether it's MEMS-based bending actuators, IP Cores or Spatial Light Modulators (SLM) with individually movable tilting mirrors, which are unique on an international level, Fraunhofer IPMS stands for innovations in the field of optical sensors and actuators, ASICs, microsystems and nanoelectronics. Fraunhofer IPMS currently has 313 pending patents. Of these, 77 are published patent applications and 236 are issued patents.

More information about our patent applications at:
<https://s.fhg.de/IPMS-Patents>

PUBLICATIONS

Fraunhofer IPMS conducts top-quality research. This is substantiated by the numerous publications that were published by scientists from Fraunhofer IPMS in 2019. A highlight of 2019 was the publication that appeared in the scientific journal "Nature Microsystems and Nanoengineering" on the topic of membraneless MEMS loudspeakers. Together with the Brandenburg University of Technology Cottbus-Senftenberg, scientists from the Fraunhofer Institute for Photonic Microsystems in Dresden and Cottbus presented a detailed report on a new, energy-efficient transducer principle using NED bending actuators in the publication.

You can find other publications at:
<https://s.fhg.de/IPMS-Papers>

DIPLOMA THESES

Implementation of a Control Algorithm with a Raspberry Pi

Vincent Fraass, HTW Dresden
Supervisor: Dr. Michael Faulwaßer

A Contribution to the Design of Vibration-loaded Micro Scanner

Oliver Kiethe, TU Dresden
Supervisors: Dr. Richard Schroedter, Dr. Ulrich Todt

Investigation of the Influence of Signal Properties of the Driver Stage when Driving Resonant MEMS Scanners

Lutz Penthin, HTW Dresden
Supervisor: Dr. Markus Schwarzenberg

Impedance Spectroscopy of Electrostatic MEMS Loudspeakers

Barbara Spitz, TU Dresden
Supervisor: Lutz Ehrig

Development of an Optical Measuring Station for Precise and Highly Dynamic Determination of the Two-dimensional Tilt Angle of 2D Micromirrors as Reference Measuring System of a Real-time Control

Friedrich Stolba, TU Dresden
Supervisor: Dr. Thilo Sandner

COOPERATIONS

MASTER THESES

Realization of a True Random Number Generator (TRNG) for Low-Power Applications in CMOS technology

Feng Liu, Friedrich-Alexander-Universität Erlangen-Nürnberg
 Supervisor: Raik Fiedler

Investigation of Gas Flow-Regulation and Generation of Active Microfluidic MEMS-Devices

Laxmi Mahati Karra, Ernst-Abbe-Hochschule Jena
 Supervisor: Linus Elsässer

Acoustic Characterization of a MEMS Loudspeaker in the Frequency Range above 10 kHz

Felix Koslowski, TU Berlin
 Supervisor: Lutz Ehrig

Processing and Characterisation of Poly(triarylamine) Field-Effect Transistors

Danilo Ocana Garcia, TU Chemnitz
 Supervisor: Dr. Olaf Rüdiger Hild

Evaluation of Organic Semiconductor Deposition and Electrical Characterization of Organic Field Effect Transistors

Sachin Raykar, TU Dresden
 Supervisor: Dr. Olaf Rüdiger Hild

A Social Media Strategy as Part of Content Marketing for the Business Unit Wireless Microsystems at the Fraunhofer Institute for Photonic Microsystems

Rebekka Wiele, Fachhochschule Südwestfalen
 Supervisor: Monika Beck

Characterisation of Ferroelectric Thin Films with Scanning Probe Microscope Methods

Mahsa Norouzi Kalkani, TU Chemnitz
 Supervisors: Dr. Thomas Kämpfe, Dr. Ramona Ecke

SCIENTIFIC COOPERATIONS

Fraunhofer IPMS is actively involved in transferring applied research into science and teaching. Through professorships of its Directors Hubert Lakner and Harald Schenk as well as Group Manager Dirk Reichelt, **Fraunhofer IPMS** is closely linked with the **Dresden University of Technology** and also with the **Brandenburg University of Technology Cottbus-Senftenberg** and the **Dresden University of Technology and Economics**. In addition to Fraunhofer IPMS industry business relationships and networking with other Fraunhofer institutes within the Fraunhofer Group for Microelectronics, these close affiliations make up a central pillar of the Fraunhofer success model. While the universities provide this special cooperation with innovative ability and competence in basic research, Fraunhofer IPMS contributes application-oriented research as well as technical equipment, contacts to businesses and market expertise. Students therefore receive both a well-founded theoretical education as well as practical training.

Further information:

<https://s.fhg.de/Kooperationen>



A mobile system for analyzing food was developed as part of the PHASMAFOOD EU project.

COMPLETED PUBLIC PROJECTS

PHASMAFOOD

Project period: 1/1/2017 – 12/31/2019
Provider of funds: EU Horizon 2020

A mobile analysis system for characterizing food was developed as part of the PhasmaFOOD project. At the same time, a system using UV / VIS fluorescence spectroscopy and complementary MEMS-based NIR spectroscopy was developed and implemented. The system was expanded with visual image capture of the samples to be analyzed. Under the EU project, Fraunhofer IPMS managed the system design activities (optics design, electronics design, opto-mechanical construction) and contributed its expertise when it came to approaching all photonic topics. A scanning/grating-based chip was implemented using MEMS components from Fraunhofer IPMS.

PRIME

Project period: 5/1/2016 – 9/1/2019
Provider of funds: EU

During the ECSEL project PRIME, over a project period of 40 months, an ultra-low power technology with all the required design blocks and integrated components for deploying new “Internet of Things” products was developed up to the demonstration stage. The main applications of the developed system modules are medical technology, agriculture, smart homes and safety technology. Fraunhofer IPMS participated in the project in the area of non-volatile memory concepts, process characterization and assessment of alternative non-toxic cleaning processes as well as electrical characterization and assessment of interface defects on FDSOI transistors.

ADMONT

Project period: 5/1/2015 – 4/30/2019
Provider of funds: EU

The ECSEL project ADMONT focused on developing a pilot line, the technology module for which was not located in a cleanroom and instead was distributed across various partners at the Dresden site. This meant that potential customers from one provider maintained an open technology platform throughout the entire value chain from silicon wafers through to the completed system at the Dresden site. In doing so, the ADMONT (“Advanced Distributed Pilot Line for More-than-Moore Technologies”) project concentrated on developing an efficient, versatile More-than-Moore (MtM) pilot line for Europe, which increases the diversification of CMOS process technologies.

NED-VAMP

Project period: 6/1/2016 – 12/31/2019
Provider of funds: European Regional Development Fund (ERDF)

Fluidic systems are essential components for developing complex systems. The aim of the NED-VAMP (Nano-Electrostatic Drive Valve And Micropump) project was to validate the concept of fluidic components by using NED actuators as the drive. In order to achieve this, MEMS test structures that generate (micropump) and regulate (microvalve) a flow were designed and manufactured. These components were then tested under varying pressures in order to assess their flow behavior. Combinations of components were also used to carry out complex work processes in order to assess the components under real conditions.

NEW PUBLIC PROJECTS

POLAR

Project period: 5/1/2019 – 4/30/2022

Provider of funds: German Federal Ministry of Education and Research (BMBF)

The aim of the POLAR project is to develop a new, cost-effective infrared sensor using modern MEMS technologies. The intention is to use doped hafnium oxide as the active material for this purpose for the first time. After the initial research findings determined advantageous properties for infrared detection, the project aims to develop a sensor chip and an integrated demonstrator for ambient air monitoring. The advantage of this is that hafnium oxide is non-toxic compared to materials used to date, and is compatible with semiconductor production.

ADELIA

Project period: 10/1/2019 – 9/30/2020

Provider of funds: German Federal Ministry of Education and Research (BMBF)

Efficient energy concepts are essential for ensuring that the artificial intelligence applications of the future preserve resources and the environment. The ADELIA project, which is part of the BMBF springboard innovation competition "Energy-Efficient KI Systems", is developing solutions for energy-efficient KI calculations taking detection of atrial fibrillation in ECG data as an example. Together with Fraunhofer IIS, Fraunhofer IPMS is developing an ASIC for the 22FDX technology from Globalfoundries, which analogously calculates a deep neuronal network more efficiently and detects the presence of atrial fibrillations with greater accuracy.

TEMPO

Project period: 10/1/2019 – 9/30/2020

Provider of funds: EU, German Federal Ministry of Education and Research (BMBF)

The TEMPO project focuses on developing and evaluating energy-saving neuromorphic computing chips in 22nm FDSOI technology nodes. Researchers are using new integrated memory technologies in innovative concepts for implementing analog and digital neuromorphic circuits. In this case, memory and chip development is driven throughout all utilization levels, from applied research, to IP generation, to integrated systems. The goal is for existing mobile and portable sensor systems to be developed, which will make it possible to reduce power consumption by several orders of magnitude.

DOSIS

Project period: 2/1/2019 – 2/1/2022

Provider of funds: SAB

The aim of the DoSIs project is conducting research into analysis methods based on ion mobility in such a way that the key components can be used for a variety of applications in the form of an Ion Mobility Spectrometer (IMS). Taking reference systems as an example, the intention is to produce fundamental evidence of functionality within a laboratory setup, which should deliver the findings required for subsequent application-orientated development. Beyond the project, the envisaged setup has the potential for participating in product-specific development of new devices, which may then be used in areas such as respiratory gas analysis, environmental analysis and civil security.

CONTACTS AND SERVICE



Linda Fischer

Site: Dresden
Phone: +49 351 8823 303
linda.fischer@ipms.fraunhofer.de

Human Resources Development & Recruiting – HRD

In the Human Resources Development & Recruiting (HRD) department, everything revolves around talent and strategic personnel management. From recruiting to personnel and organization development to succession planning, HRD ensures the right work-life balance.



Dr. Ulrich Wende

Site: Dresden
Phone: +49 351 8823 406
ulrich.wende@ipms.fraunhofer.de

Quality Management – QM

The team from the Quality Management Group within the Quality and Test Department supports Fraunhofer IPMS in maintaining and monitoring the effectiveness of existing ISO9001-certified QM systems in order to continuously develop these further. Furthermore, QM supports the business units and departments methodically with designing and improving their processes, the conformity of their products and services and the final quality assessment.



Aron Guttowski

Site: Dresden
Phone: +49 351 8823 229
aron.guttowski@ipms.fraunhofer.de

Business Development – BD

The Business Development department is synonymous with communication, customers, acquisitions, applications and ideas for innovations. The department supports the individual business units with customer work and takes care of the Institute's press and public relations work.



Dr. Sebastian Meyer

Site: Dresden
 Phone: +49 351 8823 137
 sebastian.meyer@ipms.fraunhofer.de

Environmental Sensing – ENV

The Environmental Sensing department managed by Dr. Sebastian Meyer develops sensory parts, components and sub-systems for measuring various physical and chemical parameters, such as the pH value or resonant frequency change of an acoustic transducer. The spectrum of application ranges from food monitoring, water and soil analysis, industrial metrology and security, to medical technology.

Site: Cottbus
 Phone: +49 355 69 3210
 sebastian.meyer@ipms.fraunhofer.de

Integrated Silicon Systems – ISS

At the Fraunhofer IPMS-ISS department in Cottbus, the main areas of research focus on Nanoscopic Electrostatic Drive actuators particularly for micro-fluidic applications, and terahertz micro modules. The department benefits from its local proximity to the Brandenburg University of Technology Cottbus-Senftenberg (BTU).



Holger Conrad

Site: Dresden & Cottbus
 Phone: +49 351 8823 410
 holger.conrad@ipms.fraunhofer.de

Monolithically Integrated Actuator & Sensor Systems – MAS

The MAS business unit integrates the newly developed Nanoscopic Electrostatic Drive (NED) micro-actuators in various applications. Among other things, these include MEMS micro loudspeakers based on NED actuators. They have the potential to definitively enrich the hearables, hearing-aid and in-ear headsets market. This business unit also develops micropumps and microvalves using Nanoscopic Electrostatic Drive technology.



Dr. Frank Deicke

Site: Dresden
 Phone: +49 351 8823 385
 frank.deicke@ipms.fraunhofer.de

Wireless Microsystems – WMS

Managed by Dr. Frank Deicke, the WMS business unit provides product-related partial and complete solutions for customer- and application-specific problems. The technology priority lies in the development of components for optical wireless communication (Li-Fi) and maintenance-free, battery-free RFID sensor nodes as well as the implementation of IP designs for industrial communication solutions and automotive communication. This also includes track and trace, big data and data analysis.

CONTACTS AND SERVICE



Dr. Jan Grahmann

Site: Dresden
Phone: +49 351 8823 349
jan.grahmann@ipms.fraunhofer.de

Active Microoptical Components & Systems – AMS

Within his business unit, Dr. Jan Grahmann develops active microoptical components and systems. This includes the development of customer-specific resonant and quasi-static scanning micromirrors as well as user-specific variable waveguide devices and tunable micro-lenses. Applications range from reading barcode and data code, through 3D metrology, and right up to laser projection.



Dr. Michael Wagner

Site: Dresden
Phone: +49 351 8823 225
michael.wagner@ipms.fraunhofer.de

Spatial Light Modulators – SLM

Dr. Michael Wagner's business unit focuses on Spatial Light Modulators (SLM). These consist of arrays of a large number of micromirrors on a semiconductor chip. The SLM team also develops electronics and software for mirror array control. These mirror arrays can be used in high-resolution, fast modulation of light, for example for projecting gray scale patterns in real time or for wavefront control in adaptive optical systems.



Prof. Dr. Joachim Wagner

Site: Dresden
Phone: +49 351 8823 369
joachim.wagner@ipms.fraunhofer.de

“Functional Integration for Micro-/Nanoelectronics” High-Performance Center

The Micro/Nano High-Performance Center is an interdisciplinary platform for the core competencies of system design, components and production technologies, system integration and reliability assessment. These core competences are used to work on R&D topics with high industrial relevance. Examples of these are new materials for functionalities, modular heterogeneous wafer systems and platforms for ultrasound sensor technology.



Dr. Michael Scholles

Site: Erfurt

Phone: +49 361 66338 151

michael.scholles@ipms.fraunhofer.de

“Microelectronic and Optical Systems for Biomedicine (MEOS)” Project Hub

The “Microelectronic and Optical Systems for Biomedicine” Project Hub located in Erfurt encompasses the interdisciplinary work of the Fraunhofer Institutes of Photonic Microsystems (IPMS), Applied Optics and Precision Engineering (IOF), and Cell Therapy and Immunology (IZI). The collaborative effort aims to promote the development and use of key technologies in areas including life sciences, microelectronics, optics and photonics, as well as the close cooperation with industry partners for new biomedical applications.



Dr. Matthias Schulze

Site: Dresden

Phone: +49 351 8823 335

matthias.schulze@ipms.fraunhofer.de

Engineering – ENG

The Engineering Team managed by Dr. Matthias Schulze offers its customers complete services for the development of micro-electro-mechanical systems (MEMS) and micro-opto-electro-mechanical systems (MOEMS) on 200 mm wafers.

This includes technological development and support of our MEMS technologies, from individual processes and technology modules up to complete technologies and cleanroom services. On customer request, this team can even provide piloting and can support technology transfer.



Thomas Zarbock

Site: Dresden

Phone: +49 351 8823 372

thomas.zarbock@ipms.fraunhofer.de

Fabrication – FAB

Our Fabrication Department managed by Thomas Zarbock provides internal and external services for R&D and pilot production projects conducted by Fraunhofer IPMS. This department is responsible for operation of the cleanroom according to the latest industry standards. It cooperates closely with the Engineering Department to process MEMS and MOEMS devices. Services offered by the Fabrication Department include: wafer processing; assembly and interconnection technology; and coordination of external (third-party) and supplier services.

CONTACTS AND SERVICE



Dr. Wenke Weinreich

IOT Components & Systems

Site: Dresden
Phone: +49 351 2607 30 53
wenke.weinreich@ipms.fraunhofer.de



Dr. Benjamin Uhlig

Next Generation Computing – NGC

Site: Dresden
Phone: +49 351 2607 30 64
benjamin.uhlig@ipms.fraunhofer.de

Center Nanoelectronic Technologies

The “Center Nanoelectronic Technologies” (CNT) is subdivided into two business units, i.e. Next Generation Computing (NGC) and IOT Components & Systems (IOT), which develop semiconductor technologies on 300 mm wafers and work on integrating innovative functionalities into existing CMOS platforms. Its focus currently lies in researching new memory concepts and high-frequency components using ferroelectric, CMOS-compatible materials. It also works on energy-efficient power management systems that bring together solid state batteries, harvesters and embedded condensers.

For its research, the CNT uses equipment that can be applied flexibly and a wide range of processes. Our Screening Fab concept makes it possible for consumables suppliers, plant manufacturers and semiconductor companies to try out new materials and manufacturing processes. Our service offering ranges from qualification of manufacturing steps, such as cleaning and etching, copper plating and CMP to the evaluation of new precursors for atomic layer deposition. In addition, the CNT offers a wide spectrum of methods for physical error analysis and electrical characterization of semiconductor elements.

SITES

FRAUNHOFER INSTITUTE FOR PHOTONIC MICROSYSTEMS IPMS

Maria-Reiche-Strasse 2
01109 Dresden, Germany
Phone: +49 351 8823 0
Fax: +49 351 8823 266
E-mail: info@ipms.fraunhofer.de
Website: www.ipms.fraunhofer.de

FRAUNHOFER INSTITUTE FOR PHOTONIC MICROSYSTEMS IPMS – CENTER NANOELECTRONIC TECHNOLOGIES CNT

Königsbrücker Str. 178
01099 Dresden, Germany
Phone: +49 351 2607 3069
Fax: +49 351 2607 3005
E-mail: info@ipms.fraunhofer.de
Website: www.ipms.fraunhofer.de

FRAUNHOFER IPMS – INTEGRATED SILICON SYSTEMS ISS DEPARTMENT

Fraunhofer IPMS at the
BTU Cottbus-Senftenberg
Konrad-Zuse-Strasse 1
03046 Cottbus, Germany
Phone: +49 355 69 24 83
E-mail: info@ipms.fraunhofer.de
Website: www.ipms-iss.fraunhofer.de

FRAUNHOFER PROJECT HUB MICROELECTRONIC AND OPTICAL SYSTEMS FOR BIOMEDICINE

Herman-Hollerith-Str. 3
99099 Erfurt, Germany
Phone: +49 361 66338 150
E-mail: meos@ipms.fraunhofer.de
Website: www.meos.fraunhofer.de

EDITORIAL NOTES

© Fraunhofer Institute for Photonic Microsystems IPMS,
Dresden 2020

Copyrights

All rights reserved. Reproduction requires the
permission of the Director of the Institute.

Editors

Fraunhofer IPMS

Photos

Fraunhofer IPMS
Page 8: Fraunhofer-Gesellschaft/red_gradient_©Fraunhofer_
IOF18_Quilt_Photonenquelle
Page 12: BTU Cottbus-Senftenberg
Page 16/17: Shutterstock/pop tika/shutterstock_1159171741
Page 18: Fraunhofer IPMS/© HTW Dresden 2017 - Peter SEBB
Page 19: Shutterstock/cybrain/shutterstock_506790403
Page 20: Shutterstock/Jenson1559555006096
Page 22/23: Shutterstock/metamorworks/1043682535
Page 24: Shutterstock/temp-64 GTX/1144327934
Page 25: Shutterstock/metamorworks/1558342230120
Page 27: Shutterstock/Gorodenkoff/1031105431
Page 30: Shutterstock/Andrey_Popov/1246981141
Page 30: Shutterstock/GermanVectorPro/1366160168
Page 32: Adobe Stock/Gorodenkoff Productions
OU/166977148

In relation to grammar, masculine references to people apply
equally to people of other genders, where appropriate.



Qualitätsmanagement

ISO 9001

www.dekrasiegel.de



