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FRAUNHOFER INSTITUTE FOR PHOTONIC MICROSYSTEMS IPMS

ANNUAL REPORT

2020
2021

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

With over 400 employees, Fraunhofer IPMS develops innovative, customer-specific solutions in the fields of intelligent industrial solutions, medical technology and improved quality of life at four sites in Dresden, Cottbus and Erfurt.

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

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

FOREWORD

Prof. Dr. Harald Schenk
Executive Director

Prof. Dr. Hubert Lakner
Institute Director

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

we look back on an eventful year. The coronavirus crisis has had a significant impact on all of our lives and workplaces, and it is still difficult to assess the economic impact. Against this backdrop, we are particularly pleased that we were able to finish the year 2020 with economic success and that we have now reached a remarkable size with four locations and significantly more than 400 employees, combined with a high degree of thematic diversity. What's more, we received our best evaluation to date in our customer satisfaction analysis. This shows us that our strategy of building long-term partnerships with our customers based on our unique selling points has once again paid off. Our customers rely on our services to stay competitive – especially in challenging times.

The globally increasing demand for semiconductors illustrates, especially in times of crisis, how important our research and development services are for the industry's value chains both nationally and internationally. As a result of advancing digitization worldwide, other topics are coming to the fore in addition to the availability of semiconductors: Technological sovereignty and trustworthiness in microelectronics ("Trusted Electronics"), sustainability aspects ("Green ICT") and next-generation computing are just some of the key words here. Germany is also setting these priorities and has launched a corresponding microelectronics framework program. Fraunhofer IPMS plays a major role in achieving this program's goals. Projects such as the Important Project of Common European Interest 2 (IPCEI) have also been initiated in Europe, which will lead to further expansion of capacities at German semiconductor companies. In doing so, we expect to be able to continue to significantly support companies' competitiveness through our services and innovation stimuli.

A large number of highlights in 2020 show that we are already doing this successfully: Thus, the Center Nanoelectronic Technologies was able to complete its move to the new location in the immediate vicinity of Globalfoundries and Bosch with great success. With 4,000 m² of clean room space and 80 facilities, we can now offer even more targeted applied research on 300 mm wafers for microchip producers, suppliers, equipment manufacturers and R&D partners. Our huge thanks go to the Free State of Saxony and the Fraunhofer-Gesellschaft, without whose commitment this major project could not have been realized. This support, which cannot be taken for granted, impressively shows the importance attached to the Fraunhofer IPMS and thus also to microelectronics in Saxony.

The importance of medical engineering, biomedical engineering and healthcare have been brought home to us very clearly since last year. With the "Microelectronic and Optical Systems for Biomedicine MEOS" project hub at the Erfurt site, where we conduct research together with Fraunhofer IZI and Fraunhofer IOF, we have successfully set the course for joint innovation research in these areas. Our new diagnostic imaging methods with AI-supported evaluation, innovative mobile sensors and monitoring systems are making a major contribution to driving forward the digitization of medicine.

Our institute section in Cottbus provides another highlight: Within the "Innovation Campus Electronics and Microsensorics Cottbus (iCampµs)," we have successfully completed the first project year and achieved the set goals. This shows that we are on the right track. Our thanks go to the State of Brandenburg and especially to the Ministry of Science, Research and Culture, which not only strongly supports the planned second phase of iCampµs starting in 2022, but also our planned research activities into novel sensors, sensor devices and systems for biomedical applications. In this way, we want to continue to play an active role in shaping structural change in Lusatia and continue to provide important impetus.

Topic-specific highlights should also be mentioned. After five years and having shown great commitment, the SLM Spatial Light Modulators business unit has succeeded in acquiring a major Europe-wide project on the topic of holography. In the Active Micromachined Systems AS business unit, we recorded another decisive success by signing a contract with AEye Inc. who will use our MEMS scanner mirrors in their LiDAR systems for autonomous driving in the future.

Finally, a look at our internal structures. In 2020, we adjusted our organizational structure with the aim of securing our future, thus creating the conditions for us to continue to operate efficiently and effectively going forward.

We would like to sincerely thank you for your many years of trust in our institute and look forward to continuing to work successfully with you as customers, sponsors and partners, developing solutions for industry and society and transforming innovative ideas into applications.

Harald Schenk   Hubert Lakner

CONTENT

INTERVIEW

In this interview, the two Institute Directors of Fraunhofer IPMS, Prof. Harald Schenk (left) and Prof. Hubert Lakner (right) talk about the challenging year that was 2020, their positive view of the future and the increasing importance of microelectronics in Germany and Europe.

What was your experience of the year 2020?

Schenk – We can say for sure that it was an unusual year. For society as a whole, for companies, for families and for our employees, it was marked by uncertainty and strain. We have not experienced anything like this before. In such a crisis, however, it also becomes apparent how well a team functions and what its strengths are. And when I look back on the year in this sense, I am immensely proud. Our employees have demonstrated great strength and also a high degree of resilience and flexibility. Thanks to the cooperation of all our employees, we were able to switch quickly and smoothly to remote work from home and maintain clean room operations at the same time. We ended the year with a successful financial performance, and our customers gave us their best ever ratings in our customer satisfaction survey. This is remarkable. Accordingly, I also look back on 2020 with pleasure.

Lakner – 2020 was certainly a game changer. At the same time, we have learned that we can adapt quickly and still remain innovative. I am very proud that we have managed to implement major projects despite the challenges of the pandemic: We restructured our institute organization to focus on the future and completed the move of the CNT to the new location. The fact that this was possible is thanks to our employees' support. I hope they are also proud of what they have accomplished!

And how are you looking ahead?

Lakner – For me personally, I will be retiring in a few years (laughs). But of course, I still have ideas about how we should proceed. We are currently considering the idea of a microelectronics research center in Saxony. In this way, we want to support the structural change to an innovative society through new, smart communication technologies. Together with Fraunhofer IZM-ASSID, we are further expanding our 300 mm research. In Cottbus, we are strengthening our research activities in the direction of "Next Generation MEMS" and intend to establish a center for microsensor technology in the long term. And at our MEOS project hub in Erfurt, we are working on key technologies in the field of life sciences. We have therefore laid the foundations for a successful future.

Schenk – I can very clearly see a great opportunity for Germany and Europe in the coming years in the area of technological sovereignty. I think it is enormously important that we do not allow ourselves to be left behind in the development of microelectronic systems and innovations. Research institutions and universities must be able to speak on equal terms with companies in Asia and the US, which is ultimately where most volume production takes place. For me, it all hinges on how to incorporate microelectronics – from the circuit to the finished sensor – into systems. Germany and Europe need to catch up here. After all, we are talking about such important issues as healthcare, mobility, and information and communications technology. We have the knowledge and the technologies, and now the task for Fraunhofer IPMS in particular is to further expand our application know-how.

How does Fraunhofer IPMS keep driving innovation in new areas?

Lakner – The future is not purely based on chance. You create a picture of the future and work towards it. You always have to keep an eye on the benefits to society, i.e. from the very beginning of development, you have to consider which problems you can solve with a technology. Of course, you can't predict whether innovation will emerge from this, but it helps to break away from existing patterns and gain new perspective.

Schenk – In the past, we increasingly achieved success in this area. One example: we developed an actuator technology years ago, the "nano-electronic drive." While conducting our research, we found that there was an unresolved problem in the field of micro speakers. So, we came up with a solution, created a patent that was a basic patent, built a demonstrator, and created a spin-off called Arioso Systems. Meanwhile, the spin-off has closed its first seed financing round with a whopping € 2.6 million and is in talks with the world's biggest players in mobile devices.

What do you consider to be the basis of Fraunhofer IPMS's success, even during the crisis?

Lakner – We plan for the future and constantly ask ourselves how we can make further improvements. Our motto is still "don't stop thinking about tomorrow."

Schenk – Over the years, we have placed great emphasis on building stable, long-term, strategic client relationships. We are succeeding in this because we have unique selling points worldwide that create great value for our customers. I would also like to emphasize once again that we have a really great team at Fraunhofer IPMS that, in addition to ensuring this continuity, is always open to new ideas. I think this combination makes us successful.

And how important would you say networking with partners from science and industry is?

Schenk – It is impossible to overestimate the value of networks and partnerships! We have an excellent R&D infrastructure and outstanding technological expertise at Fraunhofer IPMS. However, we cannot be experts in all conceivable applications. That's why it's incredibly important for us to enter into discussions with the right partners. Listening to where unsolved problems are, which we can solve with our technology.

Lakner – I always like to compare it to a piece of music: Soloists can only play solo pieces; a philharmonic orchestra can perform the great works. For example, the Microelectronics Research Fab in Germany: as the largest cross-location research association for microelectronics in Europe, it offers a unique range of expertise and infrastructure. The developments that have occurred here in recent years are impressive and clearly show the importance of networks.

What is your wish for the future?

Lakner – I still dream of a more interconnected Europe, socially as well as in the field of research. For Fraunhofer IPMS, my wish is that it will grow even more and that the sites will continue to develop successfully.

Schenk – Above all, I wish for us to always be in a position to shape the future! This is an immense pleasure. I would also like to see society regain a higher level of togetherness and for the willingness to communicate with each other not to break down. We have tremendous potential in Germany to positively shape our lives and the lives of our fellow citizens, also around the world. We should take advantage of that!

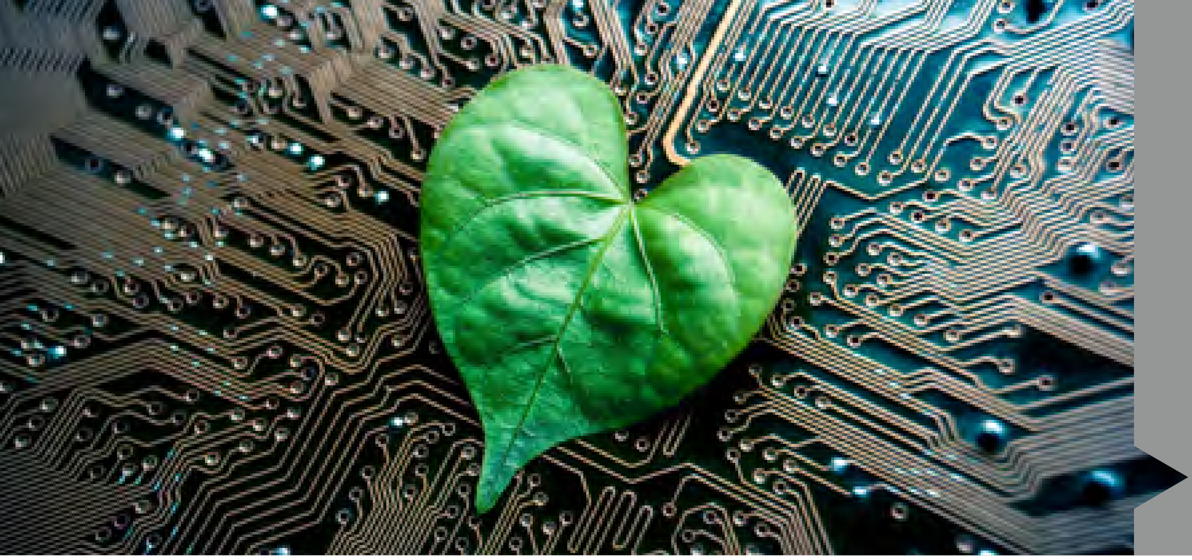
DIGITIZATION

As the basis for miniaturized, intelligent and networked sensors and actuators, microelectronics is a key technology and enabler for digitization, IoT as well as Industry 4.0.

It also plays a crucial role for the issues of the future:

- Sustainability ("Green ICT")
- Trusted electronics and technology sovereignty,
- Artificial intelligence (AI) and sensor edge nodes
- Next generation computing (neuromorphic computing, quantum computing).

We invite you to learn more about our research in these areas on the following pages.



GREEN ICT – STEP TOWARDS RESOURCE-SAVING MICROELECTRONICS

Despite all of our technical efforts, the total energy consumption of information and communication technology has risen continuously in the past. In view of the socio-political goal of reducing CO_2 emissions worldwide, the development of electronic systems faces the challenge of achieving a reduction in the resources required for both production and operation. This includes looking at the entire value chain for electronic products, including manufacturing processes and supply chains. Fraunhofer IPMS has set itself the goal of actively promoting this minimization of resources together with the Research Fab Microelectronics Germany (FMD).

The aim of the "Green ICT" initiative is to install a Green ICT competence center within the FMD, which will act as a central point of contact for industry, politics and science in Germany and Europe. Green ICT hubs focused on the topic offer project partners the opportunity to have systems and subsystems, demonstrators and prototypes evaluated and, if necessary, optimized in dedicated testbeds with regard to the special requirements of eco-friendly products.

In addition to energy-saving sensor edge cloud systems and energy-saving communication infrastructures, Fraunhofer IPMS focuses in particular on resource-optimized microelectronics production. The institute can draw on extensive experience gained within its two clean rooms (200 mm MST line and 300 mm microelectronics line). Through its expertise, Fraunhofer IPMS thus offers a broad spectrum with comprehensive offerings for plant, IC and material manufacturers to produce resource-optimized and environmentally-friendly electronics. In the field of processing, the institute supports its customers by providing resource-optimized consulting and development services, especially in the area of lithography and wet processes. This includes both investigating alternative materials (e.g. cedroxide-free slurries for CMP processes) and reducing their consumption as well as optimizing energy consumption to reduce the CO_2 impact.

In general, the clean room infrastructure is a key factor in terms of environmental impact. Here, Fraunhofer IPMS concentrates on optimized control of the infrastructure technology (e.g. recirculation technology) as well as on the use of recovery elements (cooling energy recovery or combined heat and power). The Green ICT initiative's holistic approach enables offerings for a greener future of microelectronic manufacturing.

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Fraunhofer IPMS is developing a 60 GHz RFID for trusted supply chains in microelectronics.

TRUSTED ELECTRONICS: RELIABILITY THROUGH RFID

Due to the globalized development and production of electronic components and systems, safety is of key importance for manufacturers and users. Trusted electronics is about the sovereignty of manufacturing processes, ensuring that only trusted components are installed. To achieve this, it would be beneficial to have a system in which all microelectronic components are equipped with a forgery-proof label. So far, this has failed due to the costs and the size of possible technical solutions. Fraunhofer IPMS has now developed an RFID tag measuring just 1.5 mm², which can ensure reliability when integrated into each individual microelectronic chip.

In the production of semiconductor devices, the deliberate introduction of additional functionality in order to gain information about the system and thus circumvent security is a major risk. These opportunities are facilitated by the fact that modern manufacturing of electronic components and systems is now globally distributed across many factories. For example, wafer production, assembly into the housing and final testing take place in specialized production facilities that often do not belong to a corporate group. The logistics can only be traced via the accompanying documents and serial numbers printed on the housings. This information flow is not sufficient for safety-relevant applications. It can be manipulated at will and thus does not inspire confidence in the components.

At Fraunhofer IPMS, a solution is being pursued using special RFID tags. In this process, a tiny authentication chip is installed in the housing of the microelectronic circuits to be protected. The chip operates completely autonomously and has no electrical connection to its environment. Energy harvesting principles are used for energy supply. Communication is based on the backscatter principle familiar from radar technology. The data traffic is secured via cryptographic procedures to prevent manipulation.

The basic feasibility of such concepts has already been demonstrated in preliminary projects. Now, the technical parameters are being improved by increasing the reading distance between the reader and the authentication chip tenfold to about 5 cm, reducing the chip area to below 1 mm², and lowering the authentication speed to below 100 ms. This can be achieved by using frequency bands above 60 GHz, which allows the antenna to be made smaller, and to achieve an extremely low supply voltage of 0.4 V by using state-of-the-art CMOS technology.

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SENSOR EDGE NODES – ARTIFICIAL INTELLIGENCE 2.0

Sensors are the prerequisite for automation and digitization – from Smart Health to IoT and Industry 4.0. The increasing importance and large-scale use of sensor technology comes with new challenges. As it already stands today, around 100 sensors are used in cars, for example, and the trend is rising. The evaluation and intelligent use of this data is becoming increasingly important. Currently, the data collected by the sensors is usually fed into central learning systems using cloud solutions. For applications with high requirements in terms of data volumes, latency and security, sensor-based intelligent data processing is gaining importance.

In this context, Fraunhofer IPMS offers its customers a complete solution from sensor development, sensor data preprocessing, edge AI hardware basis and software integration to application-specific implementation.

Innovative sensor solutions, such as LiDAR (Light Detection And Ranging) systems, infrared arrays or even ultrasonic arrays are used in numerous applications and generate data volumes whose transport also pushes modern bus systems to their limits. Multi-sensor systems with several networked sensor nodes also require pre-processing for data reduction in order to ensure that the amounts of data can be organized. To reduce the amount of data transmission and security in the event of a connectivity disruption, it is becoming increasingly important to implement artificial intelligence (AI) systems even on-site near the sensor system. Here, the size and power consumption have so far limited successful implementation.

Fraunhofer IPMS is dedicated to developing the necessary hardware and software as well as designing sensor data processing for this "edge AI" (power consumption < 100 mW) or the even smaller embedded AI (power consumption < 10 mW). The goal is to provide a solution for customer-specific sensor tasks using AI processing. Edge literally means "on the edge," i.e. edge nodes are decentralized nodes. In contrast to cloud-based AI approaches and solutions being explored in many places, this is particularly useful for applications that require resource-efficient processing of data on-site, i.e. directly at the sensor or actuator.

Based on an open hardware platform (RISC-V), Fraunhofer IPMS is developing the fundamentals and the necessary circuit components, software and toolchain to carry out application-specific machine processing on-site. In this innovative integration area, Fraunhofer IPMS offers customers a complete AI platform and the development of comprehensive sensor systems, including machine learning solutions.

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SENSOR TECHNOLOGY FOR COLLABORATIVE ROBOTICS

Digitization of production requires the use of sensors that function like multidimensional sensory organs. Fraunhofer IPMS develops sensors that enable systems to act autonomously, e.g. collaborative robots or autonomous driving vehicles, to detect the environment in a similar way to human sight and feeling and thus to take safe action in conjunction with humans. This would enable industrial robots to take on even more demanding tasks and react appropriately to their environment. Fraunhofer IPMS is pursuing various approaches to machine perception: from the sentient gripper hand to the "scanning eye," which is intended to enable machine vision with distance measurement in space.

Sensors are an increasingly important field of action for environmental detection in autonomously acting systems. Autonomously acting systems include, for example, collaborative robot systems, also called COBOTs, which work together with humans and are not separated from them using protective devices in the production process. Such cooperation requires that the robots do not pose a danger to the people working around them. Sensors that are to ensure this must be small, safe, and as redundant as possible to detect the environment.

Fraunhofer IPMS is working on different sensor principles to enable comprehensive environment detection by COBOTs. One goal is the development of a "seeing skin" based on networked sensors that enables comprehensive collision avoidance by the robot. For this purpose, micromechanical infrared and ultrasonic sensors are used for distance detection. The latter are based on the novel "Nano Electrostatic Drives" actuator technology developed and patented by Fraunhofer IPMS. In order to detect larger distances by sensors, Fraunhofer IPMS is also working on micromechanical LiDAR (Light Detection And Ranging) systems that constantly scan the environment like a "scanning eye."

In addition to environmental detection, Fraunhofer IPMS is also working on tactile sensor systems for safe, object-specific gripping. The aim is to enable robots to detect objects before gripping and to monitor their position during the entire gripping process with the aid of sensor technology integrated in the gripping hand. The gripping force, which can therefore be adapted to the specific object, allows gentle handling of the parts and safe transport. For this purpose, Fraunhofer IPMS is developing close-range tactile ultrasound systems based on capacitive micromechanical ultrasonic transducers (CMUT).

More information:
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THINKING CHIPS: INNOVATIVE HARDWARE FOR NEUROMORPHIC COMPUTING

Increasing digitization is constantly driving the demands for electronic hardware. Speed, performance, miniaturization and energy efficiency are increasingly important when it comes to enabling big data and artificial intelligence (AI) applications. A promising approach to solving this problem is offered by "neuromorphic computing," which aims to emulate the brain's self-organizing and self-learning nature. The Center Nanoelectronic Technologies of Fraunhofer IPMS develops materials, technologies and complete hardware solutions with high energy efficiency, especially for applications in the edge area.

Technological developments are being pursued in various stages of expansion. "Deep neural networks" (DNN) have already been integrated into applications with the help of traditional technologies (e.g. SRAM or flash-based) and initially emulate the brain's parallelism and efficiency. Further miniaturization and reduction of energy consumption for edge applications is possible using new, innovative technologies.

The subsequent generation of "spiking neural networks" (SNN) additionally attempts to physically reproduce the temporal component of neuron and synapse functionality, which enables even higher energy efficiency and plasticity. Here, too, innovative technology concepts are highly promising compared to traditional technologies.

For both generations of neuromorphic hardware, Fraunhofer IPMS is researching crossbar architectures based on non-volatile memories using ferroelectric field-effect transistors. This is being carried out within various European projects (TEMPO, ANDANTE), but also ones that are funded internally by Fraunhofer.

Particularly innovative materials research for future SNNs is being conducted as part of the Saxon MEMION project, which is evaluating the potential of lithium-based transistors. Similar to semiconductors, here the mobile lithium ions serve as a dopant that can modify the electronic conductivity of the material over a wide range. Unlike the fixed, preset dopants in silicon, their concentration is variable during operation, similar to the way a battery works. This makes it possible to manufacture components that exhibit stepless switching behavior over several orders of magnitude, making them ideal for creating neuromorphic architectures practically like no other technology. To begin with, the current challenge here is a fundamental understanding and control of ionic transport processes on nanoscopic scales.

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ANDANTE – NEW STORAGE DEVICES IN THE EDGE AI ACCELERATOR FOR NEUROMORPHIC COMPUTING

Various hardware concepts for implementing neuromorphic computing are under discussion. Basically, this type of computer is made up of countless synapses and neurons, similar to the human brain. Here, the synapses can be efficiently represented by embedded memories that describe the strength of different neurons' connections with each other. In the ANDANTE project, we are relying on ferroelectric field-effect transistors (FeFETs) to act as the ideal synapse. These are characterized by both a very high dynamic range and a very low propagation delay. This allows signals to be transmitted and collected quickly with very little loss. Additionally, these can be incorporated into a chip alongside standard logic transistors, making a scalable edge AI accelerator possible.

"Edge AI" refers to an approach in which intelligent data analysis is performed directly on the computer chip, enabling increased computational speed while reducing power consumption. As part of the ANDANTE project, launched in 2020, Fraunhofer IPMS is working on implementing FeFETs directly on the semiconductor chip, thus developing the most energy-efficient edge AI accelerators available on the market. These chips make it possible, for example, to assign objects in images to different categories or to segment areas in an image.

However, algorithms that process these tasks have high memory requirements, for example to describe the connection of the neurons, i.e. the synapses. To solve this problem, chips are being developed that directly embed the synapse function, as in the human brain. The calculations are thus realized very efficiently, since a complicated data transfer between the computer and processor is no longer necessary. This enables decentralized, lightning-fast, energy-efficient data processing for edge sensors. In the future, sensors can be evaluated in a decentralized way without having to send their data to the cloud.

FeFETs are ideal as synapses for edge AI accelerators due to their resistance change and low signal delay. In addition, Fraunhofer IPMS is also showcasing compatible neuron circuits in the ANDANTE project. In close collaboration with companies, universities and the IIS and EMFT Fraunhofer Institutes, work is being carried out on a Fraunhofer FeFET ASIC that can be used to manufacture 22FDX Globalfoundries technology. The stated goal here is to develop the most energy-efficient AI chip on the market.

ANDANTE will run until May 2023 and has a total funding volume of over €40 million. The funding sources are the European Union, the Federal Ministry of Education and Research and the Saxon State Ministry of Economics, Labor and Transport. In addition to companies from the semiconductor industry, numerous universities and research institutes are also participating in the project.

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SCALABLE CONCEPTS FOR SILICON-BASED QUANTUM COMPUTERS

Together with German and European partners, Fraunhofer IPMS is conducting research into scalable technologies for semiconductor qubits. Industry-focused CMOS-compatible manufacturing methods are being developed by various projects. From material screening to process development, from new integration concepts to characterization and implementation of necessary drive electronics, important components for future quantum computers are being investigated. The state-of-the-art 300 mm semiconductor infrastructure at the Center Nanoelectronic Technologies provides excellent conditions for this.

Quantum computers have the potential to push the limits of conventional computing systems many times over. Medicine, logistics, materials development, and cryptography are just a few of the fields that can gain tremendous advances through quantum computing. Although there are already a number of different approaches to quantum computing, there are currently only a few implementations in Germany that go beyond the laboratory setup. For future German and European technological sovereignty, also in hardware, the development of proprietary technologies to produce scalable, industry-compatible quantum computers is crucial. Fraunhofer IPMS will make important contributions here in the coming years with its 300 mm technology. Fraunhofer IPMS is focusing on manufacturing qubits and their electronic interfacing.

Concrete approaches to manufacturing qubits that offer high potential for industry-orientated scalability include Si/SiGe, Si MOSFET, and superconducting qubit technologies. Equally important is the development of new, optimized materials, processes and integration concepts for cryoelectronics as well as superconducting metallization concepts. Therefore, Fraunhofer IPMS is using its know-how and infrastructure to make possible highly scalable quantum processors that build on the achievements and advantages of silicon-based semiconductor manufacturing. For example, this relates to manufacturing processes for nanostructuring, but also material development and electrical control from the CMOS area.

In its activities, Fraunhofer IPMS connects with European partners, for example to realize the QLSI project ("Quantum Large-Scale Integration with Silicon"). This project is part of the EU's ambitious Quantum Flagship program, a 10-year, € 1 billion research initiative launched in 2018. The overall goal is to consolidate and extend Europe's scientific leadership and excellence in quantum technologies and to launch a competitive European Quantum technologies industry.

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COMMUNICATION SOLUTIONS FOR MODERN PRODUCTION

Industry 4.0 is no longer just a buzzword: in modern industrial plants, machines, logistics and products talk directly to each other and require technology solutions for fast, error-free data transmission. In this context, Fraunhofer IPMS is researching innovative solutions for industrial communication in the technology fields of Li-Fi, RFID sensors and IP cores. The services offered by Fraunhofer IPMS range from conceptual design to product development and pilot series production – from components to complete system solutions.

Until now, real-time data transmission has been carried out via cable using special fieldbus systems. However, cables are not suitable for mobile applications in industrial robots and automation technology. Wireless data transmission using Li-Fi enables fast, secure data transmission in real time via light, offering data transfer rates in the gigabyte range. This ensures efficient, problem-free communication between machines in modern industrial plants.

RFID sensors are the combination of an RFID transponder circuit and integrated or external sensors. They are able to monitor industrial plants wirelessly and also without a battery. The reader supplies the sensor with energy to perform the measurement and then transmit the measured values. In this way, temperature, air pressure, humidity and other parameters can be monitored wirelessly without any maintenance. In this field, Fraunhofer IPMS offers services for system development of battery-free RFID measurement systems.

IP-based design is an approach that helps ASIC and FPGA designers save time and effort by using specified, tested IP cores. Fraunhofer IPMS develops IP cores for industrial communication that enable deterministic data transmission (TSN) from devices on Ethernet networks. The IP core product family from Fraunhofer IPMS also includes IP cores for CAN2.0, CAN-FD and, in the future, CAN-XL as well as LIN bus systems. Selected IP cores are certified as ASIL-B-Ready or ASIL-D-Ready.

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DRIVING INNOVATION

Innovation is the driving force for the future. Fraunhofer IPMS constantly strives to drive innovation with its cutting-edge technologies.
For example, through our successful spin-offs, which integrate advanced technology into applications, or by expanding the 300 mm research at our Center Nanoelectronic Technologies, which is taking a further step toward scalable microelectronics. Also due to the fact that our research builds a bridge to industry by integrating technological developments into applications through pilot production.

On the following pages, we invite you to find out more about some of the innovative initiatives through which we are contributing to the success of the national and international economy. The aim is that research for people becomes innovations for us all.

Dr. Konrad Herre, CEO of sensry GmbH.

THE MICRO LOUDSPEAKER SPIN-OFF AND FRAUNHOFER IPMS – ON THE ROAD TO SUCCESS WITH SOUND PRESSURE

The Internet of Things, especially the Internet of Voice, requires very energy-efficient, high-quality audio devices. In particular, tiny speakers are being used in large numbers for in-ear headphones and other portable miniature devices, which are always battery-powered. The business purpose of Arioso Systems GmbH, a spin-off from Fraunhofer IPMS founded in 2019, is the exclusive use of such loudspeakers based on silicon microsystems invented, patented and developed at IPMS. These micromechanical speakers offer the potential to be both very energy efficient and to produce very high-quality sound. To enable the product launch, further development of even louder and better sounding speakers is being driven by additional joint projects.

The innovative loudspeaker concept is based on sound transducer elements that displace the volume of air in the silicon chip through their movement, meaning that audible sound is generated. The special feature is the arrangement of a large number of these transducer elements within the chip itself, as opposed to the otherwise classic arrangement as a single larger element on the loudspeaker surface. The basic feasibility of this approach has been demonstrated in the laboratory in the past. As a result, further component variants were designed and manufactured for application outside the laboratory, in particular to achieve sufficient volume or high sound pressure: However, this is not yet enough for a commercially successful application.

Three key characteristics determine the performance of micro loudspeakers: efficiency, volume and sound. All three are particularly challenging to combine, especially in the smallest systems produced as chips, which is what we are striving for. It therefore comes down to numerous other improvements. As a major milestone, transducer elements that move linearly were developed in 2020. These elements already allow particularly good quality sound to be generated without complex electronic preparation of the input audio signal. This was achieved in conjunction with a simultaneously reduced space requirement in the chip as well as lower requirements for power consumption. This allows a larger number of these elements to be accommodated in the chip and higher volume to be achieved without greater power requirements for the same chip size.

The fact that the partnership between the spin-off Arioso Systems GmbH and Fraunhofer IPMS is on the road to success was also made visible in 2020 by the acquisition of further joint funding projects. The usage potential of these novel micro loudspeakers is currently being evaluated in discussions with interested industrial customers. At the same time, the team is already working on patenting and implementing further ideas that will turn the initial idea of a new loudspeaker concept into a sustainable innovation initiative.

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SENSRY – HIGH-TECH IOT SOLUTIONS FOR MEDIUM-SIZED BUSINESSES

The technological development of microelectronics is proceeding at an increasingly rapid pace, which poses considerable challenges for medium-sized companies in particular as drivers of innovation. Until now, SMEs have mostly relied on standardized components, but these are not sufficient to enable them to develop high-performance, energy-efficient, highly integrated solutions. As part of the USeP ("Universal Sensor Platform") project funded by the Free State of Saxony and the EU, Fraunhofer IPMS, ENAS, IZM, IZM-ASSID, IIS and IIS/EAS as well as Globalfoundries Dresden are therefore developing a flexibly configurable, chip-integrated, high-performance multisensor hardware for various IoT application areas. This means that SMEs now also have access to advanced technology made in Europe for the first time. In 2019, the project gave rise to the start-up Sensry. In an interview, CEO Konrad Herre talks about how he wants to develop the start-up into the Google of the IoT.

You see yourselves as a link between medium-sized businesses and innovation. What do you mean by this?

If a company wants to equip its products with smart sensor technology, it often does not have access to advanced technology or a budget for elaborate electronics development, especially if it is a medium-sized company. Of course, companies can buy in commercially available components, but these are not tailored to the company's specific application, nor do they know how the electronics are constructed, which is critical for safety reasons. Dresden has the advanced technology and the know-how to close this gap. That's what Sensry is here to do. We provide advanced technology from Europe for Europe. We manufacture everything in Europe and also pay special attention to the safety of our solutions. "Trusted electronics" is the keyword here. Customers are also increasingly asking for this.

What was a highlight for Sensry in 2020?

It was particularly positive for me that we were able to successfully complete a pilot project: within three months, we worked with partners to create a predictive maintenance solution at Globalfoundries. This related to predictive maintenance of ultrapure water valves. Our sensor "listens" to the valve and the artificial intelligence located at the sensor node provides information on the state of the valve. Normally, such a development would take at least two to three years. We were able to do this in three months and at a fraction of the development cost.

What is your wish for the future of Sensry?

Our goal is to develop our platform into a hardware standard. Just as Google is the standard for search engines, we want to become the standard for high-tech IoT solutions. I hope that we can use this to give German industry a boost, to help start-ups and SMEs to remain innovative and to bring their products into use in a time- and cost-effective manner. I also see this as a political task for us – to provide German industry with possible solutions. It's just in our Sensry genes!

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The new CNT site with existing building in the foreground (status quo, 2021).

CNT 2.0: THE CENTER NANOELECTRONIC TECHNOLOGIES AT ITS NEW LOCATION

At the Center Nanoelectronic Technologies CNT, Fraunhofer IPMS conducts applied microelectronics research on 300 mm wafers for a variety of customers. Previously, clean room, laboratory and office space at Infineon Technologies in Dresden was used for this purpose. Due to strong economic demand, our long-time partner needed the premises for itself. Thus, 15 years after it was founded, the CNT started to move its offices as well as its sensitive, complex clean room and laboratory facilities. The new site paves the way for further innovations – the medium-term goal is even to develop the new site into a globally recognized competence center for microelectronics research in collaboration with other institutes.

In the 4th quarter of 2020, the move out of the old location in Königsbrücker Straße was completed; in January 2021, the keys were handed back to Infineon on schedule. Since then, the entire CNT with its current workforce of approx. 80 employees has been active at the new location, “An der Bartlake 5” in the north of Dresden in the immediate vicinity of Globalfoundries and Bosch. The move itself and the necessary structural adjustments to the existing buildings required a considerable amount of investment, which could only be obtained thanks to the extensive support provided by the Free State of Saxony, Fraunhofer-Gesellschaft and the Federal Ministry for Education and Research BMBF.

With the acquisition of the new property by the Free State of Saxony, the future of the CNT is now secured for the long term. At the new location, stronger technical collaboration is planned with Fraunhofer IZM-ASSID, which focuses on advanced packaging. Going forward, stronger collaboration will create a central location for applied microelectronics research based on 300 mm wafers in Dresden, Germany.

After completion of the initial relocation phase, the focus in 2021 will be on restoring the operational readiness of all facilities as quickly as possible, especially in the clean room. In December 2021, the laying of the foundation stone for a new laboratory and office building will mark the start of the next stage in the site’s expansion, which is scheduled for completion by 2024.

We have already welcomed our first guests at the new location. For example, during an information event on artificial intelligence (AI), Fraunhofer IPMS was able to present innovative AI chip concepts, especially for edge computing applications, to the Saxon Minister of Science, Sebastian Gemkow, in July 2020. Edge computing refers to data processing in the immediate vicinity of sensors (e.g. camera sensors), without transmission to a central chip unit or an external server. AI chips for edge computing are able to evaluate sensor data directly at the sensor in real time and thus control autonomous vehicles or civilian drones, for example.

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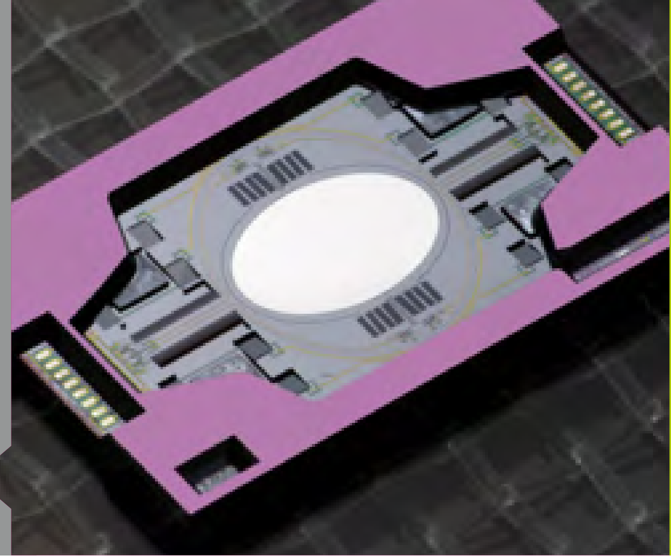

Microscanning mirrors from Fraunhofer IPMS are the heart of LiDAR sensors.

PILOT SERIES PRODUCTION OF MEMS SCANNER MIRRORS FOR AUTOMOTIVE LIDAR

Autonomous vehicles have always been one of mankind’s visions; even Homer and Leonardo da Vinci dreamed of self-driving cars. Technological developments in recent years have brought this dream ever closer to coming true. The decisive factor here is reliable detection of the vehicles’ surroundings, which is precisely where LiDAR sensors come into play. Fraunhofer IPMS develops microscanning mirrors for these LiDAR systems. The institute acts both as a development service provider for customer-specific adjustment of MEMS scanner modules and as a pilot manufacturer for bridging small and medium production quantities to mass production at foundries.

Autonomous driving has become the focus of public attention. Car manufacturers worldwide have put the five-step roadmap toward fully autonomous driving on their strategic agendas. The prospect of using new technologies such as LiDAR in the mass automobile market has led to a global wave of intensive preliminary developments in this area. More than 200 startups have emerged in the US alone. In addition, automotive companies themselves as well as their Tier 1 suppliers, universities and research institutes are jointly active in this current development market. The various system concepts for producing LiDAR sensors have reached a level of maturity whereby the focus is now on reliable and, above all, cost-efficient manufacturing of the LiDAR sensor itself and its individual components. For traditional LiDAR systems, galvanometrically driven mirrors or polygon scanners have proven their worth for optical scanning of the environment. However, these technologies are too space-consuming and expensive for mass production.

Micro mirrors (MEMS scanners) provide a solution to these problems. They can be mass-produced cost effectively using semiconductor technologies and enable the whole system to be miniaturized. Due to the dynamics of this development market, the transitions between further development, optimization and the larger component quantities that are already required, certainly up to several tens of thousands, are fluid.

Fraunhofer IPMS places itself at this juncture as a partner for industry. In addition to developing new micromirrors and scan modules (including packaging, electronics and software), conducting feasibility studies and consulting companies, we develop underlying technologies for producing micromirrors up to pilot series readiness. This allows us and our industrial partners to identify potential barriers to mass production early on, while already making larger numbers of LiDAR sensors available to Tier 1 and automotive manufacturers. In this way, we want to make an important bridging contribution to the broad commercialization of this promising technology.

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MEDICAL ENGINEERING AND HEALTH

2020 has once again shown us the importance of health. Fraunhofer IPMS has been researching technologies for improved prevention, diagnostics and treatment in the medical field for many years.

These include, for example, MEMS-based innovative imaging techniques that allow diseases to be diagnosed at an early stage. In addition, micromechanical devices enable novel forms of treatment.

The coronavirus pandemic brought some Fraunhofer IPMS research topics into sharper focus – such as respiratory gas analysis and methods for developing rapid COVID-19 tests. We are happy to tell you more about this in the coming pages.

M³INFEKT – DECENTRALIZED MONITORING OF COVID-19 PATIENTS

The Fraunhofer cluster project M3Infekt aims to develop a monitoring system that enables early intervention in the event that a patient's condition suddenly starts to deteriorate. It will be a modular, multimodal and mobile system, and will also be suitable for use in the treatment of COVID-19 patients. By facilitating the required intervention at an early stage, the system helps to lessen the effects of disease, shorten the duration of therapy and make flexible use of intensive care wards. Funding is provided by the internal Fraunhofer Vs Corona program.

The coronavirus pandemic poses a challenge for medical diagnostics. Alongside serious cases, the SARS-CoV2 virus also causes mild symptoms, but these can very quickly worsen. Currently, however, continuous patient monitoring is available only on intensive care wards. When someone's health suddenly deteriorates, there is often some delay to this being recognized, meaning the patient is taken to hospital too late. This is precisely where the M3Infekt cluster project comes in. Using various technologies, the mobile system acquires, analyzes and fuses relevant biosignals, which enables a valid diagnosis to be made of the patient's condition and the progression of the disease.

The idea is to provide a long-term solution for decentralized monitoring of patients on normal wards and in non-hospital environments using multimodal parameters of the cardiovascular system (including heart rate, ECG, oxygen saturation, blood flow) and respiratory parameters (including respiratory rate/volume, breath analysis). Machine learning methods serve as the basis for evaluating these parameters, facilitating diagnosis and enabling integration of the system into different deployment and application scenarios, regardless of location.

The planned system has a modular and mobile structure with standardized, open interfaces. These enable easy integration into other platforms and make the system suitable for use with various diseases, including influenza, pneumonia and sepsis. It will enable continuous monitoring, previously used only for patients in intensive care, to be rolled out to non-hospital scenarios, such as short- and long-term care, outpatient treatment or home settings. This way, patients can remain in a favorable environment and move to a hospital only if their condition suddenly deteriorates.

Fraunhofer IIS and the Project Hub MEOS are the project leaders in the M3Infekt consortium, which comprises ten Fraunhofer Institutes and four medical partners. The sensor modules will be developed by the end of the project in September 2021. Their clinical testing and system integration will take place subsequently.

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TAKING JOINT ACTION AGAINST CORONAVIRUS

The coronavirus crisis is a challenge that we can only overcome together. Fraunhofer IPMS therefore became involved in the fight against the pandemic in an unbureaucratic way as early as March 2020, after receiving news from Dresden University Hospital about the shortage of urgently needed items, such as gloves, protective clothing and face masks. Together with its collaboration partners, 5,000 disposable gloves were delivered at short notice. Furthermore, Fraunhofer IPMS participated in the European Union call and provided its available 3D printers to the "Coronavirus – 3D Printing" initiative coordinated by Dresden Concept e.V. to produce urgently needed parts.

On the one hand, the rapid worldwide spread of the coronavirus disrupted global supply chains for required medical parts, such as ventilators, leading to bottlenecks. At the same time, global demand for medical products for treatment and infection control increased rapidly, exacerbating the situation. Platforms have been established in some European countries to produce missing components through additive manufacturing processes to support medical device companies. Printers that are otherwise used for additive manufacturing processes of components for experiments could thus help to care for sick people. Among other things, the printers were able to produce valves for respirators, respirator masks and mask holders that relieve pressure on the ears of nursing staff, or face shields made of transparent film.

Fraunhofer IPMS also participated in the European Union's call together with other Dresden research institutions, such as the Chair of Technical Design at Dresden University of Technology, the Center for Translational Bone, Joint and Soft Tissue Research at the Carl Gustav Carus Medical Faculty at Dresden University of Technology and the Makerspace at SLUB. In the process, Fraunhofer IPMS provided the 3D printers available at the institute to the "Coronavirus – 3D Printing" initiative coordinated by Dresden Concept e.V. for the production of urgently needed parts.

On March 27, 2020, after several successful tests at Dresden University Hospital and Dresden Municipal Hospital (Friedrichstadt site), the final design for a face shield visor holder was released. At Fraunhofer IPMS alone, more than 70 head and base parts were manufactured and delivered in each case.

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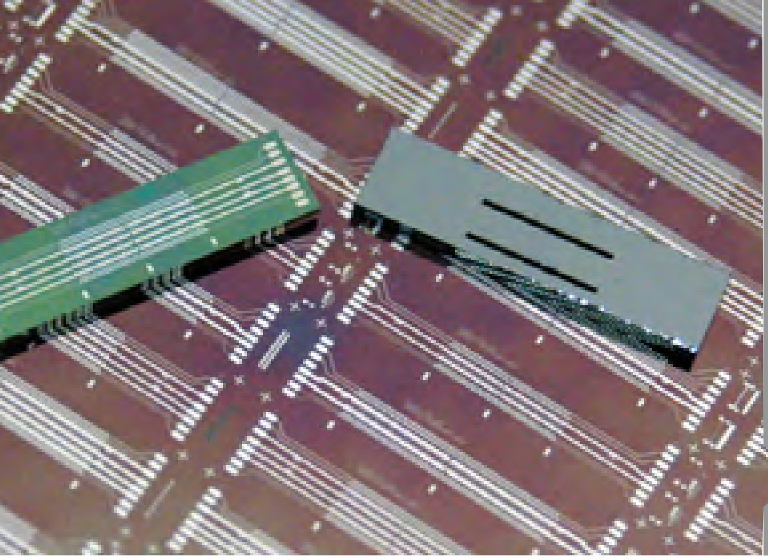
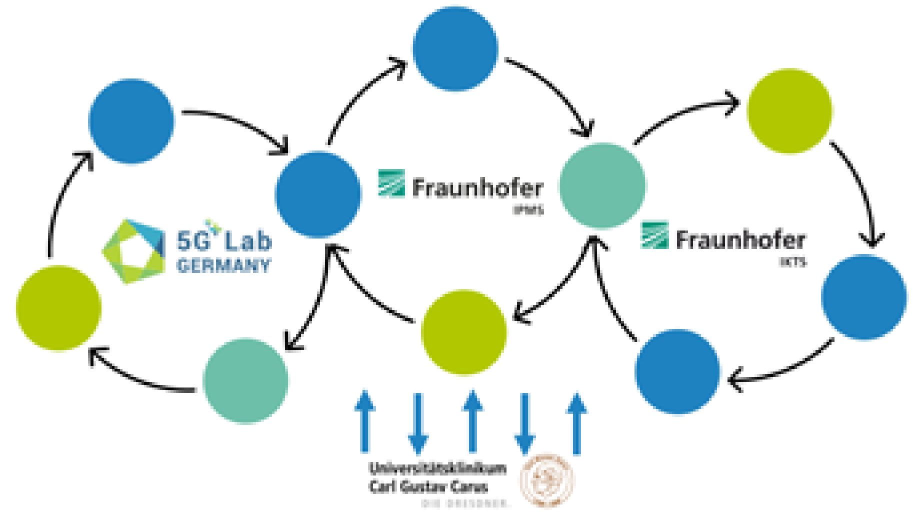


FAIMS chip in MEMS technology for breath analysis.

Innovation initiatives driven by interdisciplinary competence bundling.



BREATH ANALYSIS FOR DISEASE DIAGNOSIS

The air we breathe contains information that can be used to diagnose diseases. Researchers at the Fraunhofer Project Hub for Microelectronic and Optical Systems for Biomedicine MEOS are developing solutions that will enable qualitative analysis of breathing air in the future. In their research, they are initially focusing on the early detection of cancer. However, the distinction between flu-like infections and COVID-19 is also conceivable.

You can smell some diseases. A slightly sweet, fruity acetone odor in the breath, for example, indicates diabetes. These characteristic odors are caused by specific volatile organic compounds (VOCs). These are released on exhalation, even before symptoms occur. Often, it is combinations of several VOCs at a markedly elevated or markedly depressed concentration that are characteristic of a particular disease.

Fraunhofer MEOS uses ion mobility spectrometry for breath sensor technology. This non-invasive technology is sensitive and selective, fast, cost-effective, and also small and mobile, so it can be easily deployed in doctors' offices and hospitals.

At the heart of the novel ion mobility spectrometer is a miniaturized FAIMS chip ("high field asymmetric ion mobility spectrometry"). The MEMS device includes an ion filter and a detector. A UV lamp completes the device. First, the VOCs are pumped into the spectrometer in a carrier gas stream, where they are ionized as a next step using UV light. The charged molecules are guided into the FAIMS chip that is developed and manufactured at Fraunhofer IPMS. By adjusting the alternating voltage on the filter electrodes, you can select which VOCs reach the detector. In this way, a VOC fingerprint is obtained, which is used to identify the disease.

Work is currently underway on an optimized electronic control system and improved sampling and sample guidance. Tests with cell cultures have been successfully performed, and further investigations with human cell material are planned. At Fraunhofer IZI, one of the three institutes involved in the project hub, the system has already been used to detect seven different bacterial strains in one project. In the future, specially developed AI algorithms will facilitate the evaluation of VOC fingerprints.

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HYBRIDECHO – NEW CONCEPTS FOR MEDICAL ULTRASOUND

Sonography, colloquially known as "ultrasound", is used today as an imaging technique in almost all medical specialties and is characterized primarily by the harmlessness of the sound waves used. The technological principle used is based on the generation and detection of sound waves in the non-audible range by piezoelectric crystals. The disadvantage here is a deterioration of resolution with increasing penetration depth (at 10 cm depth approx. 1–2 mm) and limited lateral resolution, which reduces the diagnostic yield and, among other things, increases the risk of incorrect punctures during needle interventions. MEMS-based ultrasonic transducers are characterized by a much higher sensitivity. HYBRIDECHO's goal is to revolutionize sonography by combining both technologies in a hybrid ultrasound transducer.

As part of the Else Kröner-Fresenius Foundation project, "Center for the human interface to digital health", Fraunhofer IPMS is part of a consortium, together with University Hospital Carl Gustav Carus Dresden, the Technical University of Dresden, Fraunhofer IKTS and Contronix GmbH. The goal is to combine the best of both worlds in a hybrid system by combining high acoustic power piezoelectric crystals as the transmitter unit with highly sensitive CMUT (Capacitive Micromachined Ultrasound Transducers) as the receiver. In the investigations already carried out with this type of hybrid transducer, a decisive milestone was reached with evidence of a 300-fold increase in sensitivity compared to conventional systems.

The advantages gained – increased transmit/receive sensitivity, higher bandwidth, increasing number of channels – are harnessed using state-of-the-art evaluation algorithms from mobile communications technology: transmission using established methods, such as channel estimation and multistatic radar for mobile communications, also promise to increase medical image quality and transmission efficiency. In addition to significantly increasing resolution even at greater penetration depths, the consortium also aims to optimize lateral resolution. For this purpose, the next step is to develop a multi-channel hybrid ultrasound system consisting of piezoelectric and MEMS ultrasound transducers. A robotic system simultaneously simulates multi-dimensional transmit and reception problems.

The hybrid ultrasound systems have the potential to open up new applications for medical imaging due to their increased sensitivity combined with a high degree of miniaturization. Thus, future use in endoscopes and catheters for minimally invasive diagnostics is conceivable. Due to the higher resolution, the technology supports early diagnosis and thus timely treatment of diseases, which correlates with an improved prognosis and increased quality of life for patients, and also has a positive impact on treatment costs. Real added value for society.

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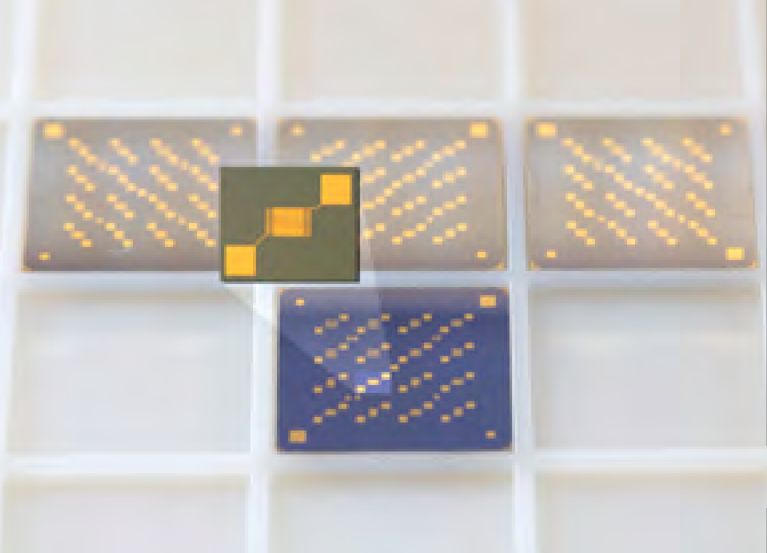
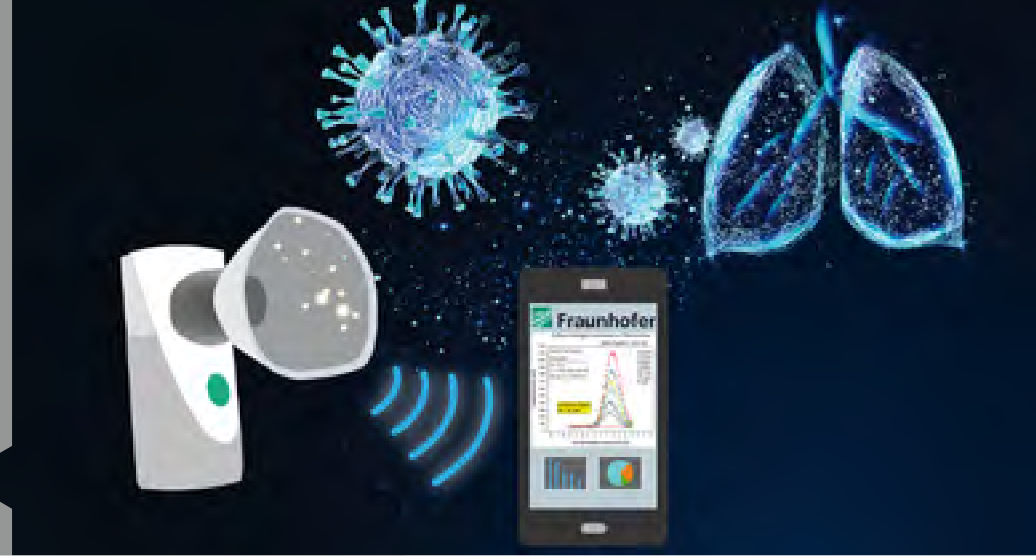


OFET substrates from the Fraunhofer IPMS.

Mobile respiratory gas analysis with MEMS-based components for detecting respiratory diseases.



VirOFET – DETECTION OF VIRUSES USING ORGANIC FIELD EFFECT TRANSISTORS

Rapid, reliable detection of infection is required to control viral diseases. This test must be available at short notice and in large quantities, and it must be possible to adapt it quickly to new viruses. One approach to solving this problem is the use of organic field-effect transistors (OFET). Here, the semiconductor can be adapted to the viruses for detection. Based on the change in the OFET's electrical parameters caused by the viruses, a qualitative statement about an infection can be made immediately. Within the framework of the VirOFET project, there is a study that aims to test the suitability of OFET technology for the production of virus detectors.

OFET are comparatively easy to produce in large quantities and can be functionalized for numerous sensory applications by selecting materials and modifying surfaces and interfaces. The way it works is that the source and drain electrodes are connected to each other via an organic semiconducting material. The charge transport in the channel between the source and drain through the semiconductor can be controlled by another electrode, the gate electrode. It is typically located below the semiconductor channel and is electrically separated from the source, drain and semiconductor channel by a gate dielectric. Through interaction of the organic semiconductor material with specific markers or even the virus itself, the electrical parameters of the OFET change and virus detection is possible.

For detection of SARS-CoV-2, graphene-based FET can be functionalized by binding SARS-CoV-2 spike protein antibodies via 1-pyrene-butyric acid N-hydroxysuccinimide esters, enabling a rapid COVID-19 test (Seo, G. et al.; ACS Nano 14, 5135-5142, 2020).

Development challenges include adequately sizing the OFET, selecting appropriate materials, controlling interfaces, and identifying suitable markers that enable selective COVID-19 detection. If this is successful, the method can also be applied to other viruses. Fraunhofer IPMS has been developing and producing silicon-based substrates with gate, drain and source for many years and aims to work together with partners to use these semi-finished products for virus detection. Therefore, the goals of the VirOFET project are to work out the requirements for virus detection using OFETs, to define requirements for a substrate and the semiconductor, to work out a process flow for substrate manufacture and to find partners for collaboration on suitable semiconductors.

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GCVID – MEMS-BASED GAS CHROMATOGRAPHY FOR COVID-19 DETECTION

The GCViD project is evaluating the possibilities and limitations of respiratory gas analysis for disease detection. A MEMS-based miniaturized ion mobility spectrometer (IMS) developed at Fraunhofer IPMS serves as the basis for this. The applicability of ion mobility spectrometry is limited when the gas mixtures to be tested contain many different volatile organic components. The combination of IMS with gas chromatographs (GC) promises to better separate these complex mixtures. With this approach, MEMS-based combined GC-IMS systems potentially allow for rapid, portable diagnostics as one building block for COVID-19 rapid testing.

Breath gas analysis provides a means of detecting virus-related diseases, because viruses produce a specific pattern in the composition of the breath gas, which can be analyzed. The advantage of respiratory gas analysis is non-invasive sample collection and, if automatic data evaluation is available, a quick, simple statement on the presence of a viral disease. Diagnostic technologies that are currently available, such as RT-PCR, are time-consuming, costly, and laboratory-bound, so they can only be carried out to a limited extent. One solution is the combination of ion mobility spectrometry and gas chromatography, which enables the highly sensitive and selective detection of volatile organic compounds (VOCs) in exhaled air and thus rapid detection of existing viral diseases, such as COVID-19.

As part of the GCViD project, Fraunhofer IPMS is working on this same combination of ion mobility spectrometry and gas chromatography. The basis of this is a miniaturized MEMS-based ion mobility spectrometer, which has been under development at Fraunhofer IPMS for several years, and is now being combined with a gas chromatograph. Currently, the two components are being integrated into an application-specific laboratory demonstrator.

Access to key MEMS technologies in the Fraunhofer IPMS clean room enables miniaturization of the device, providing an opportunity to manufacture portable devices in large quantities, enabling widespread testing outside of clinics, implementing appropriate measures, and better management of the pandemic.

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SPOTLIGHT

SLMs of Fraunhofer IPMS will enable real holographic 3D displays with superior image quality in the future.

DEVELOPMENT OF MICROMIRROR ARRAYS FOR HOLOGRAPHY

The merging of real and virtual worlds to produce mixed reality environments is becoming a realistic component of future society. It demands a natural visual experience without physiological side effects for the user and without limitations in depth perception. Fraunhofer IPMS will contribute to this goal by developing advanced MEMS spatial light modulators as the core component of 3D-displays featuring real holography for perfectly realistic images. The work is based on decades of IPMS experience at developing SLMs for other applications. It is funded by the EU in the H2020 project REALHOLO where a holographic demonstrator system will be developed in an joint effort with 7 other partners from 6 different countries.

The key component of a real holographic 3D display is a spatial light modulator (SLM), and the required properties are quite challenging to reach. The micro mirror array (MMA) SLM modulates the phase of incoming coherent light with many millions of individually deflected pixels at frame rates of several kHz. The pixels have to be only a few micrometers in size and still need to have a stroke range of about 350nm within which each pixel has to be set very precisely to one of many deflection levels. To achieve this, IPMS has developed an innovative micro electro-mechanical system (MEMS) actuator concept with a goal of 8 bit resolution. The MEMS-based SLM will also exhibit optical properties far superior to available liquid crystal-based devices.

Within REALHOLO the IPMS will research and develop this new type of SLM, as well as develop a fabrication technology for it. To be able to deflect all the pixels individually, the MMA will be fabricated on top of an active CMOS mixed signal addressing circuit which will be optimized for very low power consumption and high data bandwidth. With this innovative MEMS SLM Fraunhofer IPMS and REALHOLO will pave the way for mixed reality environments as well as virtual and augmented reality systems. Holographic displays using IPMS micro mirror arrays will provide the best possible experience for the user without physiological side effects like eye fatigue, misjudgement, motion sickness and accommodation-vergence conflict, which are known from alternative and intermediate technologies such as stereoscopic 3D. The required natural visual experience can only be achieved with real holographic displays, which have been principally demonstrated on the basis of available component technologies by a REALHOLO partner.

Fraunhofer IPMS's newly developed MEMS technology and SLM will also enable many other applications that may benefit from the fast SLM's precise phase modulation with a large number of pixels. This project is being funded by the European Union's research and innovation program Horizon 2020 under grant agreement number 101014977. It is an initiative of the Photonics Public Private Partnership.

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SENSOR TECHNOLOGY FOR THE FUTURE: NEXT-GENERATION MEMS

Micro- and nanomechanical active systems (MEMS/NEMS) are the drivers of an unstoppable technological evolution. They can be found in highly integrated applications, smartphones, wearables, autonomous IoT devices and robots. Due to increasingly demanding requirements, the classic mechanical-electrical approaches must be supplemented and replaced by more and more powerful variants. This requires new sensor and actuator concepts, new material classes and material structures. Quantum-based effects will also play a more prominent role in the future. These sensors and actuators form the next generation of MEMS/NEMS devices, referred to as next-generation MEMS, for applications ranging from Industry 4.0, Smart Health to Agriculture 4.0.

It is becoming apparent that, due to the multitude of usable physical functions, excellent price economics, and ease of integration with microelectronics, the evolutionary trend continues to move inexorably toward sensing and influencing environmental variables (to a greater extent and everywhere), performance (better and more accurate), integration in humans (implanted or worn), and machines (see and communicate, optimize themselves). One example where MEMS-based systems will be increasingly used in the future is the mobile detection of environmental pollution, be it microplastics, particulate matter or nitrogen oxides. Optical microsystems, such as MEMS spectrometers, are capable of performing sufficiently accurate measurements ubiquitously and at a reasonable cost.

The combination of nanostructures, new materials and quantum-based active principles offers the opportunity to create completely new sensory and actuator microsystems with superior properties. These sensors and actuators form the next-generation of MEMS/NEMS devices, referred to as next-generation MEMS, for applications ranging from Industry 4.0, Smart Health to Agriculture 4.0. In the spirit of digitalization, such building blocks are helping to drive the transformation to a high-tech supporting economy.

Fraunhofer IPMS has set itself the goal of developing next-generation MEMS from start to finish, starting at a lower technology maturity level and integrating them into applications. With new sensor and actuator concepts, which increasingly incorporate quantum-based effects and new materials, both basic technologies and device concepts are to be researched. Next-generation MEMS rely exclusively on silicon as the basic substrate, as this guarantees the economic implementation envisaged for the future, even for high volumes. The aim is to develop new solutions for highly sensitive sensors in the fields of environment, agriculture and industry.

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The new clean room at the
CNT's new location.

NEW LOCATION, NEW OPPORTUNITIES

More space for the 300 mm technologies of the future: the Center Nanoelectronic Technologies CNT began its move from Infineon's clean room to its own site in 2020. The former Plastic Logic building at "An der Bartlake 5" was acquired for this purpose by the Free State of Saxony and the Fraunhofer-Gesellschaft, then transferred to Fraunhofer IPMS for use. Now occupying 4000 m², the CNT can conduct even more targeted applied research on 300 mm wafers for microchip producers, suppliers, equipment manufacturers and R&D partners.

In an interview, Dr. Wenke Weinreich talks about the complexity of the move, the joy brought by the modern location and the new technological possibilities for high-tech research of the future.

Everyone knows about relocations when it comes to their private lives, but how does it feel to move a clean room to a new location?

It is a huge challenge, which becomes even bigger when you consider the complexity. I didn't really realize that until long after it had started. A classic move is one thing; upgrading the new clean room in the time available until we had to move out is a major task in its own right! Unfortunately, there is no such thing as a ready-made, ideal clean room that can be found on a greenfield site at the snap of a finger.

Fortunately, we were able to find a very good solution, working together with the state of Saxony, and are very happy with the new location. We moved into an existing building that formerly belonged to Plastic Logic. Significant adjustments and extensive conversion work were necessary to meet our high-tech production requirements. At the same time, of course, we also thought of taking a further step towards energy efficiency and resource-saving microelectronics production.

What awaits the CNT at the new location?

First of all, all employees, especially me, are excited about the opportunities and possibilities made possible by the new clean room building and space. Only then, for example, can the investments made by the Forschungsfabrik Mikroelektronik Deutschland (FMD) and the new plant technology take full effect. Of course, this means approaching the task in a structured manner, breaking down the entire project into thematic sub-areas and time phases, and most importantly, spreading the load over many shoulders.

In fact, I have a fantastic team that tirelessly tackles every task with incredible commitment and, above all, works on its own initiative. This move is a team effort, both in terms of the implementation but especially of the management and organization. In terms of time, this also means that upgrading the clean room and commissioning the equipment take top priority, and only then will the construction of the new office building be thoroughly pursued.

The 300 mm clean room at the CNT is unique in Germany. What technological developments will be possible at the new site?

Of course, we want to take full advantage of the technological potential and possibilities provided by the modern clean room and the 300-mm facilities in order to be at the forefront in terms of researching current topics. Neuromorphic computing and quantum computing are particularly worthy of mention here. For these, as well as for all future topics researched by the CNT, the focus will be on the scalability of the developed technologies and how they can be produced reliably in Germany. In the near future, for example, I also envisage a 300 mm silicon photonics platform for Germany, which offers great potential for neuromorphic and quantum computing and can also play a decisive role in the field of trusted electronics.

I also envisage the concept of sustainability becoming more prominent in microelectronics. What will microelectronics production of the future look like? How much energy will this require? How can we make production more sustainable and cleaner? How can we dispense with rare materials that are harmful to health and the environment without sacrificing performance or consuming more energy? What do the materials of the future for 300 mm technologies look like and what can we do as a research institution to bring these promising materials into production? For the CNT's research and developments, this means acting as a link between Germany's technological sovereignty on the one hand and its global responsibility for resource-conserving microelectronics production on the other.

What new ways of working does the new clean room offer to customers?

We have been providing a process and equipment platform for suppliers and toolmakers requiring 300 mm infrastructure for many years. We have also created many options for customers and research partners who want individual processes that are only available for this technology generation. For example, many of the systems can also process smaller wafer sizes. In the new, larger and above all dedicated premises, we will be able to expand this much further, also from an IP law perspective, and offer new concepts for collaboration.

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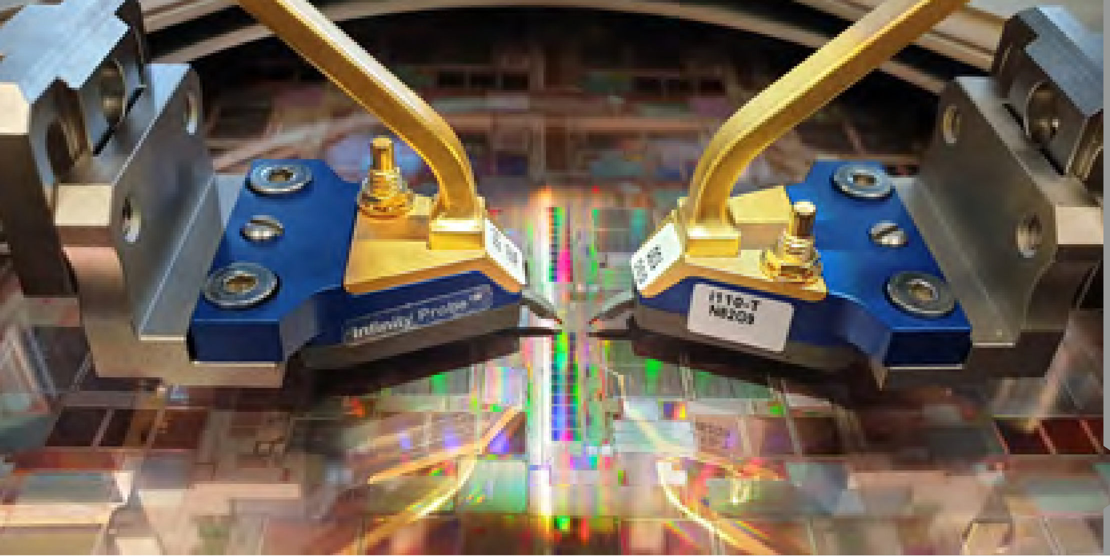

Electrical prober over 300 mm wafer and contact points.

EMMA – RADIO FREQUENCY MEASUREMENT EXPERTISE FOR 5G BASE STATIONS OF THE FUTURE

In 2018, a collaboration project for microelectronics and its user industries that the like of which had never been seen in Europe up to that point was approved by the EU Commission as an "Important Project of Common European Interest", or IPCEI for short. The project is being funded by the four countries involved – Germany, France, the United Kingdom and Italy – with total funding of € 1.75 billion. In the IPCEI, approximately 30 European industrial partners are collaborating in five technology fields during the project period of 2017–2022. The largest partner among the 18 German companies involved is Globalfoundries Dresden. Fraunhofer IPMS is proud to be involved in this IPCEI on behalf of Globalfoundries as the largest research partner by far.

The research project, which is called EMMA, includes seven work packages and a doctoral program to qualify young scientists in order to build long-term talent and promote the region's competitiveness. With a budget of more than € 15 million, EMMA is the largest industrial project order ever received by a Fraunhofer Institute from a company nationwide. As part of the project, researchers at Fraunhofer IPMS are primarily working on new process developments for Globalfoundries' particularly power-saving FDX technology. Other parts of the project focus on the development of non-volatile embedded memories and the characterization and modeling of high-frequency (RF) transistors.

Within the RF part of the project, the CNT is responsible for evaluating new RF transistor concepts in FDX technology. The aim of this is to identify particularly high-performance RF chip designs that are critical for future 5G wireless expansion. Various test designs are being examined for their functionality and reliability over extended periods of time. In addition to extensive expertise and know-how, this requires highly sensitive measuring equipment. In this case, the most important piece of measuring instrument is an electrical prober with the help of which RF transistors can be contacted and measured directly on the wafer. In combination with Globalfoundries' FDX technology, the transistors achieve very good values and only have extremely low parasitic influences. This will allow higher output powers to be achieved in future 5G base stations without having to use more expensive compound semiconductor devices or integrate different devices on one chip. This will enable more efficient, high-performance 5G chips that are easier to miniaturize compared to the alternatives.

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COMPLETION OF THE FIRST CONSTRUCTION PHASE AT THE MEOS PROJECT HUB

At the Fraunhofer Project Hub for Microelectronic and Optical Systems for Biomedicine MEOS, Fraunhofer IPMS works together with Fraunhofer IZI and Fraunhofer IOF on the further development of key technologies in the fields of life sciences, microelectronics, optics and photonics. In 2020, the first major construction phase was successfully completed. Now, to start with, four optics labs, an electronics lab, a robotics lab and a chemistry lab are available at the Erfurt site.

Our thanks go to the state of Thuringia for its generous support in funding the work on equal terms as the Fraunhofer-Gesellschaft.

The newly established chemistry lab will support project work on biofunctional surfaces and biosensing. In addition, biological work with cell cultures and microorganisms, for which no special safety requirements apply, is planned in order to further develop biomedical applications in a targeted, application-focused manner.

In the robotics laboratory, a scattered light robotics system will initially be set up to enable analysis of roughness and surface defects on optical surfaces and microstructures, while the electronics laboratory will initially provide soldering workstations and basic metrological equipment for developing and testing electronic circuits. Work will soon begin on programmable diffractive micro-mirror arrays (SLM) in one of the four optics labs. This laboratory provides workspace for setting up the appropriate measurement technology as well as for integrating an SLM-based module for structured illumination into a light microscope.

During the first phase of construction, practically the entire electrical distribution system of the building was rebuilt, including the power rail, and new network lines were laid. The laboratories were further equipped with a central compressed air and gas supply. The most elaborate work was carried out in the chemistry laboratory. In addition to a completely new laboratory facility, this was equipped with numerous technical systems, such as an autoclave, deionized water system and neutralization system.

Planning for the second construction phase is nearing completion. This will focus on the establishment of an "S2 laboratory", in which it will be possible to work in compliance with the rules for safety level S2 of the Genetic Engineering Act and biological protection level S2 according to the Biological Substances Ordinance, for example, in order to test diagnostic systems.

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Kick-off event for the iCampμs in November 2019 at BTU Cottbus-Senftenberg.

Ultrasonic sensor head based on a CMUT chip with electrically adjustable depth focus.

ONE YEAR OF THE COTTBUS iCampμs – NOVEL MICROSENSOR TECHNOLOGY FROM LUSATIA

Since November 2019, the BTU Cottbus-Senftenberg and the four institutes, Fraunhofer IPMS, Fraunhofer IZM, Leibniz FBH and Leibniz IHP, have been pooling their expertise in the field of microsensors at the Innovation Campus Electronics and Microsensors Cottbus, or iCampμs for short. After a project duration of one year, all project objectives have been met; following a positive interim evaluation, iCampμs is now on its way to becoming a permanent innovation driver in the Lusatia region.

A total of seven different technologies are being developed at iCampμs Cottbus. Moreover, as a transfer project, the focus is on connection with the local economy. Since March 2021, iCampμs has had a contact point at the Dock3 Lausitz start-up center, which was established explicitly for contacts taking place at the largest industrial park in Lausitz (IGS Schwarze Pumpe). The Executive Director of Fraunhofer IPMS, Prof. Harald Schenk, who also heads the Department of Micro and Nano Systems at BTU, is the overall project leader for the consortium. Fraunhofer IPMS is involved in a total of four work packages with its Cottbus site IPMS-ISS. The following technologies are being developed:

RF MEMS varactor
Compared to well-known MEMS varactors with traditional electrostatic deflection, the NED actuator technology developed at Fraunhofer IPMS allows larger travel distances of the grounded electrodes, thus enabling higher relative capacitance changes to be achieved. For the varactor to be used at even higher signal frequencies, a 3D metallization technology was proposed, which enables the MEMS RF varactor to also be used in 5G applications.

Silicon photodetector for NIR
Nanophotonic structures enable detection of near-infrared radiation using silicon-based components. For this purpose, manufacturing processes are optimized taking photonic simulations into account. Measurement technology for characterizing the components was procured and set up for this purpose.

MEMS-based tunable grid filter
In collaboration with the Leibniz Institute FBH, Fraunhofer IPMS is developing a portable Raman analysis system. Fraunhofer IPMS is contributing by providing a miniaturized tunable grid filter for freely selectable control of relevant spectral ranges. Thus, the core component of Fraunhofer IPMS is enabling flexible use of the Raman system for a variety of target substances.

Ultrasonic sensor
This development is based on a NED ultrasonic transducer and makes it possible to deploy a sensor with four microphones and five sound transmitters on an area of only 10 × 10 mm². The main field of application is air-coupled ultrasound in the near and medium range for applications such as predictive maintenance.

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MICRO/NANO HIGH-PERFORMANCE CENTER – RESEARCH FOR TRANSFER

At the “Functional Integration in Micro- and Nanoelectronics” high-performance and transfer center, the Fraunhofer Institutes IPMS, ENAS, IIS/EAS and IZM-ASSID are working together with institutes from the Dresden University of Technology, Chemnitz University of Technology and HTW Dresden on the development of new technologies for microelectronics and microsystems technology. Specifically, these are processes for microelectronics manufacturing on 300 mm wafers, modular heterogeneous system integration, the realization of micro-electro-mechanical ultrasonic transducers and structure-integrated networked sensor technology in tool and machine construction. Success was again impressively demonstrated during the 2019/2020 funding period: Industrial orders totaling € 6.2 million were acquired.

Research as part of a group to develop joint technology platforms for transfer to industrial partners’ applications: this summarizes the work performed at the Micro/Nano High-Performance Center in 2020. With the Test Wafer Hub project, Fraunhofer IPMS and Fraunhofer IZM-ASSID are jointly providing a 300 mm test and evaluation platform. The aim is to support developers of microelectronic products based on 300 mm wafers and the associated supplier industry in process and product development. This support ranges from supplying test wafers to providing entire technology modules on established manufacturing equipment, including subsequent leading-edge characterizations and evaluations.

Leistungszentrum
mikro I nano

Another example is the implementation of novel ultrasonic transducers based on capacitively driven micro-electro-mechanical devices (Capacitive Micromachined Ultrasonic Transducer – CMUT). These devices are designed jointly by Fraunhofer IIS/EAS and the Institute of Solid State Electronics at Dresden University of Technology. In the 200-mm clean room at Fraunhofer IPMS, CMUT components are manufactured based on the design results. The subsequent technology for assembly and connection as well as integration into a waterproof sensor head is carried out by the Center for Microtechnical Production at the Dresden University of Technology. The above photo shows this type of sensor head in its prototype form, which is used for sonographic and also photoacoustic measurement procedures. Possible applications are in medical engineering and biomedicine, e.g. in miniaturized ultrasonic measuring heads for endoscopy, as well as in industrial measurement and testing technology.

In its function as a transfer center, the Micro/Nano High-Performance Center is increasingly relying on digital channels for communication and transfer to a world that is increasingly interacting in a virtual way. An image video was created in 2020 as a building block for this. The establishment of a digital showroom is planned for 2021, in which the range of products and services and the performance capabilities of the high-performance center can be presented using virtual exhibits.

More information:
www.leistungszentrum-mikronano.de/en.html

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PVD cluster tool.

Nkon deep UV scanner.

RESEARCH FAB MICROELECTRONICS GERMANY

Together with 12 other members, Fraunhofer IPMS has formed the cross-location Research Fab Microelectronics Germany (FMD) since April 2017. With more than 2000 scientists from the Fraunhofer Group for Microelectronics and the Leibniz institutes FBH and IHP, this research association is the largest and world's leading R&D association for microelectronics and nanoelectronics applications and systems.

The FMD, with the aim to conduct research and development in Germany across several locations, was in its inauguration phase until 2020, supported by the Federal Ministry of Education and Research (BMBF) with around 350 million euros. This mainly involved modernising the research equipment of the 13 participating institutes of the Fraunhofer-Gesellschaft and the Leibniz Association. With a new concept for sustainable operation, the FMD is now entering the productive phase after the initial project period.

In addition to the range of services for its customers from industry, FMD also offers a wide variety of cooperation opportunities for its partners in science. Among the highlights are services that aim directly at processing research questions cooperatively, for example through collaborative work in joint projects and the operation of so-called Joint Labs. In addition, it is possible to commission FMD institutes to test basic research concepts in the institutes' facilities with regard to their suitability in more application-oriented environments. Good examples of cooperation between FMD and universities as well as other institutions of higher education include the ASCENT+ project, the "iCampμs" research collaboration and the SmartBeam-Lab Joint Lab in Duisburg.

Forschungsfabrik Mikroelektronik Deutschland

Bundesministerium für Bildung und Forschung

The demand for micro and nanoelectronics is constantly increasing, whether this is in cell phones, medical devices or mobility. In order to be able to continue to provide highly innovative research services in this rapidly growing market, technological equipment at an industrial level is a basic prerequisite. As part of the start-up financing for the Research Fab Microelectronics Germany (FMD), Fraunhofer IPMS was able to invest almost 21 million euros in modernizing its tool park. In the meantime, all equipment is set up in the clean room - including deposition, lithography, etching, measuring and special tools, which sustainably improve the quality and reliability of our devices. We are presenting some of them to you here as examples.

Deep UV-scanner (DUV)

The Deep UV cluster is our largest investment at around 12 million euros and consists of a Nikon DUV NSR S210D scanner that provides resolutions down to 130 nm from line-and-space. A Tokyo Electron ACT8 track is connected to this, which provides the necessary varnishes for DUV lithography. In the meantime, the artwork for providing DUV masks has been successfully converted, so that the first wafers can be patterned and processed. This offers Fraunhofer IPMS and its customers new possibilities for MEMS processing. To ensure single and mix-match lithography and to control the overlay, an overlay tool from MueTec has been added to the DUV cluster to further optimize lithography results.

300 mm CVD and PVD cluster tools

FMD facilitated investments of 40.4 million euros for new 300 mm equipment and upgrades at the CNT. Major focus is being placed on deposition equipment, including two chemical vapor deposition (CVD) cluster tools for oxide deposition and one physical vapor deposition (PVD) cluster tool. Using the PVD cluster tool, work on strategically important non-volatile memories can be further strengthened at the CNT (e.g. FRAM, RRAM). These are used, for example, in neuromorphic computing. In the field of spintronics (e.g. MRAM, Racetrack), new capabilities can be established using these facilities. The PVD cluster tool is also one of the largest systems at the CNT, with a required clean room area of over 21 m². It contains a novel measuring unit that can reliably determine coating thicknesses in the sub-nm range. This supports the expansion of the CNT as a state-of-the-art 300 mm R&D site.

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EVENTS

DIGITIZATION BOOST FOR FRAUNHOFER IPMS TRADE FAIRS AND EVENTS

Photonics West, Sensor + Test, Optatec, Electronica – at the start of 2020. We were looking forward to a busy trade fair schedule full of motivation and confidence. A total of 20 trade fairs were planned over the course of the year. But everything turns out differently than expected. Due to the coronavirus pandemic, no face-to-face events could be held after March 2020. So, Fraunhofer IPMS had to rethink, tie in with the first digital building blocks and transfer exhibits to the virtual world. Thanks to the excellent collaboration with our business units and the openness and interest of our colleagues to participate in digital formats, we can look back on two physical and seven successful virtual trade shows and events at the end of 2020.

Without question, the 2020 trade fair year was a special one. Transferring the feeling of a face-to-face trade show to the digital world seemed impossible at first. How would strolling through exhibition halls, explaining technical exhibits and networking together in virtual space work? With a lot of creativity and a strong team, Fraunhofer IPMS successfully transferred its exhibits to the digital world in a short time and developed exciting additional offers for visitors to the virtual booths.

A highlight in this area was the Digital Day, where we presented to a broad target audience how, for example, a rainbow is created or what makes an engineer a superhero. In addition, we also offered speed recruiting and an Escape Game online. At the same time, we reported live from the event on our social media channels. Around 200 interested participants attended that day.

Our participation in the American Medical Wearables conference with an accompanying exhibition was also very successful. To provide comprehensive insight into our research, we supported our scientists' presentations with extensive videos, animations and a broad social media campaign. The matchmaking opportunity offered via the trade show platform led to many exciting conversations with customers and partners thanks to appointments made in advance, thus enabling previously sorely missed networking to also take place in the digital sector.

Our realization is that virtual formats cannot replace physical trade shows, but they can complement them well. With the push towards digitalization triggered by the pandemic, we have been able to add a lot of virtual content to our physical exhibits, giving our customers a 360° view of our technologies. Nevertheless, we look forward to getting back in touch at physical trade shows as soon as possible. Until then, we invite you to stop by our virtual booths and learn more about our technologies and projects.

More information:
https://s.fhg.de/Events-IPMS
https://s.fhg.de/IPMS-Youtube

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AWARDS

FRAUNHOFER AWARDS JOHANNES ZIEBARTH AS ONE OF THE BEST TRAINEES IN GERMANY IN 2020

November 16 and 17, 2020, saw an awards event for the best of the best: Fraunhofer-Gesellschaft trainees and students on a dual degree program who have achieved a very good degree were presented with awards. During this ceremony, Johannes Ziebarth, a former Fraunhofer IPMS trainee, was also honored for his very good performance together with his trainer Henry Niemann.

Johannes Ziebarth passed his training as a Technical Product Designer (product design and construction) with 98 out of a possible 100 points, achieving the best result in his training profession on a chamber, state and national level. Heartfelt congratulations to him on this outstanding achievement from Fraunhofer IPMS. In addition, the Institute thanks Henry Niemann for his excellent, valuable support during the training. The result speaks for itself!

This year, the awarding of the certificates and subsequent celebration organized by the Fraunhofer-Gesellschaft could not be held as a face-to-face event as usual, but took place virtually via MS Teams. The first day included, among other things, a joint exploration of the Fraunhofer-Gesellschaft's new virtual escape room. This was followed by the awards ceremony, which was also virtual, conducted by Fraunhofer board member Prof. Alexander Kurz, with the onsite award being led by the Executive Director for Fraunhofer IPMS, Prof. Harald Schenk. In addition, Johannes Ziebarth and Henry Niemann were also invited to the celebration at the Dresden Chamber of Commerce and Industry in early November. There, in addition to honoring Johannes Ziebarth, Fraunhofer IPMS was also to receive an award for being an excellent training company in 2020. Unfortunately, this event could not take place due to the pandemic.

We sincerely congratulate Johannes Ziebarth on this excellent achievement and are particularly pleased that he has remained loyal to Fraunhofer IPMS after completing his training. As a member of the Ultrasonic Components group, he is now working on developing and constructing a demonstrator for non-invasive intraoperative tumor diagnostics for oncological surgery, among other projects.

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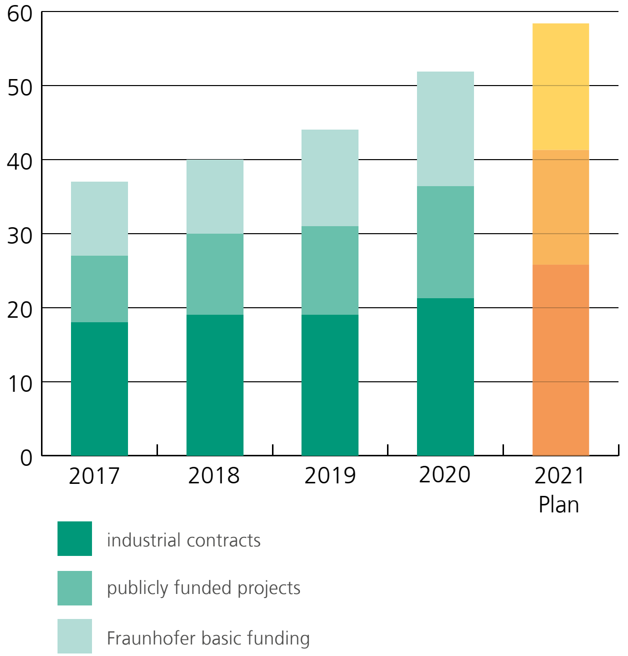
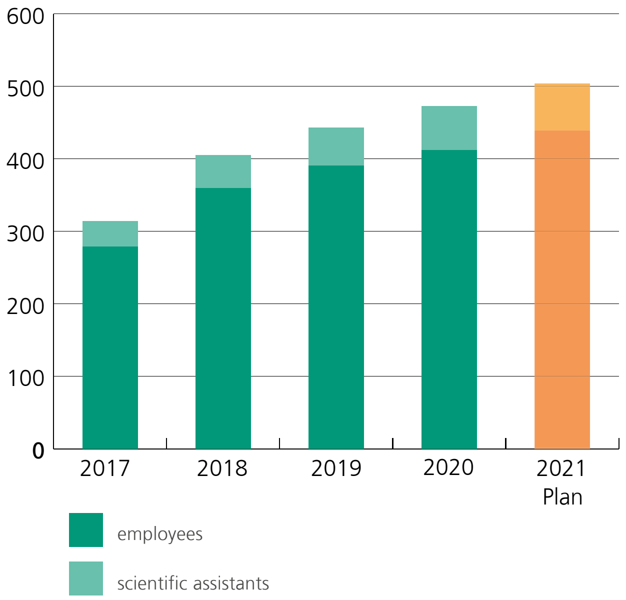
FRAUNHOFER IPMS AT A GLANCE

FRAUNHOFER IPMS IN FIGURES

BUDGET (IN MILLIONEN EURO)



EMPLOYEES



AT A GLANCE

	2017	2018	2019	2020	2021
Industry	48.5%	47%	42.7%	43.5%	47.2%
Public Funds	24.6%	27.3%	27.1%	31.1%	28.3%
Total Revenue	73.2%	74.3%	69.8%	74.6%	75.5%
Employees	314	405	443	473	504

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German Federal Ministry of Educa-
tion and Research,
Advisor

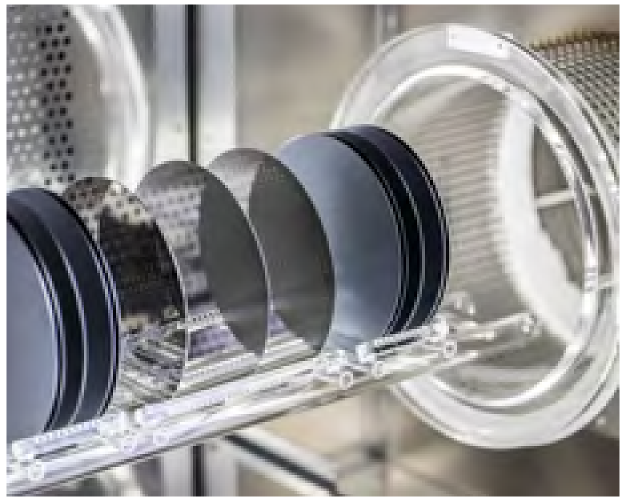
Photo taken in 2019.

SERVICES

Fraunhofer IPMS offers you a selection of services:

MEMS Technologies Dresden

Fraunhofer IPMS offers its customers a complete service for the development of micro-electro-mechanical systems (MEMS) and micro-opto-electro-mechanical systems (MOEMS) on 200 mm wafers.



Technological development of MEMS technologies and support in this area, from individual processes to technology modules to complete technology, as well as process-related support using equipment in the clean room, is provided by our team of over 90 engineers, operators and technicians.

At the customer's request, we handle pilot production following successful development or we support the technology transfer. We thus cover technological maturity levels (TRL) from 3 to 8.

300 mm semiconductor processes & screening fab

We provide technology development and services in the fields of FEoL and BEoL. For series production of semiconductor devices, such as microprocessors, each individual process step is important for evaluation and optimization. Test vehicles and test wafers are essential for testing developments and new materials under production conditions and enabling a rapid response to process changes as well as a transfer of chemicals or processes from "lab to fab."

In the "Screening Fab", we offer screening and evaluation services for materials, processes, chemicals as well as consumables from laboratory to production scale, under industrial conditions and in a state-of-the-art 300 mm clean room.

EVALUATION KITS

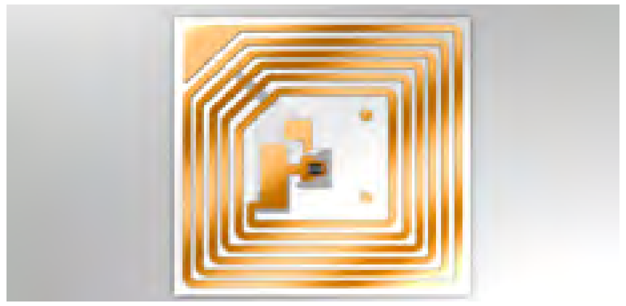
With our evaluation kits you get a fully functional experimental setup and can immediately test our technology for your application.

MEMS scanner

The "QSDrive Scan Kit" evaluation kit allows small and medium-sized companies in particular to operate MEMS scanners from Fraunhofer IPMS according to specifications without the need for costly in-house development of drive electronics. The evaluation kit consists of a ResoLin device – a gimbal MEMS scanner with a linear axis and an optional, orthogonally oriented resonant axis – and drive electronics. The component is supported by a scan head, which is also included in the scope of delivery. Thanks to its special design, it can be easily integrated into common optical experimental setups.

RFID

This evaluation kit includes commercial and in-house developed RFID transponder ASICs for different frequency ranges. Thanks to an agile interface concept, we are able to flexibly integrate analog and digital sensor technology. In addition, our evaluation kits contain a software solution as middleware. Communication with any readers, identification and sensor transponders in the various frequency ranges (LF, HF, UHF and NFC) and from different manufacturers can be implemented in a uniform manner.



CMUT

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

NETWORKS AND COLLABORATIONS

"WHEN FRAUNHOFER IPMS WAS FOUNDED IN 2003, SILICON SAXONY WAS STILL IN ITS INFANCY AFTER HAVING BEEN ESTABLISHED IN 2000. SINCE THEN, WE HAVE GROWN ALONGSIDE AND WITH EACH OTHER AS RELIABLE INSTITUTIONS WORKING TOGETHER IN A SPIRIT OF TRUST.

WHETHER AS A PART OF THE RESEARCH FAB MICROELECTRONICS OR WITH ITS EXPERTISE IN THE FIELDS OF OPTICAL SENSORS AND ACTUATORS, ASICS, MICROSYSTEMS (MEMS/MOEMS) AND NANOELECTRONICS, FRAUNHOFER IPMS IS AND REMAINS A KEY PARTNER FOR OUR HIGH-TECH NETWORK.

THANKS TO PROF. HUBERT LAKNER, AS AN IMPORTANT DECISION MAKER ON OUR SCIENTIFIC SILICON SAXONY ADVISORY BOARD, WE ALSO RECEIVE THE BEST RESEARCH EXPERTISE AND A DIRECT LINE TO FRAUNHOFER IPMS. WE LOOK FORWARD TO CONTINUING OUR CLOSE COLLABORATION GOING FORWARD FOR THE BENEFIT OF SAXONY AS A BUSINESS AND A SCIENCE LOCATION."

Heinz Martin Esser
Chairman of the Board, Silicon Saxony

„ORGANIZATIONS SUCH AS FRAUNHOFER IPMS ARE KEY TO KEEP A HEALTHY PHOTONIC ECOSYSTEM BY PROVIDING THE INDUSTRY WITH INNOVATIVE SEMICONDUCTOR PROCESSES COMPATIBLE WITH LARGE-VOLUME MANUFACTURING. FRAUNHOFER IPMS IS PLAYING AN IMPORTANT ROLE IN THE DEVELOPMENT OF THE NEW GENERATION OF PHOTONIC MICROSYSTEMS, SUCH AS MEMS MICROMIRRORS AND MINIATURIZED SENSORS, WHICH ARE ALREADY HAVING A REAL IMPACT IN THE SMART INDUSTRY AND HEALTHCARE SECTORS."

Dr. Ana Gonzalez
R&D Manager, EPIC

SCIENTIFIC COLLABORATION

Fraunhofer IPMS is actively involved in transferring applied research into science and teaching. Through professorships of its Directors Prof. Dr. Harald Schenk and Prof. Dr. Hubert Lakner, **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/Collaborations

PATENTS

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 268 issued patents. 325 patent applications are still pending.

More information on our patents:
https://s.fhg.de/Patents

PUBLICATIONS

PUBLICATIONS

Fraunhofer IPMS conducts top-quality research. This is substantiated by the numerous publications that were published by scientists from Fraunhofer IPMS in 2020. In addition to outstanding technological papers, one highlight in 2020 was a very different kind of publication: Under the name "Brave New World", Dr. Christine Ruffert, group leader "Monolithic Integrated Actuator and Sensor Systems", published a vision of the future in the short story collection "Tales of Science – Future Stories from Microsystems Technology" of the microTEC Südwest network. In it, she describes a modern retirement home of the future and the role that next-generation sensors from Fraunhofer IPMS could play. Definitively worth reading!

You can find other publications at:
https://s.fhg.de/IPMS-Paper

THESES

BACHELOR THESES

Evaluierung der optischen Eigenschaften von polymeren Materialien zur Faltmontage
Johannes Anton, TU Ilmenau
Supervisors: Prof. Dr. E. Rädlein; Dr. H. Grüger

Implementierung und Erprobung einer portablen Sensorplattform auf Basis von RISC-V
Stephan Enseleit, TU Ilmenau
Supervisors: Prof. Dr. K. Henke; Dr. Andreas Weder

Untersuchung des Verhaltens von MEMS-Mikrolautsprechern auf mechanische Schockbelastung
Michalina Kulas, Brandenburgische Technische Universität Cottbus-Senftenberg
Supervisors: Prof. Dr. H. Schenk; M. Sc. M. Stolz

Modellierung eines Li-Fi Transceivers zur optischen Freiraumdatenübertragung
Jan Rödel, TH Nürnberg
Supervisors: Prof. Dr. R. Engelbrecht; Dipl.-Ing. R. Kirrbach

Entwurf, Konstruktion und Vorbereitung des Aufbaus eines hochminiaturisierten Gitterspektrometers für den Nahinfrarotbereich
Antonia Starcke, TH Lübeck
Supervisors: Prof. Dr. M. Beyerlein; Dr. H. Grüger

DIPLOMA THESES

Kundenakquise öffentlicher Forschungseinrichtungen in Deutschland
Steffen Grebe, TU Dresden
Supervisors: Prof. Dr. M. Schefczyk; Dipl.-Kffr. C. Ernst; S. Titze

Analysis of the Reliability of Ferroelectric Field Effect Transistors in Combination with Crossbar Circuits for Neuromorphic Computing
Tudor Hoffmann, TU Dresden
Supervisors: Prof. Dr. R. Tetzlaff; Dr. T. Kämpfe; Dr. I. Messaris

Ein Beitrag zur Modellbildung und Regelung eines mikromechanischen Scannerspiegels mit hybrid integrierten Stellantrieben zur hochdynamischen vektoriellen Strahlpositionierung
Paul Hünig, TU Dresden
Supervisors: Prof. Dr. K. Janschek; Dr. T. Sandner

Entwicklung eines analogen 100 Mbit/s-Transceiver-Frontends für die Li-Fi-Kommunikation mit harten Echtzeitanforderungen
Benjamin Jakob, TU Dresden
Supervisors: Prof. Dr. W.-J. Fischer, Dipl.-Ing. R. Kirrbach

Entwicklung eines Aufbaus für die teilautomatisierte Montage von Mikrospektrometern
Jens Kruse, HTW Dresden
Supervisors: Prof. Dr. W.-J. Fischer, Dr. J. Knobbe

Medizinisches Implantat mit drahtloser Energie- und Datenübertragung zur Ansteuerung einer implantierten Schmerzpumpe
Lukas Oeser, TU Dresden
Supervisors: Prof. Dr. W.-J. Fischer

Entwicklung eines universellen WLAN Kommunikations-Moduls für Messgeräte
Weixian Song, TU Dresden
Supervisors: Prof. Dr. W.-J. Fischer

MASTER THESES

Modelling of three dimensional deep trench capacitors and identification of parasitic elements
Rishabh Agarwal, TU Dresden
Supervisors: Prof. Dr. H. Lakner; Prof. Dr. M. Czernohorsky

High resolution measurement of large out-of-plane displacements utilizing digital holographic microscope
Prashant Akkal Devi, Ernst-Abbe-Hochschule Jena
Supervisors: Prof. Dr. R. Gerbach; S. Shashank

Development and Characterization of Transition Metal Silicides for Metallization Application
Sarallah Hamtaei, Universität Freiburg
Supervisors: Prof. Dr. M. Fiederle; Dr. T. Sorgenfrei; M. Eng. M. Wislicenus

Thin-Film Development of Cobalt Monosilicide for Spintronic Applications
Meike Hindenberg, TU Bergakademie Freiberg
Supervisors: Prof. Dr. G. Heide; Dr. M. Wagner-Reetz

Entwicklung eines integrierten, digitalen Empfängers für echtzeitfähige, leitungsungebundene, optische Übertragungen
Hagen Steinbach, HAW Hamburg
Supervisors: Prof. Dr. A. Ebberg; Dr.-Ing. M. Faulwaßer

Investigation of Gas flow-regulation and -generation of active Microfluidic MEMS-Devices
Surendran Velmurugan, TU Dresden
Supervisors: Prof. Dr. W.-J. Fischer; M. Sc. S. Uhlig

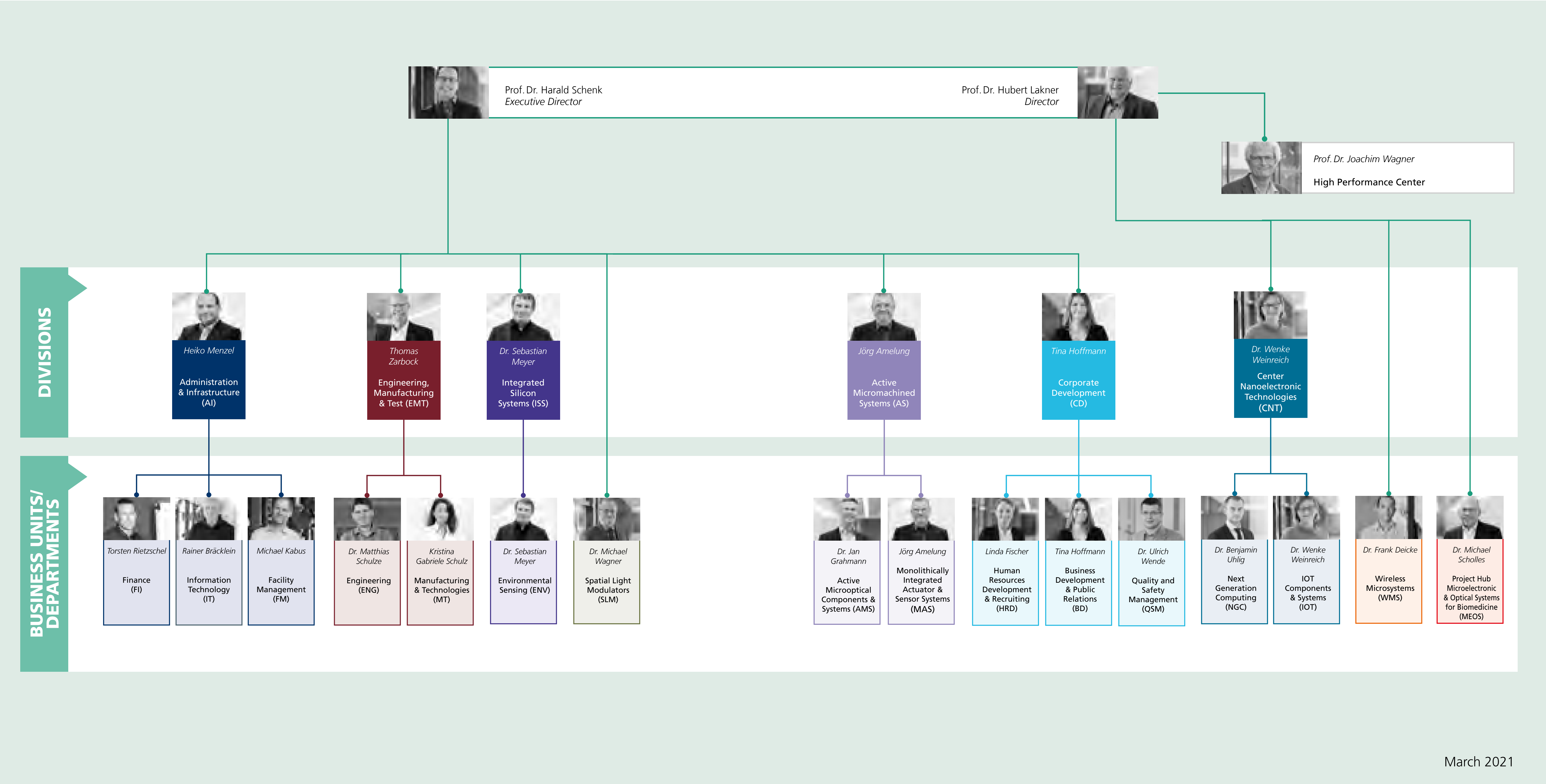
Optimising the crystallisation process of hafnium oxide for improved ferroelectric properties
Pratik Bagul, TU Dresden
Supervisors: Prof. Dr. H. Lakner

DISSERTATIONS

Mechanisch gekoppelte mikroelektromechanische Ultraschallwandler
Marcel Krenkel, TU Dresden
Supervisors: Prof. G. Gerlach; Dr. H. Grüger

Contributions to the design of Fourier-optical modulation systems based on MOEMS tilt-mirror arrays
Matthias Roth, TU Dresden
Supervisors: Prof. Dr. H. Lakner

ORGANIZATIONAL CHART



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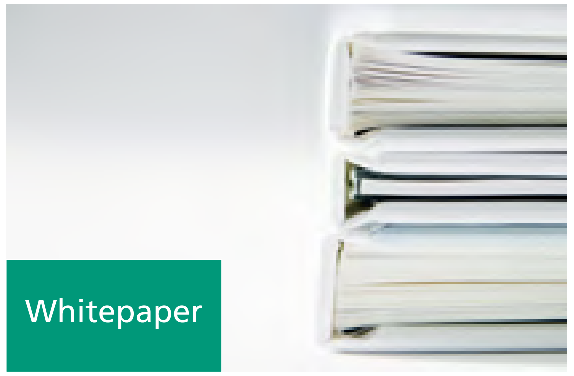

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