Microelectronics News

Fraunhofer MIKROELEKTRONIK

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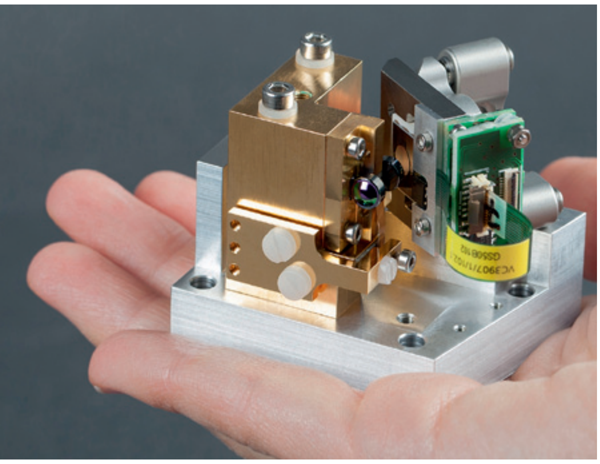
MIRPHAB: pilot line for customized spectroscopy solutions



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Every chemical substance absorbs a very specific portion of infrared light. Like a fingerprint, this absorption can be used to identify a substance. The EU-funded MIRPHAB project is helping companies to set up specially customized sensors and measuring technology in the mid-infrared range (MIR).

»» page 4

A conversation with Dr. Ralf Ostendorf from Fraunhofer IAF regarding the opportunities presented by the use of MIR semiconductor lasers.
© Fraunhofer IAF *» page 5*

■ From the institutes

Sens-o-Spheres: mobile spheres as a measuring device

Fraunhofer ENAS, in conjunction with several partners, has developed a new type of measuring device for bioprocess engineering. Small spherical sensors with a diameter below 8 mm are directly brought into such processes instead of using conventional electrodes.

»» page 9

■ From the institutes

Joseph von Fraunhofer Prize: double success for Group institutes

Not one but two institutes within the Group for Microelectronics were able to impress the jury of the Joseph von Fraunhofer Prize, and in two different areas – they were Fraunhofer IIS and Fraunhofer IKTS.

»» page 10

Both humans and technology are often subjected to heavy loads in industrial plants. The SOI high-pressure sensor from Fraunhofer IZM can withstand considerably higher temperatures than conventional sensors.
© MEV Verlag *» page 7*

■ Short news

Precisely predicting microchip aging

»» page 12

■ Short news

Leti and Fraunhofer sign cooperation agreement

»» page 13

■ Short news

Optimizing protective housings for sensitive electronics

»» page 14

■ The last word …

… comes from Jörg Amelung from the FMD

»» page 16

■ Content:

Events

Date	Event / WWW	Location	Group institutes involved
10/23 – 10/25	MikroSystemTechnik-Kongress 2017 www.mikrosystemtechnik-kongress.de	Munich, Germany	Group Institutes
10/24 – 10/26	Airtec 2017 www.airtec.aero	Munich, Germany	ENAS
11/06 – 11/10	#Berlin5GWeek 2017 www.berlin5gweek.org	Berlin, Germany	FOKUS, HHI
11/07	EDA-Workshop »Radar Signatures & EM Benchmarks« www.fhr.fraunhofer.de/en/events	Brussels, Belgium	FHR
11/07 – 11/10	13th Blechexpo – International trade fair for sheet metal working www.blechexpo-messe.de/en	Stuttgart, Germany	IZFP
11/08 – 11/09	15th FAD-Conference "Challenge - Exhaust Aftertreatment for Diesel Engines" www.fad-diesel.de/conference-2017	Dresden, Germany	IKTS
11/08 – 11/10	9th International Symposium on NDT in Aerospace aero.nuaa.edu.cn/NDT2017/HOME.html	Xiamen, China	IZFP
11/12/ – 11/18	Agritechnica 2017 www.agritechnica.com/en	Hannover, Germany	ENAS
11/13	Workshop "Challenges and Opportunities in Packaging for Automotive Electronics: On the Road to Autonomous Driving" www.emft.fraunhofer.de/en/events.html	Munich, Germany	EMFT
11/13 – 11/16	Medica 2017 www.medica-tradefair.com	Düsseldorf, Germany	Group Institutes
11/13 – 11/16	Compamed 2017 www.compamed-tradefair.com	Düsseldorf, Germany	Group Institutes
11/14 – 11/17	SEMICON / Productronica 2017 www.semiconeuropa.org / www.productronica.com/index-2.html	Munich, Germany	Group Institutes
11/15 – 11/16	2017FLEX Europe – Be Flexible www.semiconeuropa.org/ProgramsandSessions/FlexEurope	Munich, Germany	EMFT
11/28 – 11/30	SPS IPC DRIVES www.mesago.de/en/SPS/home.htm	Nürnberg, Germany	Group Institutes
12/07	Industry Partner Day www.ipms.fraunhofer.de/en/events/2017/IndustryPartnerDay2017.html	Dresden, Germany	IPMS
01/16 – 01/18	Euroguss www.euroguss.de/en	Nürnberg, Germany	IIS – EZRT
01/27 – 02/01	Photonics West 2018 www.spie.org/conferences-and-exhibitions/photonics-west	San Francisco, USA	Group Institutes

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Cockpit view in the live demo.
© Bertrandt AG

Precise local information paves the way for autonomous driving

Autonomous driving is the future topic of the automobile industry. To get closer to this target, networked assistance systems are indispensable. Together with the Bertrandt AG company, Fraunhofer IIS is developing a solution to make driving in the future more convenient and safer, while also making sure that it uses fewer resources.

Automated and precise stopping with satellite-based locating only

Existing GPS receivers integrated into vehicles allow positioning accurate to the nearest meter. For more precise locating, the developers at the Fraunhofer Institute for Integrated Circuits IIS are working on combining the satellite receiver with correction data transmitted via the DAB digital radio standard. In the future, other channels will be possible, e.g. the new cellular phone standard 5G or LTE. If the communication systems fail, the vehicle can also access its own data – such as measurements of the wheel revolutions.

The increased precision is made very clear based on the scenario of automated stopping at a stop line. Customers and partners were presented with the advanced assistance system at a live demo in July. The experts from the automobile industry were very impressed by the result, which was a maximum deviation of 50 cm from the line. This result was achieved with only satellite-based locating and the intelligent combination of information. "We wanted a specialist audience to give a critical evaluation of what can be done with current technology," explains Dr. Wolfgang Felber from Fraunhofer IIS. That is why the team only uses components that are already found in every modern vehicle. There are no costs associated with the development and installation of new hardware and the driver is not distracted by additional systems.

Improved quality of swarm data

The position of the stop line is currently communicated to the car in advance. In the future, this infrastructural data is intended to be generated dynamically. High-precision locating data from vehicles will also contribute to improved recording of swarm data and will ultimately promote networked autonomous driving. Networking of different vehicles and the quality of the data could, for example, optimize vehicle speeds on bends, for example, and conserve resources by avoiding effects such as tire wear. The position of potholes could also be determined more precisely, which in turn could lead to automatic adjustment of the dampers or, if required, to schedule repairs.

The team from Bertrandt AG and Fraunhofer IIS with the test vehicle. © Bertrandt AG

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MIRPHAB: pilot line for customized spectroscopy solutions

Every chemical substance absorbs a very specific portion of infrared light. Like a fingerprint, this absorption can be used to identify a substance. The EU-funded MIRPHAB project is helping companies to set up specially customized sensors and measuring technology in the mid-infrared range (MIR).

If a company needs a sensor in order to identify a particular substance within the production process, there are often very specific requirements, starting with the materials to be identified and continuing with the number of necessary sensors and the speed of the production process. Generally, an “off-the-rack” solution is not sufficient, and several suppliers are required in order to develop an optimum solution.

This is where the European pilot line MIRPHAB (“Mid InfraRed PHotonics devices fABrication for chemical sensing and spectroscopic applications”) comes in. This pilot line is a cooperation of leading European research facilities and companies intended to offer customized solutions from a single supplier. Thanks to EU funding, these solutions are also suitable for early adopters.

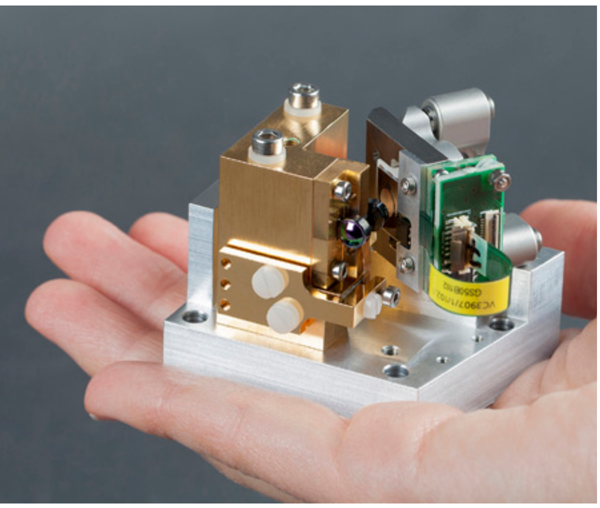
Customized MIR laser source

One central component of the MIRPHAB sensor solutions is provided jointly by the Fraunhofer Institute for Applied Solid State Physics IAF and the Fraunhofer Institute for Photonic Microsystems IPMS in the form of a spectrally adjustable laser source that emits within the mid-infrared wavelength range. Fraunhofer IAF’s contribution is quantum cascade laser technology that emits laser light in the MIR range. With this type of laser, the wavelength range of the light is very wide and, during chip manufacture, can be customized by means of the growth of the semiconductor. In order to select a specific wavelength, an optical diffraction grating is used within an external resonator, and after the wavelength is selected, it is re-linked back into the laser chip. Turning the grating can continuously adjust the wavelength of the laser. A grating of this type is manufactured in a miniaturized form in MEMS (micro-electro-mechanical system) technology at Fraunhofer IPMS. This makes it possible to allow the grating to oscillate at a frequency of up to 1 kHz and thus to tune the wavelength of a laser source up to a thousand times per second across a very wide spectral range. To make the manufacture of lasers and gratings more efficient and to optimize it for pilot series production, the Fraunhofer Institute for Production Technology IPT in Aachen is also involved in MIRPHAB. With its expertise, the institute is able to integrate the manufacture of the quickly adjustable MIR laser into industrially usable production processes.

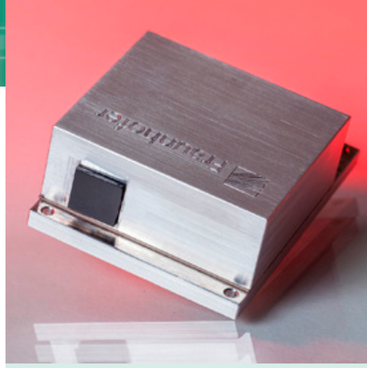
Process analysis in real time

At the moment, many spectroscopy applications operate in the visible or near-infrared range and use relatively weak light sources. MIRPHAB offers solutions based on infrared semiconductor lasers. These have a much greater light strength and thus allow for new applications. With the MIR laser source, for example, up to 1000 spectra per second could be included, which would allow automatic monitoring and control of chemical reactions and biotechnological processes in real time, for example. Processes such as these are used in, say, the chemical industry, the health sector, and in forensics.

MIRPHAB can thus make important contributions to the journey to the factory of the future and Industry 4.0.



Demonstrator of miniaturized laser source comprising a quantum cascade laser chip and a MEMS grating scanner. © Fraunhofer IAF



Miniaturized and broadband-spectrally adjustable quantum cascade lasers with emission wavelengths in the mid-infrared range and a high scan frequency of up to 1 kHz. © Fraunhofer IAF

About the project:
The following project partners work in the European pilot line MIRPHAB (“Mid InfraRed PHotonics devices fABrication for chemical sensing and spectroscopic applications”). CEA LETI (Coordinator) • Nanoplus • VIGO • IMEC • III-V-Lab • Alpes Lasers • Norsk Elektro Optikk • CSTG • Quantared • CSEM • IQE • Cascade Technologies • Bosch • mirSense • Phoenix • EPIC • Tematys • Fraunhofer Institute for Applied Solid State Physics IAF • Fraunhofer Institute for Photonic Microsystems IPMS • and the Fraunhofer Institute for Production Technology IPT

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Dr. Ralf Ostendorf. © Fraunhofer IAF

"Advancing into real-time-capable spectroscopy offers great potential"

The development of reliable and efficient sensor technology presents researchers with new challenges, time and again. Fraunhofer Microelectronics spoke to Dr. Ralf Ostendorf from Fraunhofer IAF regarding the opportunities presented by the use of mid-infrared (MIR) semiconductor lasers.

About Ralf Ostendorf:
After obtaining his doctorate in physics at the University of Münster in 2005, Ralf Ostendorf joined Fraunhofer IAF in Freiburg as a research associate and project manager. There, he first worked on the development of GaAs-based high-performance diode lasers. In 2009, he moved to the area of quantum cascade lasers (QCLs) in the infrared wavelength range, concentrating on the development of wavelength-adjustable QCLs for infrared spectroscopy. He has managed several national and international projects covering this topic. Since the beginning of 2016, Dr. Ralf Ostendorf has been responsible for the Semiconductor Lasers business unit at Fraunhofer IAF.

MIR sensors and measuring technology are particularly suited to detecting chemical substances. Dr. Ostendorf, what are the main strengths when compared to other sensor technologies?

The medium infrared range of 4 – 12 µm is of particular interest to spectroscopy, as this is where the basic modes of the combined rotation-oscillation modes of many chemical substances are found. The resulting absorption bands are characteristic, just like a fingerprint, and thus allow for unequivocal identification of chemical compounds. Light with the right wavelength is particularly well absorbed in this range. Other optical measuring methods, such as those in the near-infrared wavelength range around 1 µm, only measure the higher orders – echoes of a sort – of these basic oscillations, and these demonstrate much less extensive absorption. For this reason, much higher sensitivity and precision of measurement can be achieved in the mid-infrared range.

You specialize in the development of semiconductor lasers for the infrared wavelength. What advantages do these lasers offer?

One main application of our MIR lasers is sensors and spectroscopy. In general, lasers offer a very high degree of light intensity, which can also be easily bundled into a point or towards a certain area. The high spectral LED, for example, allows uncooled detectors to be used in sensor systems with MIR lasers. A complex cooling system using liquid nitrogen, as usually found within this wavelength range, is not necessary. This means that systems of this kind can be made smaller and more compact. Furthermore, MIR lasers offer the option of investigating very absorbent substances within this spectral range, such as water, as a laser is capable of penetrating much thicker films of water than e.g. a conventional light source for infrared, or an LED. The property of bundling the laser light across a long distance opens up the option of measurements with stand-off capability. We were thus able to demonstrate the presence of the tiniest traces of explosives from a distance of more than 20 m.

Fraunhofer IAF already produces specifically adapted sensors and measurement setups. Which applications do you find particularly exciting and what do you expect the future to bring?

Together with Fraunhofer IPMS, we continued to shrink the laser source and considerably increase the speed at which the wavelength is tuned. We are now able to detect chemical substances with our MIR semiconductor lasers within a few milliseconds. This advance into real-time-capable spectroscopy offers great potential. It allows analysis of large samples within a very short time, as required, for example, for 100 % inspection during tablet manufacture in the pharmaceuticals industry. The miniaturization of the laser source offers great opportunities for realizing handheld and compact sensor devices.

Within the EU's "MIRPHAB" pilot line, you are working with many facilities and companies from the MIR sector. What do you hope this collaboration will bring?

Nowadays, new technologies need to be developed along the complete value creation chain, up to and including demonstrators and prototypes. No single institute or firm can master this challenge alone. MIRPHAB offers us a way of bundling our skills from all areas of MIR sensor systems and from all across Europe. That is the only way we can remain competitive in the long term.

Dr. Ostendorf, thank you very much for talking to us.

Dr. Ostendorf was talking to Maximilian Kunze.

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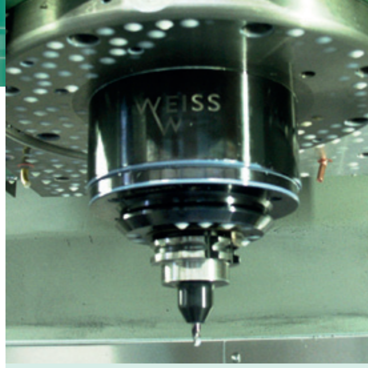
Individual life-cycle record for every tool



Drill spindle in the industrial manufacturing process: "smart" tools for Industry 4.0 can be used to optimize processes autonomously.
© Fraunhofer IMS

Tools such as drills, milling machines, or planes are currently replaced or reground on a regular basis – a high-maintenance and cost-intensive process. Researchers from Fraunhofer IMS are now working on a more efficient solution. Using an individual "life-cycle record" for tools and a new transmission technology by means of an RFID tag, they intend to optimize the productivity, quality, throughput time, and stock of manufacturing businesses in the Industry 4.0 age.

Work steps such as drilling, milling, turning, or planing do leave their mark on the tools used and, over time, lead to wear and tear. The service life determines when the time has arrived to replace or re-grind the tool. Due to the varying effects on a tool while it is being used, however, this time is very difficult to determine exactly. Tool characteristics can be calculated, but the machine setting is usually made by an employee, which represents an untraceable influence on the machine in question. In order to avoid downtime and damage to workpieces, tools are therefore often replaced too quickly. This may result in additional costs of up to 50 %.

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RFID tag allows interruption-free operation

To ensure that maintenance or replacement does not take place until necessary, however, many specific factors would have to be taken into account, such as the cutting task in question, the machine settings made by employees, or the material that the workpieces are made of. The solution: an individual life-cycle record that contains every event in the life of a tool. Based on this data, a special management tool then creates a digital tool twin that can be used to precisely determine when a tool should be replaced or repaired. In order to transmit the "real" data from the tool to the management tool, researchers at the Fraunhofer Institute for Microelectronic Circuits and Systems IMS have chosen RFID technology. As part of the "Cute Machining" project, they have developed new transponders that work in a frequency range of 5.8 GHz and that can be read from a distance of one meter, even in the difficult metallic environment of production facilities. Because the RFID transponder takes up less than 5 mm², it can be easily installed on a tool's surface.

New applications for Industry 4.0

Manufacturing companies benefit from this technology not only because their tools are used to optimum capacity. By capturing the most comprehensive data possible from the production environment, companies are able to create a transparent and more efficient production process – a central aspect of the path towards Industry 4.0. The first step the new technology takes is to identify the tool. Later on in the project, however, the sensors could also be used to supply not just tool-related data, but also information about the environment in which the tool is used. But this technology could also be used in other areas of Industry 4.0. For example, all "assets" on the lower physical levels, such as tools, workpieces, machines, or vehicles, could be fitted with RFID tags in order to gain an even wider range of information. This information could then be used to identify more potential for optimization.

About the project:
The project consortium comprises, in addition to Fraunhofer IMS, the technology companies CIMSOURCE GmbH and PROMETEC Gesellschaft für Produktions- Mess- und Automatisierungstechnik mbH, ID4US GmbH, the Heinz Nixdorf Institute at the University of Paderborn and the application partner Sandvik Coromant Deutschland. "Cute Machining" is funded by the state government of North Rhine-Westphalia and the EU as part of the EFRE-NRW program.

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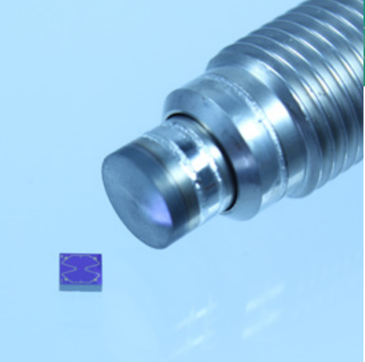

High-temperature sensor for extrusion facilities: SOI chips (L) and housing (R). © Fraunhofer IZM

High-pressure sensors for extreme temperatures

In cooperation with the Technical University of Berlin and the University of Applied Sciences Berlin, Fraunhofer IZM has developed a high-pressure sensor that can be used at significantly higher temperatures than conventional MEMS sensors.

High-accuracy pressure control is a key feature in many industrial processes (e.g. plastic, ceramic, chemical, aerospace, or pharmaceutical industry). However, these processes often require measurements at elevated temperatures (> 150 °C); standard silicon pressure sensors cannot withstand at direct exposure. Measuring via coupling media restricts dynamics and precision as measured results are extrapolated subsequently. The usage of mercury or oil as a coupling medium (not allowed in the food industry and the EU) and the fact that the steel membrane for media separation is prone to rupture are additional drawbacks. For the first time, it has now been possible to develop a high-pressure sensor for use at up to 400 °C. The sensor has already proved itself in extrusion facilities for processing plastics, where it uses pressure and temperature measurement to improve quality of the extrusion process (such as product quality, throughput, protection, and safety).

A sensor with an innovative structure

The innovative pressure sensor chips fabricated from SOI substrates (Silicon-on-Insulator) featuring stand-alone, isolated piezoresistors forming a Wheatstone bridge enable the best electrical isolation. To prevent environmental effects, the SOI chip is housed in a glueless ceramic body, attached to a steel membrane that is connected to a steel cylinder. The sensor is fitted neatly in a so-called "floating" design: it floats in the casing between the electrical contacts, which avoids any need for additional filler. The SOI chip is connected to the ceramic housing by wire bonding.

Advantages when compared to conventional pressure sensors

The SOI sensor can be used at temperatures of up to 400 °C. Conventional MEMS sensors can only handle 125 °C. Furthermore, the SOI technology does not require the use of additional fluids such as oil or mercury. This means that measurement results can no longer be falsified. The sensor also represents an alternative for the future, as e.g. oil and mercury can be expected to be banned from many products. Time and material can also be saved within the injection molding process thanks to the precise measuring method used by the SOI sensor – this method makes it considerably more efficient when compared to classic sensors.

Development of high-pressure sensors is not yet complete

In the future, sensors are planned that will withstand temperatures of 600 °C and more. This requires a replacement for the silicon, as it becomes self-conducting at more than 400 °C, which would make it incompatible with pressure measurements. Silicon carbide (SiC), which retains much better electrical properties even at high temperatures, is already being analyzed as a potential replacement. The research on SiC-based sensors has already begun.

Both humans and technology are often subjected to heavy loads in industrial plants. The SOI high-pressure sensor from Fraunhofer IZM can withstand considerably higher temperatures than conventional sensors. © MEV Verlag

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Living cells and microelectronics: a replacement for animal experiments

Where possible, biomedical research now replaces animal experiments with test systems that use biomolecules isolated from organs or tissue. In-vitro assays of this type, however, are insufficient when it comes to showing the complex interactions within a real organism. Researchers at Fraunhofer EMFT are deploying living cells in the assays and using microelectronic tools to monitor and analyze them.

In many biomedical areas, such as testing new medications, in-vitro tests with isolated biomolecules have reduced or even replaced animal tests in the early stages of development. And this is not just for ethical reasons: one great advantage of these in-vitro model systems is that they can be carried out with high throughput and in reproducible laboratory conditions. Often, the complex biological system is replaced with individual, isolated, purified receptor molecules (proteins, nucleic acids) in order to ensure that the number of molecular components involved remains manageable. Then, over a set period, the experiment is monitored to see whether and how the active ingredient being tested binds to the receptor molecules. The disadvantage is that this simplified model does not allow the complex conditions and processes within a real organism to be accurately reproduced.

Living cells as a "happy medium"

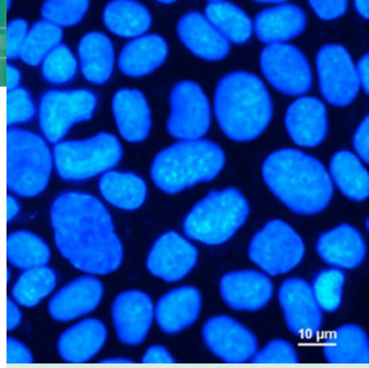
Researchers at the Fraunhofer Research Institution for Microsystems and Solid State Technologies EMFT in Regensburg are pursuing a promising alternative approach: as a sort of "happy medium" between animal testing and purified molecules, they are using living cells for their tests. These have many different receptors on their surface and signaling chains inside them that allow them to detect and react to various molecules in their environment. The research team's approach is based on capturing how the cell reacts to the test substance being bound to the receptors – and on using the cell in this manner as a high-sensitivity test system for bioactivity or toxicity testing.

The cells are applied – either individually or in the form of a tissue compound – to the surface of a physical signal converter such as metal or polymer electrodes on which they can grow. Instead of looking at the binding of an active ingredient to a target molecule in the cell, the Regensburg-based research team analyzes the reaction of the cells to this stimulus. This may include the vitality, the speed of cell division, the speed of cell migration, or changes in the cell volume. This process is not only much closer to the complexity of real conditions, it also has additional advantages: the reaction to an experimental stimulus (chemicals, pharmaceuticals, microorganisms) without the use of additional reagents (label-free) can be followed for individual time periods of between milliseconds and several days.

Wide usage spectrum for medical engineering and pharmacology

The areas of application for these cell-based sensors range from basic medical engineering issues and drug development to toxicity testing and regenerative medicine. One current example with great potential is the culture of cardiac muscle cells on stainless steel electrodes. The rhythmic beating of the cells is registered in a time-resolved manner by measuring the electrode impedance, which allows new pharmaceuticals to be tested with regard to a possible effect on the heartbeat.

Organic disposable polymer electrodes for impedance analysis of living cells. © Fraunhofer EMFT



The nuclei of a dog's kidney cells, colored using a selective fluorescent dye. © Fraunhofer EMFT

About the project:
Since January 1, 2017, the development and adjustment or optimization of cell-based sensors and/or assays have been part of the services offered by Fraunhofer EMFT. The team at the Regensburg location offer consultancy regarding detection principles, materials selection, the functionalization and integration thereof into individual test environments, as well as data analysis and feasibility studies for special assay formats and technologies.

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Sens-o-Spheres demonstrator. The picture shows the charging station, the base station, the Sens-o-Spheres and a handheld to apply the spheres sterile.
© Technical University of Dresden

Sens-o-Spheres: mobile spheres as a measuring device

Fraunhofer ENAS, in conjunction with several partners, has developed a new type of measuring device for bioprocess engineering. Small spherical sensors with a diameter below 8 mm are directly brought into such processes instead of using conventional electrodes. This addresses the problems of classical measurement methods for biotechnological process engineering.

Process monitoring in bioreactors

Bioprocess engineering is essential to the development of pharmaceutical products, obtaining enzymes from renewable resources, and other biotechnological products. To achieve highly efficient, resource friendly and consistent biological target products, the exact knowledge of the data within its process is one of the main issues.

Innovative sensor spheres

The Sens-o-Spheres are about the size of a pea. Several of them are applied into the reactor at once, enabling a measuring resolution across the entire volume of the sample. Due to the spheres' extremely small diameter of only 7.9 mm in combination with their special encapsulation, the procedure is minimally invasive. Furthermore, innovative bioreactors for new biotechnological production processes frequently make the installation of conventional probe systems impossible due to their design or dimensions, or else they exhibit inhomogeneities.

The spheres are equipped with advanced electronics for the measurement and the communication. The measured data is continuously transmitted to an external base station until the process is completed. Using this information, the base station can immediately influence the process. With a suitable encapsulation of the electronics, the measurement device is minimally invasive. In order to let the measurement device float freely in the fluid, its density has to be identical to the density of the medium itself. For a fully autarkical operation, a battery powers the electronic components. Using a specially developed wireless charging technology, the spheres are charged up again simultaneously after a process is completed.

Until now, the Sens-o-Spheres are equipped with a temperature sensor. In the future, however, the spheres will be combined with other typical measuring devices – for pH values or dissolved oxygen content, for example.

In current applications, typical bar shaped sensor electrodes are installed via a standard port into the bioreactor, representing a measured value only in one spot of the reactor. This can lead to false control settings and thus to suboptimal or unexpected outcomes. Furthermore, these classical measurement devices have an impact on the mixing procedure and the transport processes within the liquid. The necessary screw connections and cabling also considerably increase the work required. The Sens-o-Spheres address all of these problems, setting new standards for measuring technology.

The development of the Sens-o-Spheres involved, in addition to the Fraunhofer Institute for Electronic Nano Systems ENAS, the Technical University of Dresden and four partners from industry. The project is funded by Germany's Federal Ministry of Education and Research (BMBF).

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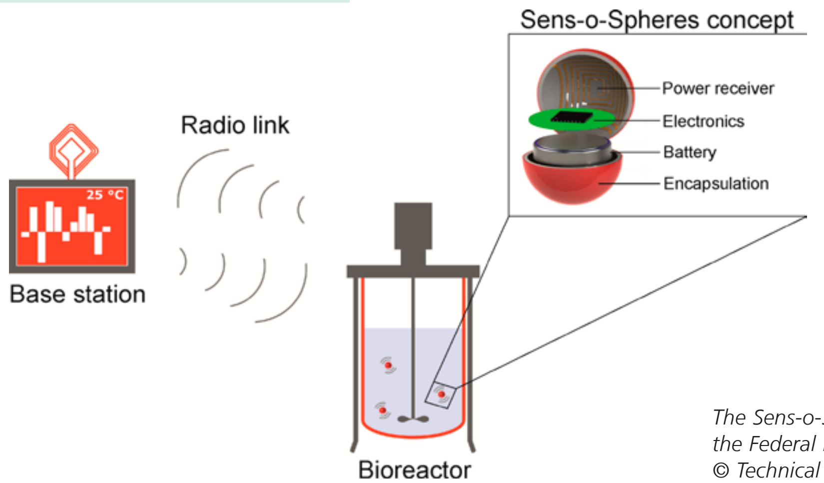

The Sens-o-Spheres concept. This project is supported by the Federal Ministry of Education and Research (BMBF).
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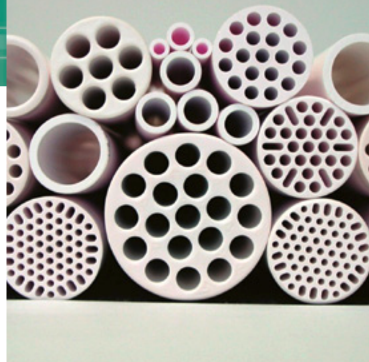

Ceramic membranes from Fraunhofer IKTS.
© Fraunhofer IKTS

Joseph von Fraunhofer Prize: double success for Group institutes

Not one but two institutes within the Group for Microelectronics were able to impress this year's jury of the Joseph von Fraunhofer Prize in two different areas – they were Fraunhofer IIS and Fraunhofer IKTS. The awards went to a new codec for improved voice quality in mobile telephony and a nano-filtration membrane for sustainable water purification.

Water is not only vital to the survival of the organism, but also plays an important role in a wide range of everyday processes – whether in the home or in industry. Water consumption continues to increase, but this invaluable resource is not inexhaustible. This highlights how important it is to purify and reuse service and waste water. Ceramic membranes offer a good opportunity to do just that: as they use a mechanical separation process – much like a coffee filter – they are particularly energy-efficient. Until now, however, this method has reached its limitations at a molecule size of 450 daltons.

Molecules only 200 daltons in size separated for the first time

Researchers at the Fraunhofer Institute for Ceramic Technologies and Systems IKTS have now moved this boundary a considerable distance: the team led by Dr. Hannes Richter, Petra Puhlfürss, and Dr. Ingolf Voigt has achieved a molecular separation limit of 200 daltons using the nano-filtration membrane they developed – achieving an entirely new quality of wastewater purification. The innovative ceramic membranes also offer advantages to industrial production processes: they can be used to clean partial streams directly within the process, after which the purified water can be run in circulation – this saves water and energy. "The design challenge laid in producing a membrane with small enough pores that even the tiniest molecules could be reliably separated. To do so, all pores need to be as close to the same size as possible, as a single larger opening is enough to let molecules escape. A modification to the sol-gel technique enabled us to achieve this," according to Dr. Hannes Richter, department head at Fraunhofer IKTS.

Transfer from the lab to practical application

The second hurdle was to make membrane layers of this type that would be free of defects even over larger areas. Although usually only areas of a few square centimeters are coated, the IKTS-researchers set up a pilot system with a membrane area of 234 m² for their development. This system was commissioned by Shell and built by Andreas Junghans – Anlagenbau und Edelstahlbearbeitung GmbH & Co. KG in Frankenberg, and is located in the Canadian province of Alberta. Since 2016, the system has been successfully cleaning waste water that is used for extracting oil from tar sands. The researchers are currently planning the first production system, with a membrane area of more than 5000 m². The jury of the Joseph von Fraunhofer Prize recognized the first implementation of this idea for filtration purposes in this material class by awarding the coveted prize.

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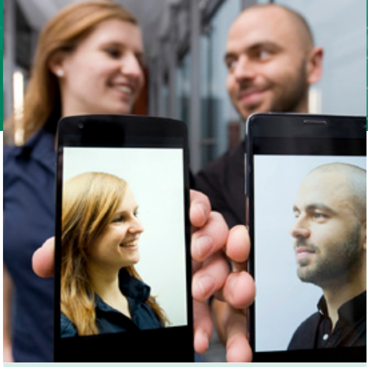
The ceramic membranes developed by (from left to right) Dr. Hannes Richter, Petra Puhlfürss, and Dr. Ingolf Voigt achieved a molecular separation limit of 200 daltons for the first time. This means that waste water can be cleaned even more efficiently. © Fraunhofer / Piotr Banczerowski



The EVS codec transmits voice calls in crystal-clear quality, making a phone call sound as good as a conversation taking place in the same room. © Fraunhofer IIS

Voice quality like being face to face

In a completely different category, another research team from a Fraunhofer Microelectronics institute did well this year: Markus Multrus, Dr. Guillaume Fuchs, and Stefan Döhla from the Fraunhofer Institute for Integrated Circuits IIS, together with a team of around 50 researchers and engineers, have developed a new codec that is intended to considerably improve voice quality in mobile phone calls. As far as functionality goes, modern smartphones can almost match a PC – but voice calls have been left out of recent leaps in innovation and their quality has been at the same level for decades.

The new standard, Enhanced Voice Services, or EVS for short, is set to change that: instead of a hollow, distorted call quality, the new technology allows users to hear the other person's voice as clearly and naturally as if they were speaking face to face. The codec was initiated and developed by the international mobile communication standardization committee 3rd Generation Partnership Project (3GPP). A large team from Fraunhofer IIS in Erlangen made a significant contribution to the project. The demands placed on a standard of this kind are high. The basic requirement is firstly to transmit voice calls in significantly higher quality than before – while keeping data rates low, to ensure that transmission remains economical. Furthermore, the codec needs to be robust against transmission errors. This ensures that the call is not interrupted in bad reception conditions. The codec also needs to be able to handle other signals well – and to transmit hold music in good sound quality, for example. However, this is not that simple, as voice and audio coding are two different worlds. That is why the codec performs an analysis 50 times per second to check whether voice or music is currently being transmitted – and applies the appropriate algorithms in each case.

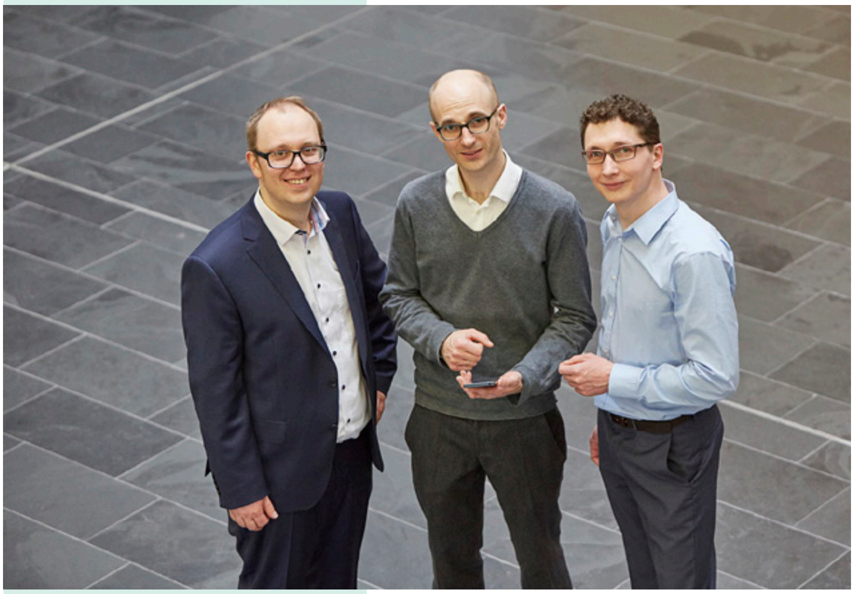
Transmitting the entire audible frequency spectrum

But what exactly is the technical difference between existing codecs and EVS? "The human ear can perceive frequencies of up to 20 kHz," explains Guillaume Fuchs, who drove forward the scientific development of EVS at Fraunhofer IIS. "The existing codec can only transmit sound signals in a frequency range of up to 3.4 kHz – the range between 3.4 and 20 kHz is simply cut off. That is why the voice sounds hollow. Depending on the bit rate, the new codec can transmit frequencies of up to 16 or even 20 kHz." In short, the codec covers the complete audible frequency spectrum – at data rates that are comparable with existing mobile communication codecs.

No different from natural speech

The codec has been evaluated by several thousand test listeners in numerous tests around the world. The result: listeners deemed the new standard to be significantly better than the existing processes. The codec has now been standardized within 3GPP; according to estimates, 50 to 100 million devices have already been equipped with EVS, including in Japan, Korea, the USA, and Germany. With this success, the Erlangen-based researchers were also able to win over the jury of the Joseph von Fraunhofer Prize. The jury based its decision to award the prize on factors including "the worldwide use and the high expected licensing revenues."

Since 1978, the Fraunhofer-Gesellschaft has awarded the Joseph von Fraunhofer Prize annually for its researchers' outstanding scientific achievements that solve application-oriented problems. This year, four prizes were awarded, each worth €50,000.



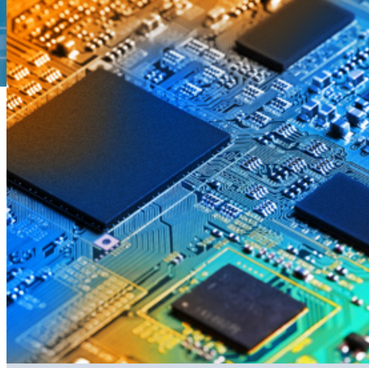
EVS developers Markus Multrus, Dr. Guillaume Fuchs und Stefan Döhla (from left to right). © Fraunhofer / Piotr Banczerowski

Precisely predicting microchip aging

Particularly in medical and vehicle engineering, electronics need to be extremely reliable. That is why we apply the principle of "over-design": additional safety reserves are planned at the design stage. This, however, is not only very costly, but in addition – as technology gets smaller and smaller – is becoming increasingly difficult to implement. That is why it is possible to simulate the wear experienced by semiconductors. The standard simulations for new types of production technologies, however, often do not produce the desired results. For this reason, researchers at Fraunhofer IIS/EAS have developed mathematical models that can be used to forecast the aging processes of transistors years in advance.

The models take account not only of typical effects such as hot carrier injection or bias temperature instability (BTI). New types of models developed by Fraunhofer IIS/EAS are also used. For the first time, accurate models can be used to determine the recovery effects in the context of BTI aging, saturation behavior across the lifecycle, and other complex dependencies. All models are produced by Fraunhofer IIS/EAS consistently and for all common design environments used around the world.

"For the first time, we offer our customers the option of verifying and validating the function of complete electronic systems in different operating conditions," explains Roland Jancke, Director of the Department of Design Methods at Fraunhofer IIS/EAS.



The models of Fraunhofer IIS/EAS can be used to quickly and precisely calculate the forecast operating life of electronic systems.
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JOSEPHS® innovation laboratory named a "Place of Excellence in the Land of Ideas"

"Fresh thinking to allow new ideas to flow" is the 2017 theme of the "Places of Excellence in the Land of Ideas" competition. This was the motto under which the open innovation laboratory JOSEPHS® was named one of the hundred best projects out of around 1000 applications.

Germany is an imaginative country: the "Places of Excellence in the Land of Ideas" competition is intended to highlight that fact. Outstanding ideas for towns, the countryside, the digital world, and the visual appearance of neighborhoods were all premiered over the last four years. The aim of the competition is to design tangible projects to provide answers to important social questions of the future. The jury's verdict was that JOSEPHS® takes advantage of openness and makes an outstanding contribution to Germany's innovativeness and future sustainability.

In a space of over 400 m², visitors can aid in developing and optimizing current innovative corporate concepts such as new services, products, and business models. The JOSEPHS® hands-on laboratory is free of charge and is open from Monday to Saturday for everyone who is interested. Since it opened in 2014, there have been 13 themed areas and 72 innovation projects. Over 33,000 co-creators and visitors have made an active contribution to these projects. JOSEPHS® hosts over 250 events each year. JOSEPHS® also offers workshops and lectures in the think tank, inspiration in the gadget shop next door (Ultra Comix), and relaxation in the world of enjoyment operated by Caffè CORRETTO.

JOSEPHS® is a project run by the Fraunhofer Center for Applied Research on Supply Chain Services SCS in conjunction with Friedrich Alexander University of Erlangen-Nürnberg, and is funded by the Bavarian Ministry of Economic Affairs and Media, Energy and Technology

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The NOMAD project contributes significantly to making nuclear power plants safer. © Thorsten Schier / Fotolia

Improved safety in pressure vessel walls of nuclear power plants

Around 200 nuclear reactors are currently in operation in the European Union, and many countries will, in the future, continue to view nuclear energy as a central energy supplier. In order to ensure maximum safety, the lifetime of the reactor components must be calculated reliably. As part of the ten-partner EU research project NOMAD, Fraunhofer IZFP in Saarbrücken is leading the challenge to find methods for characterizing material changes in reactor pressure vessel steels in a focused and timely manner.

The reactor pressure vessel protects the outside world from radiation from the fuel elements. Over the long term, however, this radiation can lead to vessel wall embrittlement. Sudden failure of a reactor pressure vessel due to embrittlement would be disastrous for humanity and our environment. Until now, safety routines have been based on monitoring concepts in which small samples are already taken during the manufacture of the reactor pressure vessels, placed inside the vessel and intermittently extracted for destructive tests. “However, the material of a reactor pressure vessel is not always homogeneous; thus, such samples cannot be always considered a solid reference for the entire pressure vessel,” explains Dr. Madalina Rabung of Fraunhofer IZFP, coordinator of the NOMAD project. Here, solutions are being developed that can be used to carry out regular, non-invasive inspections of the complete reactor pressure vessel wall using intelligent sensors based on electrical, ultrasonic, acoustic and micromagnetic techniques. These are important steps towards even safer operation of nuclear power plants.

This project has received funding from the Euratom research and training programme 2014-2018 under grant agreement No. 755330.

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Fraunhofer and Leti are forging the future of microelectronics

On June 28, 2017, in Grenoble, two leading European research institutions – the Fraunhofer Group for Microelectronics and Leti, a French research institution within CEA Tech – signed a new agreement to develop forward-looking microelectronics technologies. They are pursuing their aim of spurring innovation in Germany and France and strengthening the strategic and economic independence of Europe. During the ceremony to mark the signing of the agreement, which was part of the Leti Innovation Days event, both sides highlighted the necessity of pooling Europe’s strengths. The new cooperation agreement is intended to be a starting point for a strategic research cooperation of both countries and to support the Important Project of Common European Interest (IPCEI) in microelectronics and nanoelectronics, which is just starting up.

The focus of the shared research is on the further development of CMOS and more-than-Moore technologies for sensor and communication applications in order to pave the way for the next generation of electronic devices and systems. These could then be used, say, in the Internet of Things, augmented reality, automobile manufacture, health services, or aviation. In a second phase, the cooperation is to be strengthened with the addition of more partners, both from universities and from other countries.

To a successful cooperation: Dr. Maria Semeria, Leti CEO, and Prof. Hubert Lakner, managing director Fraunhofer Group for Microelectronics, signing the agreement. © Pierre Jayet

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Optimizing protective housings for sensitive electronics

If the housing is damaged, the entire electronic device may fail. This means that the material compositions and processing technologies of the housings need to be optimized. © Fraunhofer IMWS / Sven Döring

Electrical devices are often integrated into plastic housing for protection against factors such as humidity, heat, or magnetic fields. How can these protective housings be made as robust as possible? This question is being investigated by Fraunhofer IMWS and the Präzisions-Plastic-Produkte GmbH company as part of the Design4LES research project. By June 2018, common housing materials will be characterized with regard to their behavior in electrical fields. The injection-molded test specimens, which are optimized for this purpose, will be inspected with regard to the microstructure after being subjected to extreme conditions. The intention is to examine the mechanisms of failure as precisely as possible. "Until now, even experts have not had a proper scientific understanding of these processes. The link between the microstructure – such as the pores or the adhesion between the glass fibers and the plastic – the processing technology, and the electrical failure behavior of thermoplastic materials in a damp environment is largely unknown," explains group leader Sandy Klengel from Fraunhofer IMWS. "That is why we are paying particular attention to the mechanisms that lead to loss of performance in thermoplastic housing materials when moisture gets in. We are investigating how the structure of the materials changes and how this affects the properties of the material used. That is an important question, particularly for applications within power electronics," confirms Bianca Böttge, who leads the power electronics team within the group. The understanding gained allows manufacturers to optimize the formulation of the material and the production steps – such as the right figures for temperature, dwell times, and injection molding parameters. Finally, this allows the quality and performance of electronic housings to be increased significantly.

The project is funded by the European Regional Development Fund and the state of Saxony-Anhalt.

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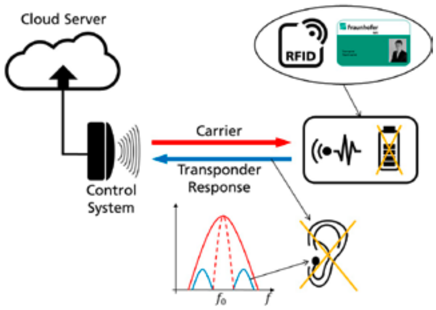
Inband RFID communication: energy-efficient and secure



© Fraunhofer IMS

Modern production environments are becoming more and more communicative: sensors integrated into machines and systems measure and collect data and forward it, either to other systems or to a central control unit. Without wireless radio technology, networked production environments such as these would be impossible. Nevertheless, the current industrial wireless standards (such as Wi-Fi, Bluetooth, and ZigBee) still have one critical weakness: they are very energy-intensive. The radio interface of a wireless sensor, for example, has a 60 – 95 % share of the system's overall energy consumption. With passive data transmission technology, which is based on what is known as load modulation, this share would be completely eliminated. However, this technology does not fulfill the requirements for robustness, real-time capability, and resistance to interception; furthermore, its wireless range is somewhat smaller.

Researchers at Fraunhofer IMS have now had the idea to use inband communication processes (which are also part of the future 5G cellular phone standard) with RFID transponders. Combining the inband method with the RFID communication approach based on load modulation results in a highly efficient wireless transmission process known as "inband RFID." In addition to full-duplex transmission (simultaneous transmission and reception) and energy efficiency, inband RFID communication offers a high immanent resistance to interception compared to established wireless standards.

In addition to applications in "Industry 4.0," inband communication with load modulation – due to its resistance to interception – offers interesting approaches to solutions for part of the current "Keyless-Go" and "Keyless-Entry" problems currently being discussed in the automobile sector. The properties of the new technology mean that potential attackers – in this case car thieves – perceive the carrier signal transmitted as interference when they attempt to listen in to the data connection. This means that intercepting the car key signal is not possible.

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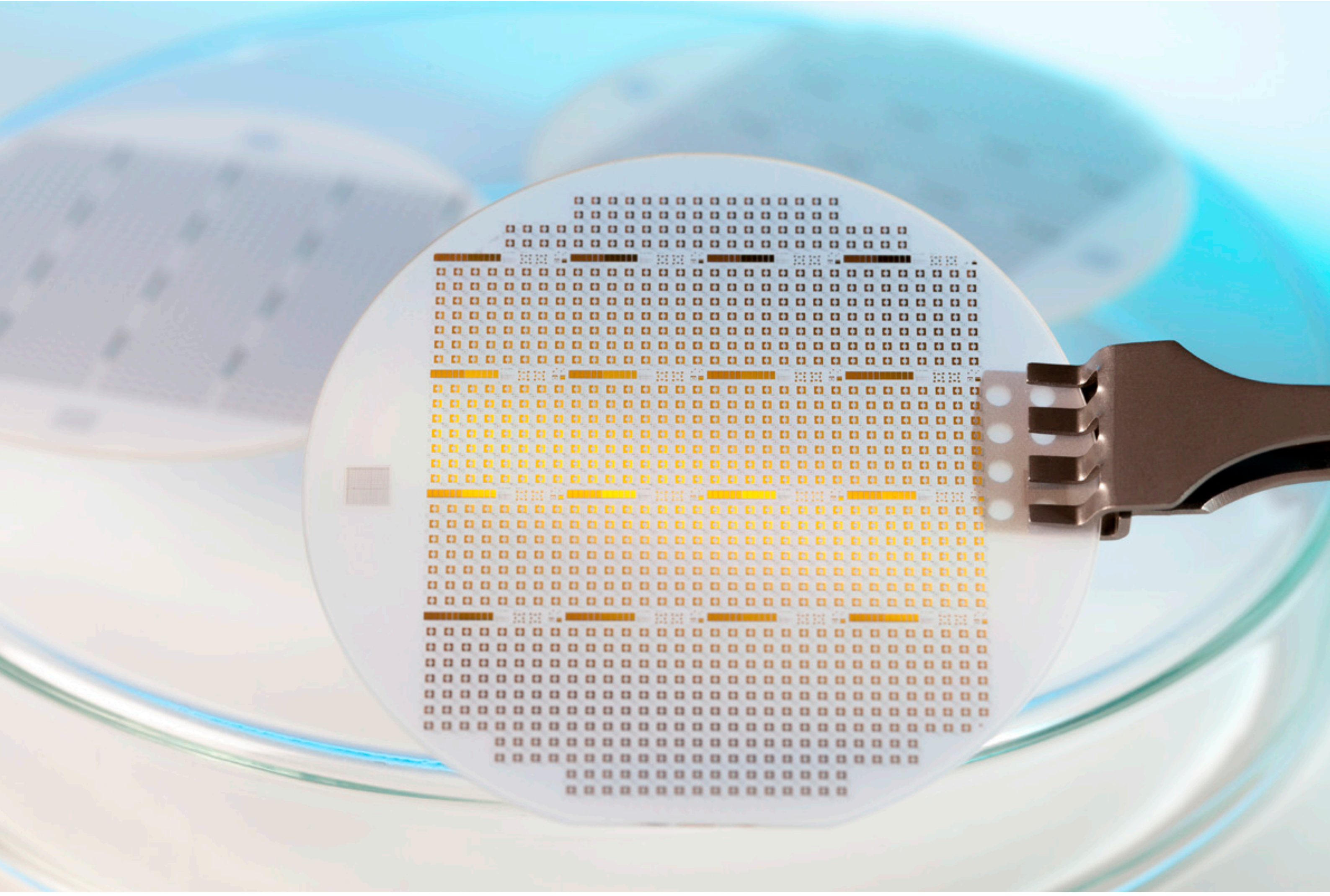

This 2-inch wafer contains aluminum gallium nitride photodiodes that measure extremely short-wavelength and very high energy UV C light. The photodiodes developed by IAF can be adapted very precisely to the desired broad- or narrowband wavelength range and can be used in water purification and to cure adhesives and paints. © Fraunhofer IAF

Editorial notes

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The Fraunhofer Group for Microelectronics, founded in 1996, combines the expertise of 18 Fraunhofer institutes, with a total of more than 3,000 employees. Its main focus is the preparation and coordination of interdisciplinary research projects, conducting studies and to assist in the process of identifying strategies.

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The last word ...

Jörg Amelung. © Private collection

... comes from Jörg Amelung from the FMD

Mr. Amelung, you are provisionally directing the Research Fab Microelectronics Germany (FMD). What are your main tasks at the moment?

At the moment, my main tasks involve establishing the structures and the staff of the technology park management. These tasks were planned, naturally enough, but we were surprised by the very early requests for a marketing department that would organize state-specific opening events. I also continue to manage the work of the technology park "Silicon-based technologies." There, we are working on harmonizing the technology facilities at the various institutes.

The FMD is organized into four "technology parks." What exactly is a "technology park" and what tasks do you expect to arise here?

Each technology park looks after related topics. We currently have the technology parks Silicon-based Technologies, Compound Semiconductors, Heterointegration, and Design, Test and Reliability. This division is what makes it possible to manage the field of microelectronics from a technological point of view. The main tasks of the technology park managers are thematic coordination of the investments and the inventory in order to be able to define technological offerings and identify synergies.

Let's look into the future. What would you like to have achieved in five years' time with the FMD?

The Research Fab is intended to be completely established in five years. It will be easier to plan larger projects within the Fraunhofer-Gesellschaft and there should be a synergetic approach to work. The FMD is also intended to become known as a contact with the outside world for top technological research and to be networked with European partners.

Which of the projects being worked on by your colleagues in other Fraunhofer institutes interests you in particular?

I am extremely interested in all projects that are currently looking at autonomous driving and e-mobility. The changes in this field will change all of our lives in the next 15 – 20 years, which makes this a very interesting area in which to do research.

What invention would you not like to do without in daily life?

GPS navigation. I am from a time when you had to plan all trips in advance and make sure you had the right maps for all the places you would be passing through. It seems surprising today that we always reached our destination.

What do you wish you had more time for?

I would like to be able to spend more time with friends and to enjoy life outside of work.

What was the last book you read?

The last book was The Swarm by Frank Schätzing, which I had read before. It's an excellent book, even the second time around.

Last, but not least: can you tell us what motto you live by?

It is hard to find a proper motto. I am mostly guided by the question "What comes next?" And maybe the legendary quote from The Hitchhiker's Guide to the Galaxy: "The Answer to the Ultimate Question of Life, The Universe, and Everything is... 42!"

From June to August, regional launch events were held for the Research Fab Microelectronics Germany in individual states. Our photo shows Jörg Amelung (third from the left), the provisional director of the FMD, at the Fraunhofer IAF event in Baden-Württemberg. © Fraunhofer IAF

About Jörg Amelung:
After completing his degree in physics at the University of Duisburg in 1993, Jörg Amelung worked at Fraunhofer IMS in Duisburg. In 1998, he moved to Fraunhofer IPMS in Dresden, where he managed the Institute's technology department. He then set up the Center for Organic Materials and Electronic Devices Dresden (COMEDD). In 2009, he founded Tridonic Dresden, a joint venture for OLED lighting components between the Zumtobel Group and the Fraunhofer-Gesellschaft. He also managed the joint venture. In 2013, he moved to Tridonic Dornbin as Program Manager. From the end of 2014, he was the MEMS Business Manager at Fraunhofer IPMS and, since April 2017, has been technology park manager and provisional director of the FMD within the Fraunhofer Group for Microelectronics. He is based in Berlin.

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