Microelectronics News

Fraunhofer MIKROELEKTRONIK

August 2020 79

■ Microelectronics vs. Corona

#WeKnowHow: Fraunhofer solutions to combat the COVID-19 pandemic

Experts from the member institutes of the Fraunhofer Group for Microelectronics are actively involved in combating the pandemic. Microelectronics itself is an important key technology in this context. We present current projects and initiatives from our member institutes.

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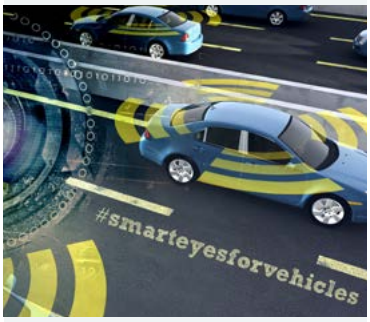

Systems for vehicle environment detection are essential for autonomous driving and digital manufacturing. With smart solutions from the FMD these systems are further developed. © Fraunhofer

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Energy-saving chips for artificial intelligence

The Fraunhofer Institutes EMFT, IIS and IPMS research energy-efficient neuromorphic hardware. The hardware architecture of the chips profits from embedded non-volatile storage and in-memory computing.

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Machine Close-Up

215 newly installed machines in 2019: As part of the Research Fab Microelectronics Germany's (FMD) investments, the 13 member institutes are expanding and modernizing their infrastructure. Two examples illustrate the institutes' new competencies gained by this.

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Sensitive detection of cancer cells in lymph nodes

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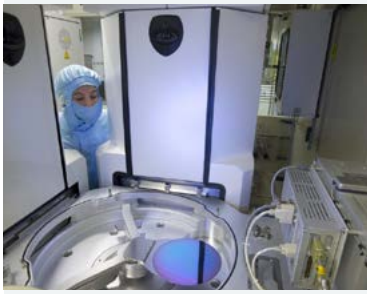

Fraunhofer EMFT develops energy-efficient technologies for neuromorphic computers.
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Upcoming Digital Events of the Institutes of the Fraunhofer Group for Microelectronics

Date	Topic	Institute	Further information on program and registration
09/01	Electronics Goes Green 2020+	IZM	www.electronicsgoesgreen.org
09/07 – 09/10	EDCC 2020	IKS	www.iks.fraunhofer.de/en/events/edcc-2020.html
09/28 – 09/30	The Edge Event	FOKUS	tmt.knect365.com/the-edge-event/
10/07 – 10/08	TSN/A Conference	IPMS	www.events.weka-fachmedien.de/tsna-conference/home/

Scheduled On-site Events of the Institutes of the Fraunhofer Group for Microelectronics

Date	Topic	Institute	Further information on program and registration
09/11 – 15/11	IBC 2020	HHI	www.show.ibc.org
09/21 – 09/22	Wide-Bandgap User Training	IZM	www.izm.fraunhofer.de/en/news_events/trainings-and-workshops/ws_18.html
09/21 – 09/25	IEEE Radar Conference 2020	FHR	www.radarconf20.org
09/29	Hands-On Technology Workshop | Li-Fi Wireless Data Transmission with Light	IPMS	www.ipms.fraunhofer.de/en/events/2020/lifi-workshop.html
10/05- – 0/08	International Radar Symposium	FHR	www.mrweek.org/irs/
11/04 – 11/05	Medical Wearables	IPMS	www.medwearablesconference.com
11/10 – 11/13	Semicon Europa	ENAS, IPMS	www.semiconeuropa.org
11/10 – 11/13	electronica 2020	IPMS	www.electronica.de

Webinars available at any time

On our website, you will find an overview of tech webinars and online events of the institutes of the Fraunhofer-Group for Microelectronics. This will be updated continuously. You will also find an overview of webinars whose recorded content is freely available.

Verification of the deep learning algorithm for the implementation of neuromorphic hardware.
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Energy-saving chips for artificial intelligence

The Fraunhofer Institutes EMFT, IIS and IPMS research energy-efficient neuromorphic hardware.

Neuromorphic hardware uses specialized computing architectures that reflect the structure (morphology) of neural networks from the bottom up: When we think, our brain processes a vast amount of information. This is made possible by billions of nerve cells interconnected by billions of synaptic connections. Neuromorphic computing – a key technology for artificial intelligence – imitates the morphology of the brain by means of processing units that emulate the behavior of neurons and synapses. This increases the energy efficiency for AI applications, because at present the complex thinking power of computers still consumes a lot of electrical energy.

Within the ECSEL project TEMPO, researchers are therefore developing novel and energy-efficient neuromorphic systems for semiconductor chips. The hardware architecture of the chips profits from embedded non-volatile storage and in-memory computing overcoming the limited data rate transfer between processor and external memory (von-Neumann bottleneck).

The researchers use new integrated storage technologies in innovative concepts for the realization of analog and digital neuromorphic circuits.

Fraunhofer expertise

Within the ECSEL project TEMPO (Technology & Hardware for Neuromorphic Computing), the Fraunhofer Research Institution for Microsystems and Solid State Technologies EMFT, the Fraunhofer Institute for Integrated Circuits IIS and the Fraunhofer Institute for Photonic Microsystems IPMS are working on the realization of neuromorphic hardware.

Fraunhofer EMFT focuses on the development of key IPs for analog and mixed-signal signal processing for neuromorphic structures. In detail, these are power-saving neuromorphic computer chips in the 2x nm technology node. Together with Fraunhofer IIS, Fraunhofer EMFT is the central contact regarding the development of key components for analog and mixed-signal neuromorphic hardware.

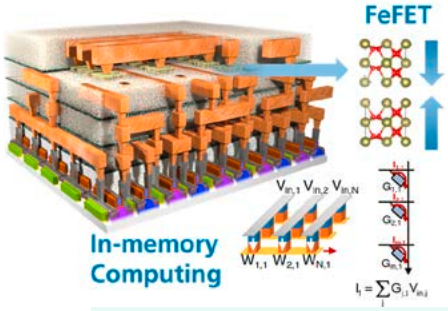
In this project, Fraunhofer IIS will lay the foundations for analog and digital deep learning reference accelerator components that will be used in future IP core products and subsequent industrial and funding projects. Based on these foundations, ASIC-based mixed-signal accelerators consisting of digital and analog components will be realized. Fraunhofer IIS develops for the digital inference accelerator a decompressor unit. Fraunhofer IIS is responsible for both the coordination and introducing the architectural design of a flexibly programmable digital deep learning accelerator together with videantis GmbH.

Fraunhofer IPMS works on the development and evaluation of power-saving neuromorphic computing chips in the 22 nm FDSOI technology node. The developers use new integrated memory technologies based on ferroelectric hafnium dioxide in innovative concepts for the realization of analog and digital neuromorphic circuits. Fraunhofer IPMS focuses on the development of memory technologies and IPs for analog and mixed signal processing in the memory cells to enable efficient calculations.

Fields of application

The chips designed and manufactured in the project are to be used primarily for classification tasks in image recognition systems as well as for processing other sensor data. The possible fields of application include the automotive, space and health sectors. The chips can reduce the power consumption of signal processing of mobile and portable sensor systems by several orders of magnitude.

This minimizes the energy consumption for complex computing power and enables a novel computer architecture for artificial intelligence applications.



By means of ferroelectric field effect transistors (FeFET) based on HfO2 in the 28- or 22-nm technology node, the weight values required for deep learning algorithms can not only be stored directly in the chip but also be calculated with.
© Fraunhofer IPMS

About TEMPO:
The project is funded by the EU and by the German Federal Ministry of Education and Research.

Further information on the project is available at: www.tempo-ecsel.eu

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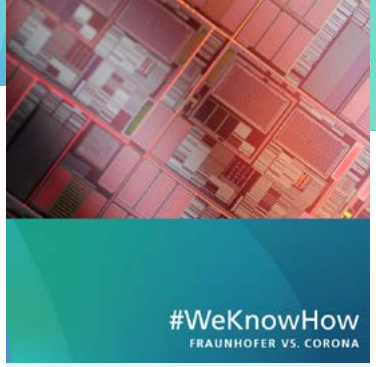

Microelectronics is a key technology for measures to combat the COVID-19 pandemic. © Fraunhofer

Fraunhofer solutions to combat the COVID-19 pandemic

The COVID-19 pandemic is leaving its mark on everyday life, on people's health and companies as well as on the local and global economy. The current situation and dynamic developments face society with exceptional challenges. Experts from the member institutes of the Fraunhofer Group for Microelectronics are actively involved in combating the pandemic and are thus helping to cope with its direct effects and future economic and social consequences.

Microelectronics itself is an important key technology in this context. For example, it forms the basis of technological solutions for contact tracking and faster test procedures, it serves to secure supply chains, maintain technological sovereignty and provide technologies for small and medium-sized enterprises to speed up the re-start.

In this issue, we present current projects and initiatives from our member institutes, which are also part of the program Fraunhofer vs. Corona. For example Fraunhofer IZM is participating in the development of a rapid corona test (see page 5), and Fraunhofer IIS adapts initiatives for the supply of the rural population to current developments (see below). Furthermore, the Fraunhofer-Gesellschaft has developed its own approach for a German proximity tracing app.

We will continue to inform you about current projects and initiatives in the coming issues.

You can find further information on our website: www.mikroelektronik.fraunhofer.de/en/corona

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Digital solutions and services for rural areas

"Mobile Village Store": Local supply during the Corona crisis

As a "walk-in supermarket", the "Mobile Village Store" connects around 33 villages, 4,000 people and 20 producers. The linchpin of the project under the direction of Fraunhofer SCS is a digital platform intended to link customers, operators and producers of regional goods with each other. Among other things, it will use intelligent route planning as well as inventory cross-checking and serve as a means of communication for all those involved. The "Mobile Village Store" supplies interested persons with goods for daily needs, while deeply involving regional producers in the product range and is very well accepted by different population groups. The offer of the mobile village store is especially important for elderly citizens in the current times of crisis: they are at present making increased use of services such as ordering and (door-to-door) delivery of goods.

"DIGI-ORT": Platform solution for digital medical and nursing care

In the "DIGI-ORT" project, Fraunhofer SCS is researching a digital platform for medical and nursing care in rural areas. This platform networks outpatient care services, general practitioners and people in need of care, the chronically ill and their relatives in order to simplify coordination processes. As this simplifies routine work, everyone involved gains more time to work directly with the people. In addition, the use of new, textile-integrated vital data sensors and technical assistance systems available on the market is being investigated to support independent living in one's own home.

The "Mobile Village Store" is a digital solution for the local supply of goods for daily needs and helps to secure supplies also in times of crisis. © Steinwald Alliance

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New diagnostic method for early corona detection in 2.5 hours

A new rapid corona test was developed thanks to technologies developed by Fraunhofer IZM.

Robert Bosch GmbH has introduced a test for COVID-19 which promises "results at the point of care in less than 2.5 hours". With the new rapid test, the original waiting time of up to two days can be reduced to a few hours. The rapid test is based on a PoC analysis platform, which Fraunhofer IZM helped to develop as part of a collaborative project for situations in everyday medical practice.

Rapid diagnosis

The new "Vivalytic" test uses a molecular diagnostic platform integrated into a test cassette. To test a patient, a smear is taken from the nose or throat. One of the main advantages of the device is that the test does not require a laboratory with trained medical personnel. Patients tested can expect a rapid result more than 95% accurate and covering not only coronavirus but also nine other respiratory diseases such as influenza A and B. "The differential diagnosis also saves doctors time for further tests, quickly provides them with a well-founded diagnosis, and enables them to initiate suitable therapy more quickly," explains Marc Meier, Managing Director of Bosch Healthcare Solutions.

Underlying technology

The technology on which the test is based was developed in an EU project of the EU Joint Undertaking ENIAC. 25 partners from eight European countries were involved in this "CAJAL4EU" project. Their common goal was to develop technologies and components for a lab-on-chip system with electrical detection capabilities – in particular a microfluidically integrated biosensor platform with an amperometric detection chip and the necessary algorithms to enable the early detection of hospital pathogens.

Contributions by Fraunhofer IZM

Fraunhofer IZM was involved in the integration of electronic, functionalized and passive-functionalized chip components. The detection of pathogens in bloodstream infections was chosen as a use case because the fast and effective identification of infections in the patient's blood is essential for early targeted treatment. This development work is now also being successfully applied in the fight against the SARS-CoV2 pandemic. The full version of the text can be found at blog.izm.fraunhofer.de.

Use of the Covid-19 rapid test. © Bosch

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Machine Close-up: 12” thin wire bonder and X-ray photoelectron spectrometer

The newly acquired thin wire bonder at Fraunhofer ISIT. © Fraunhofer ISIT

215 newly installed machines in 2019: As part of the Research Fab Microelectronics Germany’s (FMD) investments, the 13 member institutes are expanding and modernizing their infrastructure. The following two examples illustrate the institutes’ new competencies gained by this.

Fully automatic: 12” thin wire bonder at Fraunhofer ISIT

The newly installed thin wire bonder Bondjet 855 of the company Hesse mechatronics was modified according to the requirements of the employees of the working group “Module Services” at Fraunhofer ISIT. The software and also the specific innovations are very different from the predecessing model. Different bond heads can now be mounted on the new device, which are optimized for the respective task. Thanks to the high performance, up to seven bond connections per second can be realized. In addition, it is possible to suck in wafers of up to 12” in size using vacuum, to heat them and to process them completely.

The machine has three working areas which automatically detect the wafer size and switch the vacuum separately. Each wafer size is thus ready for programming and processing at the push of a button without any conversion. For boards, ceramics and individual components to be taught and bonded, the thin wire bonder also has a large, rectangular working area with suction holes. The distance between them is very small in order to hold the flat samples well. The table of the machine is heatable which allows a wide variety of wire and ribbon materials to be used, such as gold, copper, silver and platinum wires as well as aluminum and gold ribbons.

View into nano-depths: X-ray photoelectron spectrometer at Fraunhofer IPMS

Silicon chips are the nerve cells of artificial intelligence. Their surfaces contain billions of tiny components that transmit important information and signals. But the demands on semiconductor chips are increasing. Fraunhofer IPMS has acquired a new X-ray photoelectron spectrometer (XPS) from Physical Electronics GmbH as part of the FMD investments. The spectrometer is used to analyze the surfaces of silicon chips and to realize experiments in the nanoscale. Thus, surface features, thin-film structures and contaminations can be examined down to the nano range without damage. The research in this area is important to analyze the exact chemical composition of the chip surfaces. With this, processes for the production of semiconductor chips can be better understood and their later properties can be optimized.

A further advantage of the new acquisition is its versatility. In addition to conventional XPS measurements with an Al X-ray source, analysis experiments can be carried out with an extended depth. Moreover, thanks to the short-wave spectrum, transition metals can be analyzed and the system can be used for cleaning the sample surface and for depth profiling. In addition, the XPS allows temperature experiments from -120 °C to 300 °C and experiments with electrical sample contacting.

This publication is partly funded by the German Federal Ministry of Education and Research under the project reference numbers 16FMD01K, 16FMD02 and 16FMD03.

The spectrometer is used to analyze the surfaces of silicon chips and to realize experiments on the nanoscale. © Fraunhofer IPMS

Further FMD investments in the video portrait:

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Christoph Galle is the FMD expert and contact person for vehicle environment detection.
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#smarteyesforvehicles: Farther, more precise, smaller

Whether in traffic, robotics or industry: smart solutions for environment detection systems are in demand. The Research Fab Microelectronics Germany (FMD) significantly contributes to the further development of technologies and thus to increasing the safety of road users or players in the industrial environment.

Mr. Galle, you are the FMD's contact person for vehicle environment detection. Which technologies does this term entail?

Vehicle environment detection means technologies around LiDAR, RADAR, sensor data fusion and of course the related integration technologies. It is about multi-sensorial detection of the environment in 360° near and far. This includes the detection of people, the roadway or – in industrial applications – the classification of objects.

What competencies does the FMD have in this area?

The 13 member institutes of the FMD have different special knowledge of the technologies and components, which complement each other in an ideal manner. In the field of LiDAR, for example, this ranges from the various components of a system, such as laser sources, optics, beam guidance equipment or detectors in different wavelength ranges, to intelligent signal processing.

Which projects are currently being carried out within the FMD in this area?

In the large-scale project "miniLiDAR", we are developing components for a miniaturized LiDAR system for robotics together with an industrial partner. Four FMD institutes are involved. Leibniz FBH in Berlin is developing the pulse laser sources. Fraunhofer IPMS in Dresden implements the development of the beam deflection device. Fraunhofer IZM in Berlin is dedicated to the topic of optical phased arrays and Fraunhofer IMS in Duisburg realizes the detector development.

In another project with the startup OQmented, we are in the final stages of implementation. Here, the Fraunhofer Institutes ISIT and IMS as well as the Leibniz FBH are developing a Wide-Field-of-View LiDAR demonstrator with a single MEMS mirror working in coordination with a SPAD detector. The demonstrator features a field-of-view of more than 160° at a resolution of 0.1° and has very good sunlight suppression properties.

How do you support customers interested in projects?

We as the FMD are the one-stop shop for our customers for technologies in vehicle environment detection. We put together a consortium of experts, tailored to the technological requirements. This enables us to offer tailor-made solutions. The customer has access to a complementary portfolio of solutions through one contact person.

What technological trends are emerging in this area?

"Farther", "more precise" and "smaller" are keywords we deal with every day. In order to meet these demands on the sensor technology of vehicle environment detection, we are working on solutions on different levels. Compound semiconductors such as InP-based lasers or InGaAs-based detectors could signifiacntly improve the performance of LiDAR systems. However, problems have to be solved in order to meet the cost requirements. Heterointegration is certainly a crucial issue: The combination of the mentioned detectors with silicon-based readout electronics is a solution idea we are addressing.

About Christoph Galle:
Studied industrial engineering and management at the TU Berlin. Worked as a project manager at the Brandenburg Economic Development Agency with a focus on the strategic development of the transport, mobility and logistics clusters as well as ICT, media and creative industries. Since 2018 program manager at the FMD. Strategic development and business development for the topic of vehicle environment detection.

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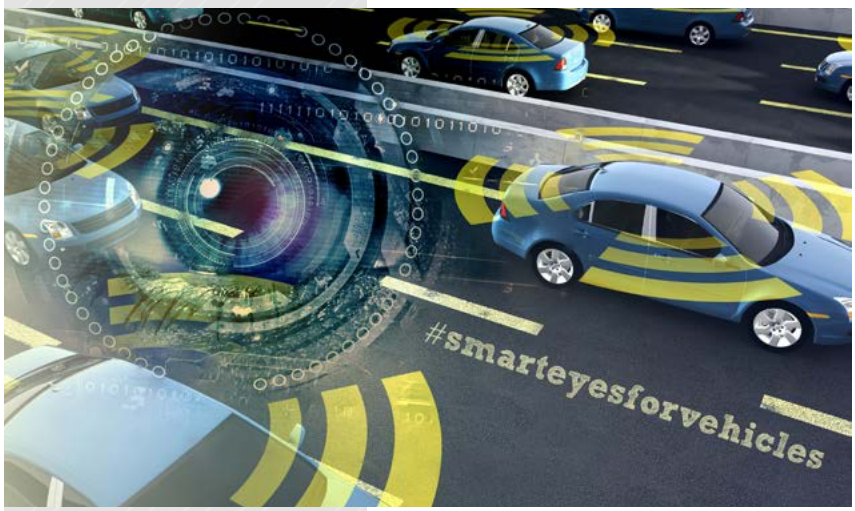
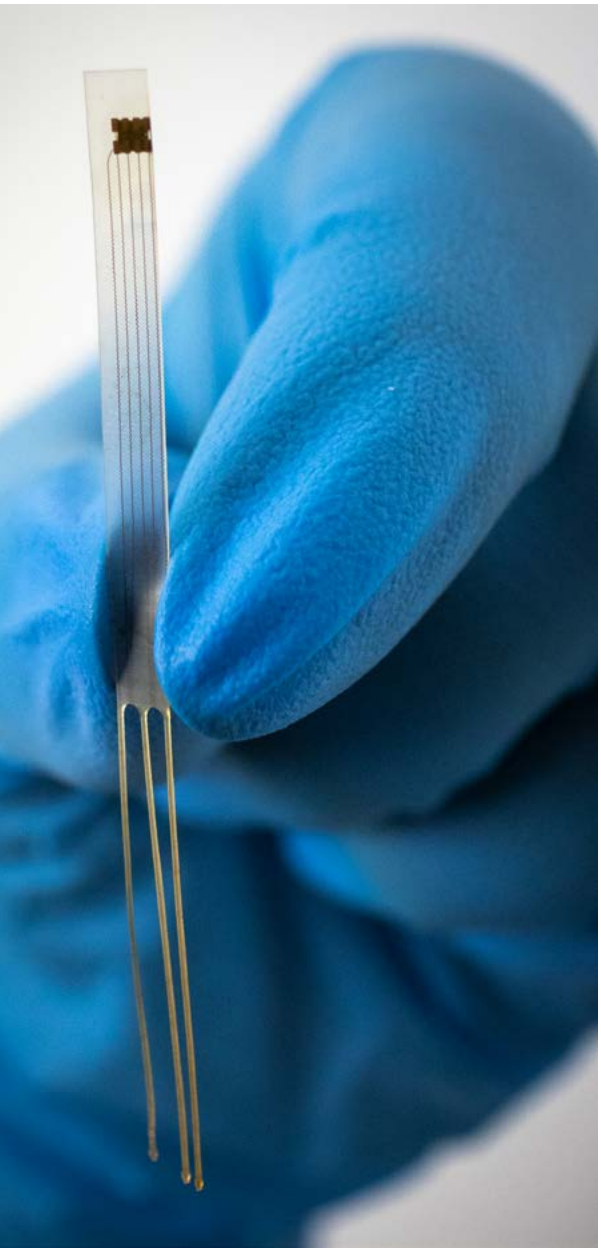


Electricity, not pills

Fraunhofer IZM and the Delft University of Technology are developing electroceutics for the drug-free treatment of chronic diseases.

According to a 2007 study by the Robert Koch Institute, one in four women is affected by urinary incontinence. This form of bladder weakness often has to be treated medically and even surgically – a process that can be lengthy and expensive and may include side effects. The working group "Technologies of Bioelectronics" at the Fraunhofer Institute for Reliability and Microintegration IZM is therefore researching the use of electronic microimplants as an alternative.



Pharmaceutical implants enable the drug-free treatment of chronic diseases.
© Fraunhofer IZM / Tim Hosman

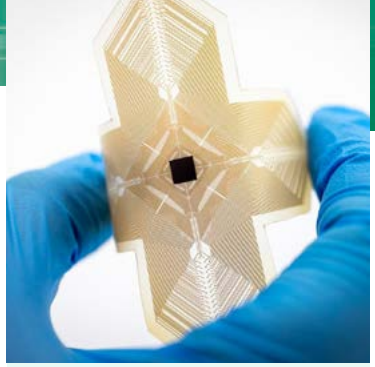
Electrical impulses regulate body functions

Electroceutical implants can electrically stimulate nerve cells in a targeted manner to trigger or block body signals or to send them to other places in the body. Physiological processes can thus be activated or inhibited depending on the nature of the disease. Feedback loops between nerve cells and microimplants allow therapies to be personalized for patients. The use of electroceutics thus enables completely new therapeutic methods and minimizes the risk of possible side effects. In the case of bladder incontinence, a sensor system is being developed to monitor the bladder volume and, if necessary, send a message to plan the visit to the toilet in good time.

Unintentional emptying of the bladder can be prevented by high-frequency stimulation of the nerve concerned. Electroceuticals can also be used to treat many other chronic diseases whose mechanisms of action respond to electrical stimulation. These include asthma, diabetes, Parkinson's disease, migraine, rheumatism and high blood pressure.

Challenges and solutions

For use in the body, the system must be wireless and work through tissue and body fluids. The battery is therefore charged via ultrasound, which sets vibrating bodies in the implant in motion. The kinetic energy is then converted into electricity. To ensure that the body does not reject the implant, the researchers use biocompatible materials such as special polymers, precious metals or silicon. The researchers are constantly working on miniaturizing the system, aiming for a total size of less than 1 cm^3. The implants shall last several decades. Reliability and durability tests are carried out in fast motion with the expected exposure to electromagnetic vibrations, humidity and temperature. In parallel, test models are currently being developed which are also suitable for clinical research.



The flexible implant with 324 electrodes and integrated electronics stimulates and records neuronal activity on the brain surface.
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With the help of artificial intelligence, industrial processes can be efficiently monitored and controlled.
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Artificial intelligence optimizes production processes

Together with partners from industry and research, Fraunhofer IIS develops holistic AI solutions for Industry 4.0.

Microelectronics, when combined with sensor technology and software, can be used to digitize production processes and operating procedures in Industry 4.0, thus making them more efficient. However, currently available electronic systems for data acquisition and signal processing are not optimized for this application area. Especially digital signal processors (DSP) or field-programmable gate arrays (FPGA), which are suitable for the use of universal AI algorithms, are not only expensive – they also exceed the space and energy requirements of many sensors commonly used in Industry 4.0. Direct replacement of individual elements is therefore not possible.

Combination of hardware and software

The "KI-Predict" project follows a holistic approach that combines AI methods with specially optimized integrated hardware. This interconnection of hardware and software enables intelligent process monitoring with data processing directly at the sensor. The sensor interface ASIC developed by Fraunhofer IIS is specifically designed for condition monitoring sensors and real-time process control. Features are captured energy-efficiently and also from high-frequency sensor signals. This enables decentralized analyses and forecasts with very low latency. The system can directly detect faulty sensors by interpreting anomalies.

Possible applications in the entire industry

The system is compatible with standard industrial interfaces and networks; the hardware can be automatically adapted to a wide range of applications. Industrial partners can thus increase the functional scope of their systems without additional infrastructure costs. By using more complex methods of AI and machine learning, the system can e. g. also be used to monitor industrial plant status and product quality completely digitally. This optimizes operations, ensures the required product quality, and ultimately reduces costs. KI-Predict is funded by the German Federal Ministry of Education and Research (BMBF). The project runs from March 2020 to February 2023.

KI-Predict
Besides Fraunhofer IIS, the following partners are involved in KI-Predict:
- CANway technology GmbH
- GFE Schmalkalden e.V.
- ODION GmbH
- Sensitec GmbH, Lahnau
- SNR Wälzlager GmbH
- Saarland University

"KI-Predict" combines AI methods with specially optimized integrated hardware. The picture does not show the finished IC.
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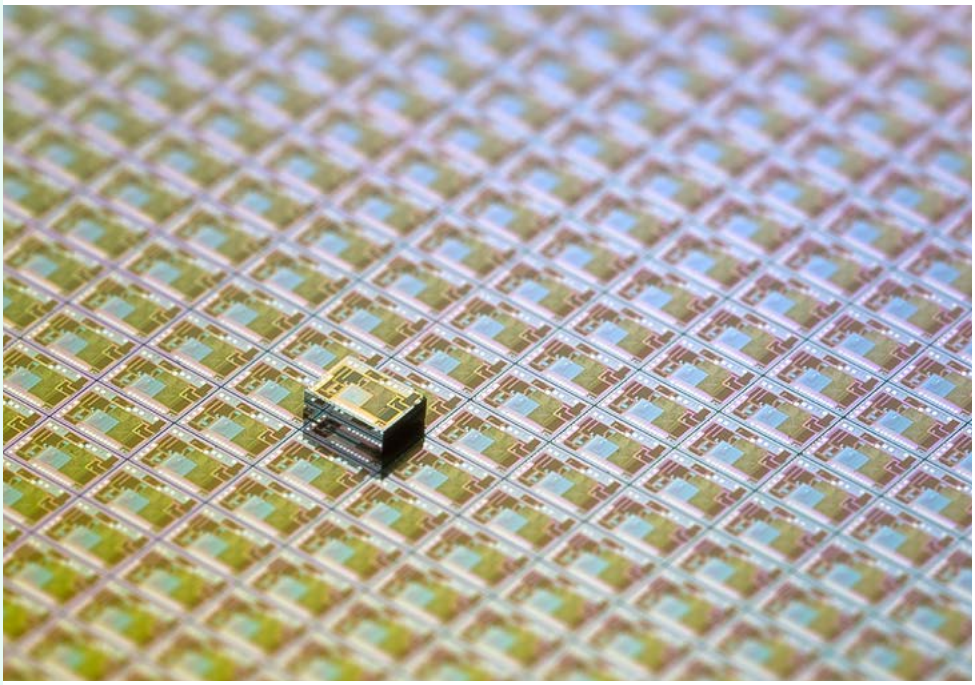

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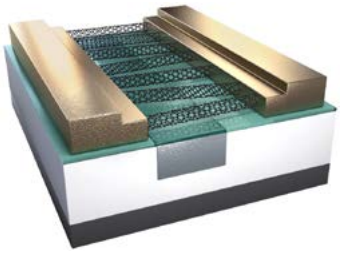


Cross section of a carbon nanotube-based transistor.
© Fraunhofer ENAS

CNT integration for high-performance components

Fraunhofer ENAS develops industrial compatible integration technologies for carbon nanotubes in electronics and sensors.

Carbon nanotubes (CNTs) are key components of future electronic devices. They extend the functionality of existing microelectronic systems and even enable completely new electronic concepts. However, persisting challenges for manufacturing and integration processes hamper their widespread implementation.

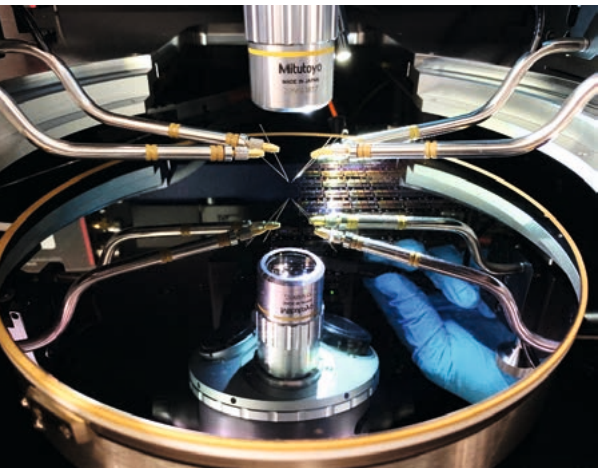
Universal transistor technology enables CNT integration

The Fraunhofer Institute for Electronic Nano Systems ENAS and the Center for Microtechnologies at Chemnitz University of Technology have established a technology platform for industry-compatible CNT integration. On 200 mm wafers, CNT-based transistors can be implemented for various applications. The technology features high yield and integration density as well as low component variability. Due to the modular process, different substrate complexities can be realized.

As a technology service, CNT layers can be directly provided for application developments in research and industry. Sensor applications with flexible designs and adaptable processes for the integration of e. g. electrodes are possible. The portfolio also includes advanced transistor technologies. For example, device concepts implementing structured back-gate and up to seven lithography levels have already been successfully realized. The technology is compatible with conventional micro technologies such as used for ASICS, MEMS and MOEMS.

Versatile applications from sensors to high-frequency electronics

The 1-2 nm thin CNTs are an ideal material basis for sensors. CNT-based strain sensors are five times more sensitive than conventional silicon sensors. CNTs can also be functionalized highly specifically for the detection of gas and biological species. Optical, mechanical and chemical sensors have already been realized with the aid of CNT-based transistor substrates. Further possible applications are in high-frequency electronics. For example, CNT technologies can reduce the energy requirement of the transceiver module of a mobile phone by up to 30 %. Gigahertz-capable high-frequency components for transmitter and receiver units have already been realized with CNT technologies. Transit frequencies of over 14 GHz have been achieved with a 300-nm transistor technology. Special designs can improve the component linearity of the transistors and increase their speed by up to 20%. In addition, device technology was optimized to minimize parasitic capacitances and to form defined contact barriers.



200 mm wafer with CNT transistors.
© Fraunhofer ENAS

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RehaToGo helps to detect movement errors early on and thus prevent long-term damage. © MEV Verlag

Mobile walking lab

In the project "RehaToGo", a mobile system for the observation and correction of patients' movements is being developed.

After an accident, an illness or surgery, movement errors often creep in, which can lead to long-term damage if undetected. However, technologies for walking analysis are currently only available in special centers. Access is therefore limited and not affordable for many physicians' practices. In addition, monitoring ends with the stay of the patients. The researchers involved in RehaToGo are therefore developing a cost-effective, mobile alternative suitable for everyday use.

Precise observation in everyday life through RFID

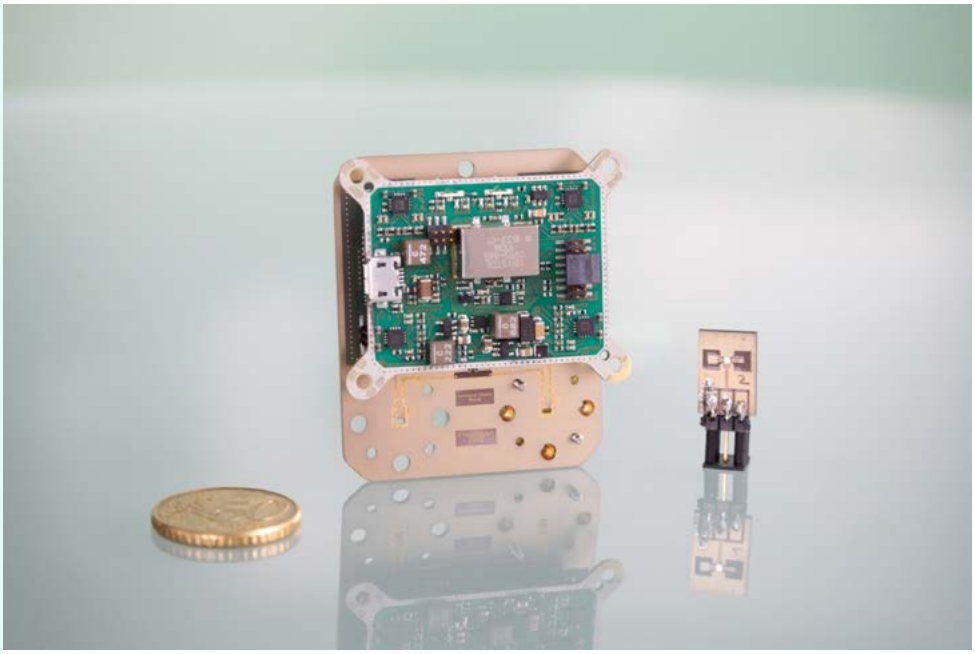
The RehaToGo system precisely measures the movement patterns of arms and legs via Radio Frequency Identification Tags (RFID). These are simply integrated into everyday clothing so that patients are not restricted. The Fraunhofer Institute for High Frequency Physics and Radar Techniques FHR, together with the Chair for Integrated Systems at the Ruhr-Universität Bochum, couples RFID technology with high frequency radar systems. This makes it possible to precisely track the individual tags. Miniature readers read out the collected measurement data and further process them.

Direct feedback optimizes movement sequences

Patients receive direct online feedback on their movement sequences and the execution of physiotherapeutic exercises, and can thus improve them on their own. At the same time, medical staff can also observe the movement sequences and quickly and reliably identify harmful walking patterns. This optimizes the quality of treatment and also increases patient safety. Hospital stays can be significantly shortened with RehaToGo, which relieves both patients and medical staff.

The project is funded by the European Regional Development Fund ERDF.

Test setups of radar reader and tag to prove the principle in the laboratory.
© Fraunhofer FHR / Alex Shoykhetbrod



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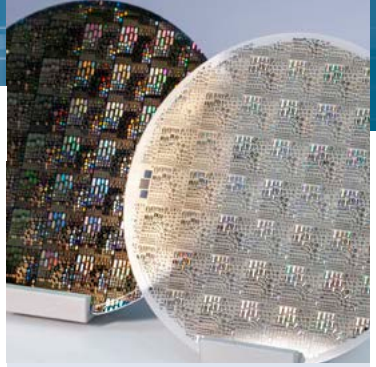
AlScN – Alternative material for more efficient smartphone hardware

In order to cope with the constantly growing mobile data traffic, new mobile phone standards such as 5G are being implemented. These occupy more and higher frequency ranges. To enable devices to reach these frequencies, the requirements for radio frequency (RF) components are increasing. Fraunhofer IAF has developed more compact and energy-efficient RF filters with high bandwidths for this purpose. In the course of the "PiTrans" project, it has been possible to use aluminum scandium nitride (AlScN) to create electroacoustic components for smartphones that meet these requirements.

AlScN is one of the most promising materials to replace aluminum nitride (AlN), which is used in conventional RF filters of mobile phones. By adding scandium (Sc) to AlN, the electromechanical coupling and the piezoelectric coefficient of the material is increased, allowing a more efficient conversion of mechanical to electrical energy. This in turn allows the development of significantly more efficient RF devices. Up to now, the instability of the piezoelectric AlScN crystal phase has been an obstacle to the industrial use of the material, since segregation of Wurtzite-type AlN and cubic ScN usually occurs during growth.

In the course of the project, the researchers have now succeeded in growing highly crystalline AlScN layers with different Sc fractions of up to 41 %. A good homogeneity of the layers was achieved over the entire silicon wafer (Si) with a diameter of up to 200 mm, which also meets the requirements of industrial production.



Processed surface acoustic wave structures (SAW structures) on AlScN/Si (left) and AlScN/Al2O3 (right). © Fraunhofer IAF

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Voice assistance in everyday working life

Together with partners from industry and research, the Fraunhofer Institutes IIS and IAIS are developing an AI-based voice assistant platform for business-to-business applications.

With voice assistant systems, people and technology can interact via spoken, natural language. In medicine and care, for example, this enables the intuitive and hands-free documentation of disease progression and diagnoses. Artificial intelligence supports medical staff in this process through efficient data aggregation and evaluation. Processes in industry, service and administration can also be made more efficient and reliable with speech assistance.

The necessary infrastructures, technology modules and standards will be developed within the framework of the "SPEAKER" project. The system is going to implement European standards of data security. The platform can be individually adapted to the terminologies, workflows and needs of the respective industry. The pilot applications are developed in close cooperation with the future users in order to be able to transfer the first prototypes directly into application.

SPEAKER is funded by the German Federal Ministry for Economic Affairs and Energy (Funding number: 01MK20011A). The implementation phase has been running since 1 April 2020. Further information on the project and the partners involved can be found at: www.speaker.fraunhofer.de

SPEAKER was awarded in the 2019 innovation competition "Artificial intelligence as a driver for economically relevant ecosystems" run by Germany's Federal Ministry for Economic Affairs and Energy. © BooblGum / Adobe Stock

Supported by:
Federal Ministry for Economic Affairs and Energy
on the basis of a decision by the German Bundestag

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The TissueGrinder enables gentle tissue dissociation. © Fraunhofer IPA

Sensitive detection of cancer cells in lymph nodes

With the help of lymph node diagnostics, it is possible to determine whether a tumor has already spread in the body and formed regional metastases. An interdisciplinary team of researchers from the Fraunhofer Institutes IIS, IPA and ITEM and the University Hospital Regensburg has now optimized and automated this diagnostic method. Up to now, the lymph node tissue removed has been hardened in the laboratory, cut into thin slices and examined under the microscope. Since only a small part of the tissue is naturally examined in this so-called sectional diagnosis, tumor cells may remain undetected.

In the newly developed approach, the tissue is no longer cut up, but broken down into individual cells. A team at Fraunhofer IPA has developed the necessary grinding device, the TissueGrinder. In the next step, the tumor cells are stained with methods based on Fraunhofer ITEM's findings. The entire slide is then automatically digitized with a whole slide scanner. Using AI-based image analysis, individual tumor cells are detected with high sensitivity and reliably distinguished from other artifacts such as color aggregates or unspecifically stained cells (Fraunhofer IIS). Finally, tumor cells detected this way can be localized with micrometer precision, "isolated" from the slide and, thanks to DNA amplification, subjected to individual molecular diagnostics (Fraunhofer ITEM).

This workflow was evaluated on patients with skin cancer as well as lung cancer. Thanks to automation, the new LyDia HD diagnostics is not only more accurate, but also faster and more cost-effective than previous methods, providing important information about tumor cell characteristics. The new system thus creates an important prerequisite for the personalized medicine of the future. The project was successfully completed in 2019. Further samples are currently being evaluated in order to publish the results of this evaluation. Fraunhofer is looking for commercialization partners for the system. As part of the Fraunhofer spin-off program AHEAD, a start-up is currently being prepared with the aim of making the TissueGrinder subcomponent of this workflow commercially available from autumn 2020.

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GaN high frequency transistors achieve record efficiency at 100 V

A 100 V gallium nitride power transistor with an output power of 600 W at a frequency of 1.0 GHz. © Fraunhofer IAF

Researchers at Fraunhofer IAF have succeeded in significantly increasing the output power of their GaN-based high frequency transistors for the frequency range from 1-2 GHz: They have doubled the operating voltage of the components from 50 V to 100 V, thus achieving a power efficiency of 77.3 %. With this technology, it is now possible to develop highly efficient amplifiers with even higher power, as required for applications in the fields of plasma generation, industrial heating, communication and radar technologies.

Through vertical and lateral scaling of the transistor design, it has been possible for the first time in Europe to realize high frequency transistors suitable for applications with an operating voltage of 100 V. This increase in operating voltage enables higher power densities. A system can therefore deliver more power on the same area.

The high performance has already been proven in the laboratory for the frequency range of 1-2 GHz: Measurements showed a power density of more than 17 W/mm and a power-added efficiency (PAE) of 77.3 % at a frequency of 1.0 GHz – the highest power efficiency achieved for 100 V operation in this frequency range.

The long-term goal of the researchers at Fraunhofer IAF is to operate at up to 10 GHz. This enables, among other things, the further technological development of high-performance applications such as particle accelerators, industrial microwave heaters, mobile phone amplifiers, pulse and continuous wave radars, and amplifiers for plasma generators. As a rule, such systems require a great deal of power while at the same time requiring only a small volume of components – in other words, exactly what 100 V technology is supposed to enable.

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Thermally assisted chemical vapor deposition on an 8" wafer. © Fraunhofer EMFT / Bernd Müller

Energy-efficient technologies for neuromorphic computers

In the EU project "NeurONN", in which Fraunhofer EMFT is also involved, components and architectures for neuromorphic computing are being developed.

In the course of the AI megatrend, neuromorphic computing is also gaining in importance. Neuromorphic computers imitate the human brain and nervous system. The two key components – the "neurons" and "synapses" – replicate the distributed computing and memory units. Neuromorphic computers can thus solve complex associative learning problems and are also much more energy efficient than current silicon-based circuits.

In the "NeurONN" project, Fraunhofer EMFT and its partners are researching energy-efficient elements and architectures for neuromorphic computing. The approach involves encrypting information in the phase of coupled oscillating elements that are interconnected to form a neural network. The neurons used are novel elements based on vanadium dioxide, which can be 250 times more efficient than state-of-the-art digital oscillators based on CMOS.

Fraunhofer EMFT is responsible for the development of the synapses, which consist in designing memristive systems based on novel two-dimensional materials. These are expected to be 330 times more efficient than currently used technologies in terms of switching speed, lifetime and power consumption. For the first time in Germany, EMFT will make available processing technology of two-dimensional materials monolayers on 8" diameter wafer.

The project runs from January 2020 to December 2022 and is funded under the EU's Horizon 2020 research program.

NeurONN
Besides Fraunhofer EMFT, the following partners are involved in the NeurONN project:
- Centre National De La Recherche Scientifique CNRS, France (project coordination)
- IBM Research, Zurich
- CSIC/University of Seville, Spain
- Silvaco, United Kingdom
- AI Mergence, France

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Water disinfection with ozone

Together with partners from industry, Fraunhofer ISIT is developing an ozone generator for water disinfection.

Ozone is an effective and environmentally friendly disinfectant. With the help of a boron-doped diamond layer it can be generated electrolytically directly from water. This method is fast, safe and allows an exact dosage.

Within the framework of the "MIKROOZON" project, funded by the state of Schleswig-Holstein, a miniaturized ozone generator with integrated sensor technology and microprocessor-based control is being developed. It is to be used for the regular disinfection of small and household appliances, shower-toilets or beverage dispensers. Device manufacturers can easily integrate the generator into their systems and thus develop individual hygiene solutions for their customers. Fraunhofer ISIT contributes the electrode substrates of the electrolysis cell and a sensor chip to the ozone generator. This chip monitors the parameters mass flow, temperature and conductivity. A control unit processes the measured data and controls the ozone production of the MIKROOZON cell in order to optimize the operating conditions and extend the life of the cell.

In addition to Fraunhofer ISIT, GO Systemelektronik GmbH and CONDIAS GmbH are involved in MIKROOZON.

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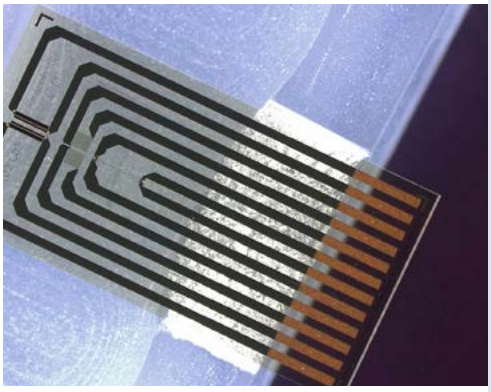
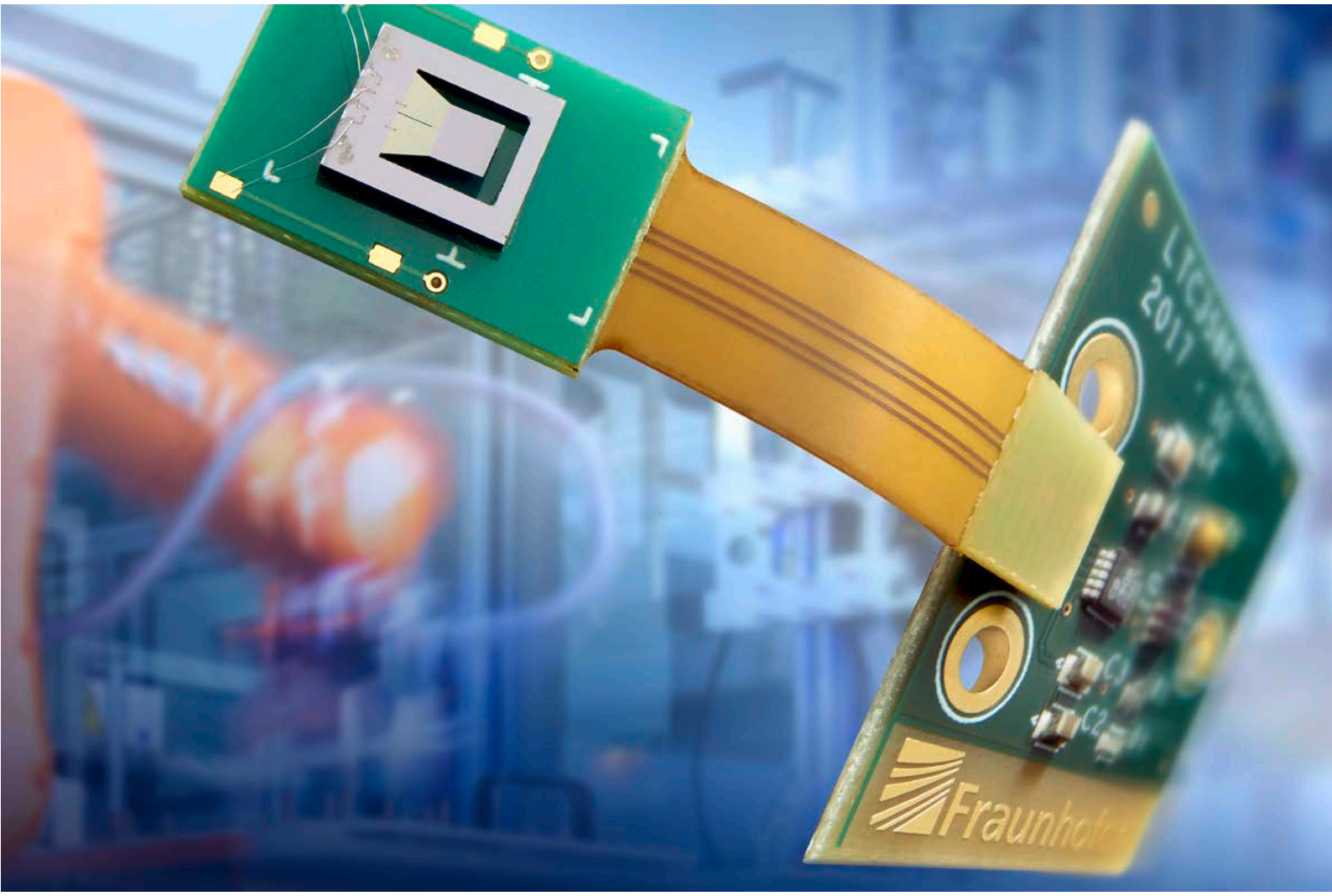


The sensor unit of the ozone generator is integrated on a glass chip. It monitors the water flow into the electrolysis cell. © Fraunhofer ISIT



Sensor systems are dependent on energy self-sufficient operation in many application areas that do not allow energy supply via power cable or battery replacement. Our picture shows a broadband MEMS "energy harvester", which is being developed by Fraunhofer ISIT in the Fraunhofer lead project "Towards Zero Power Electronics". The aim is to convert mechanical and magnetic ambient energy into usable electrical energy. The applied Powder MEMS Technology for the integration of three-dimensional magnetic particle structures makes it possible to realize novel chip-based MEMS harvesters – with a high energy yield at minimum component size. © Fraunhofer ISIT

Editorial notes

Microelectronics News, Issue 79
August 2020

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The Fraunhofer Group for Microelectronics, founded in 1996, combines the expertise of 16 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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... goes to Dr. Dirk Nüßler from Fraunhofer FHR.

Dr. Dirk Nüßler. © Fraunhofer FHR

About Dr. Nüßler:
Dr. Dirk Nüßler studied electrical engineering in Siegen and then began his research at the then Research Institute for High Frequency Physics (FHP). In the first years, he was engaged in the development of array antennas at 94 GHz and measurement techniques for radar absorbing materials. His professional career finally led him to the development of methods for industrial measurement technology and civil security. Dr. Nüßler led several research projects and became team and group leader. With the integration of the Fraunhofer FHR into the Fraunhofer-Gesellschaft, he established the business field Production. In 2017 Dr. Nüßler became head of the newly founded Department for Integrated Circuits and Sensor Systems.

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Dr. Nüßler, you head the Department of Integrated Circuits and Sensor Systems at Fraunhofer FHR. How did this specialization come about?

From 2005 on I started to become more interested in other applications of radar technology. The topic of material analysis has fascinated me from the beginning. With the integration of the Fraunhofer FHR into the Fraunhofer-Gesellschaft in 2009, the opportunity arose for me to further deepen the topic scientifically.

Which project are you currently working on and how can this be classified within the FMD framework?

Unfortunately, my work as a department head does not leave me much time for my own projects. But there are some topics that I try to push forward. These certainly include the heterointegration of SiGe and InP technologies. The development potential of high-frequency structures is one reason why we at Fraunhofer FHR have focused on the topic of additive manufacturing and are continuing to expand this within the framework of the FMD.

How has the cooperation in FMD changed your professional everyday life?

It broadened my view and showed me the potential of different technologies. When we develop solutions for our customers today, we always take a closer look at the technologies of the other FMD partners. I am firmly convinced that we can further expand and strengthen our competitiveness through the cooperation within FMD.

What other project in the FMD universe would you like to be involved in?

Within the FMD, we are currently trying to set up the topic of millimeter wave / THz line scan cameras for industrial applications. If this is successful, I would like to participate in this project in order to develop a solution suitable for industrial applications. Almost all member institutes have to contribute their special skills to this end. This project would probably be the biggest challenge of my professional career so far and my personal dream.

A look into the future: Which technology will continue to prevail?

I personally find the great technologies such as quantum computing or AI systems very fascinating, but I still find it difficult to assess their potential. But what I do see is that systems are becoming more and more intelligent and flexible. Front and back ends are moving closer together and in the future chips will be usable for a much wider range of applications.

Which personality – dead or alive – would you like to meet and why?

I would like to talk to the great inventors and theorists like Hertz, Maxwell, Tesla or Marconi. Some of them were far ahead of their time and have shaped our understanding of technology to this day. If you look at the resistance against which they partly created the basis for today's high-frequency technology – that is absolutely fascinating for me.

Is there that one book for you that should be read?

One? Thousands! eBook-Reader are the best invention of my time. I love books, especially when they're made of paper, but eBooks allow me to walk around with my entire library at all times. For a book fanatic like me, it's just the perfect device or software.

Whether as eBook or printed – Dr. Nüßler is a passionate reader. © MEV Verlag