

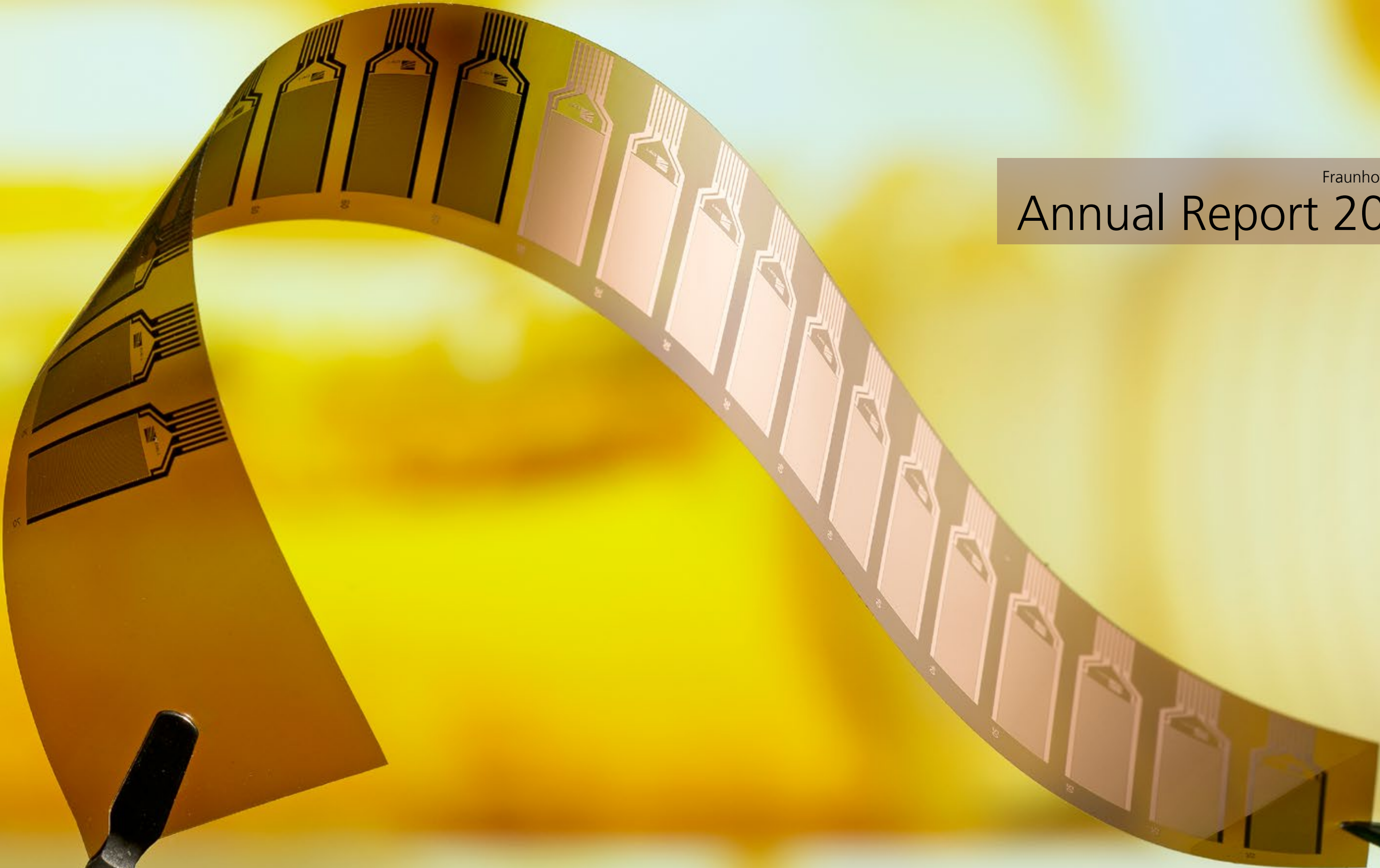


**Fraunhofer**  
EMFT

FRAUNHOFER RESEARCH INSTITUTION FOR MICROSYSTEMS AND SOLID STATE TECHNOLOGIES EMFT



**ANNUAL REPORT**  
**2019**



Fraunhofer EMFT

# Annual Report 2019





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## FOREWORD

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Dear friends and partners of the Fraunhofer Research Institution for Microsystems and Solid State Technologies EMFT, dear readers,

There can be no doubt that Artificial Intelligence (AI) is the buzzword of the year – and it certainly hasn't failed to leave its mark on Fraunhofer EMFT. Nowadays it's by no means rare to hear people say – with a touch of irony – that 'everyone is doing AI'. The underlying view here seems to be that AI is a self-contained subject discipline. I beg to differ here: as I see it, AI is highly interdisciplinary and covers a diverse range of technologies.

As a research institution with a focus on sensors and system integration, Fraunhofer EMFT has some fundamental points of contact with AI. It's very simple: without sensors, AI wouldn't exist. After all, it is the sensors that pick up the information from the analog world and feed it into the digital world. But in order to be able to pass on the correct information as required, the sensors themselves have to be intelligent. Sensor systems need to be able to analyze measurement data on site, distinguishing relevant from irrelevant data so as to avoid unnecessary cost and effort in the data transfer. This is where methods for evaluating the data such as Artificial Intelligence (AI) and machine learning come into play. Collaborative ventures with well-established industry clients are already underway in this area at the High Performance Center for Secure Intelligent Systems (LZSiS) that is currently being coordinated at Fraunhofer EMFT: together with vacuum pump manufacturer Edwards, for instance, a sensor setup has been built for improved characterization of the condition monitoring of vacuum pumps. In particular, research was carried

out into the correlation between process and pump response. Machine learning is used to detect abnormalities in the sensor data recorded.

So AI has become an exciting focus for us this year – and it fits very well into the internal change process we initiated at the beginning of 2019. One of our aims here is to align our broad and authoritative competence portfolio even more closely with the relevant applications. In doing so we pay particular attention to the interfaces between our departments. After all, it is precisely this kind of cross-technology collaboration that has the greatest potential in terms of being able to offer our customers comprehensive solutions. Our employees are crucial to the success of this change process, of course – and I am greatly impressed by the outstanding commitment and the wealth of ideas so many colleagues have contributed to making internal processes more effective and optimizing knowledge transfer. I should like to take this opportunity to express my thanks to our great staff!

I hope you are now curious enough to want to explore the pages that follow in more detail. As always, I will be grateful for your feedback and look forward to lots of fascinating discussions with you.

I wish you an enjoyable read!  
Best regards,

*Prof. Christoph Kutter*  
*Director of the Fraunhofer Institution for*  
*Microsystems and Solid State Technologies EMFT*

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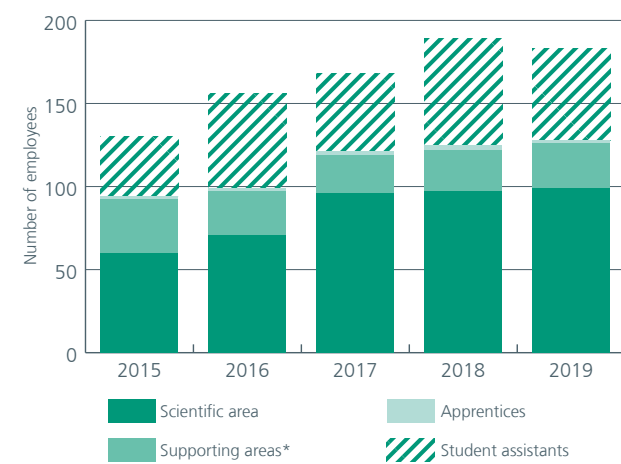
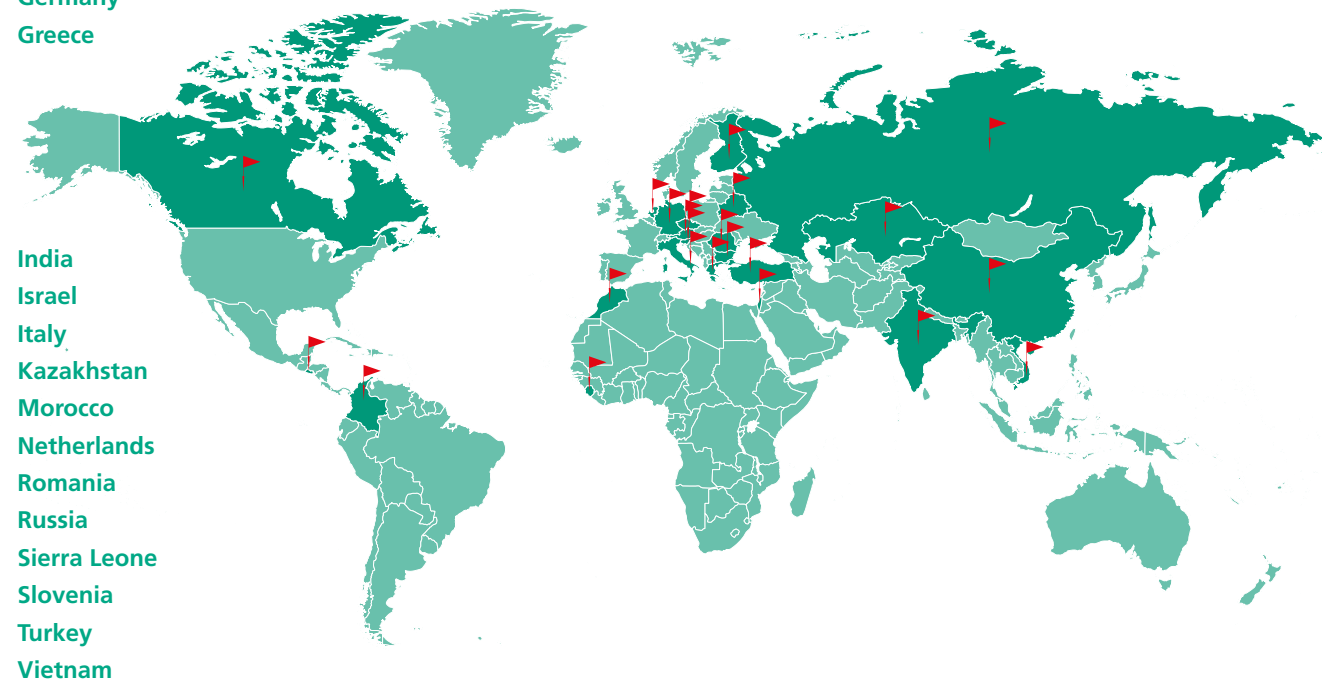
FRAUNHOFER EMFT



## PEOPLE, FACTS AND FIGURES

Austria  
Belarus  
Bulgaria  
Canada  
China  
Columbia  
Czech Republic  
El Salvador  
Finland  
Germany  
Greece

We at Fraunhofer EMFT stand for outstanding expertise from all over the world: our team comes from a total of 23 different countries – of which are naturally very proud. Together, we drive forward research and development of sensor systems and actuators for human beings and the environment. Our multicultural background is a key advantage, enabling us to look at scientific issues from a diverse range of perspectives. We make the most of this opportunity to inspire each other in terms of our mindset and our problem-solving strategies.



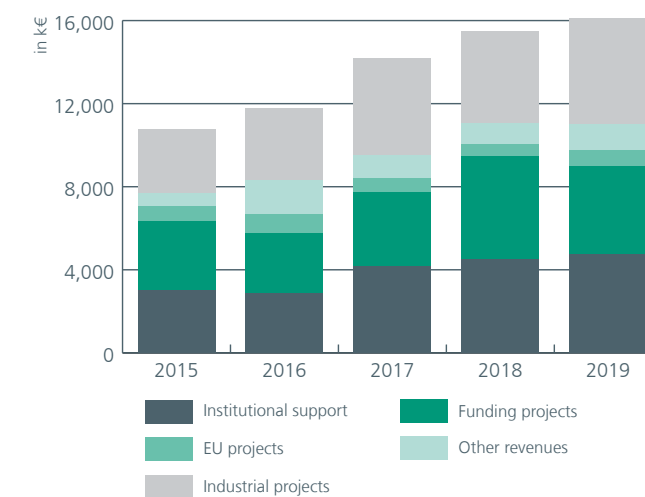
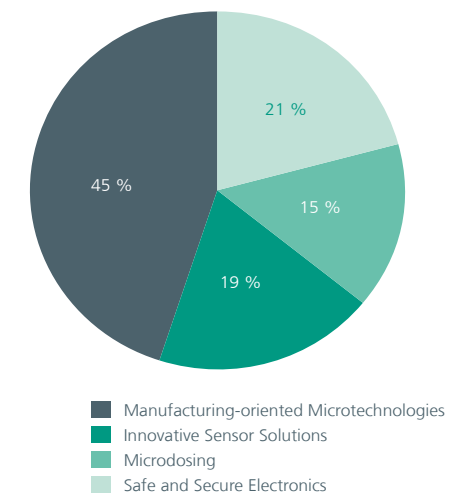
As compared to the previous year, the permanent staff at the institution increased by six people in 2019, with a total of 128 as of the end of the year: of these, 99 people are employed in the scientific area and 27 in support areas. The latter are made up of marketing, IT, administration, technology, quality management, organization and services. In addition, the Fraunhofer EMFT team is supplemented with two trainees.

Another 55 student assistants from a wide range of educational institutions were employed at Fraunhofer EMFT in the course of the year, writing their final thesis and/or working on Fraunhofer EMFT research topics.

\* Marketing, IT, Administration, Technology, Quality Management, Organization and Services



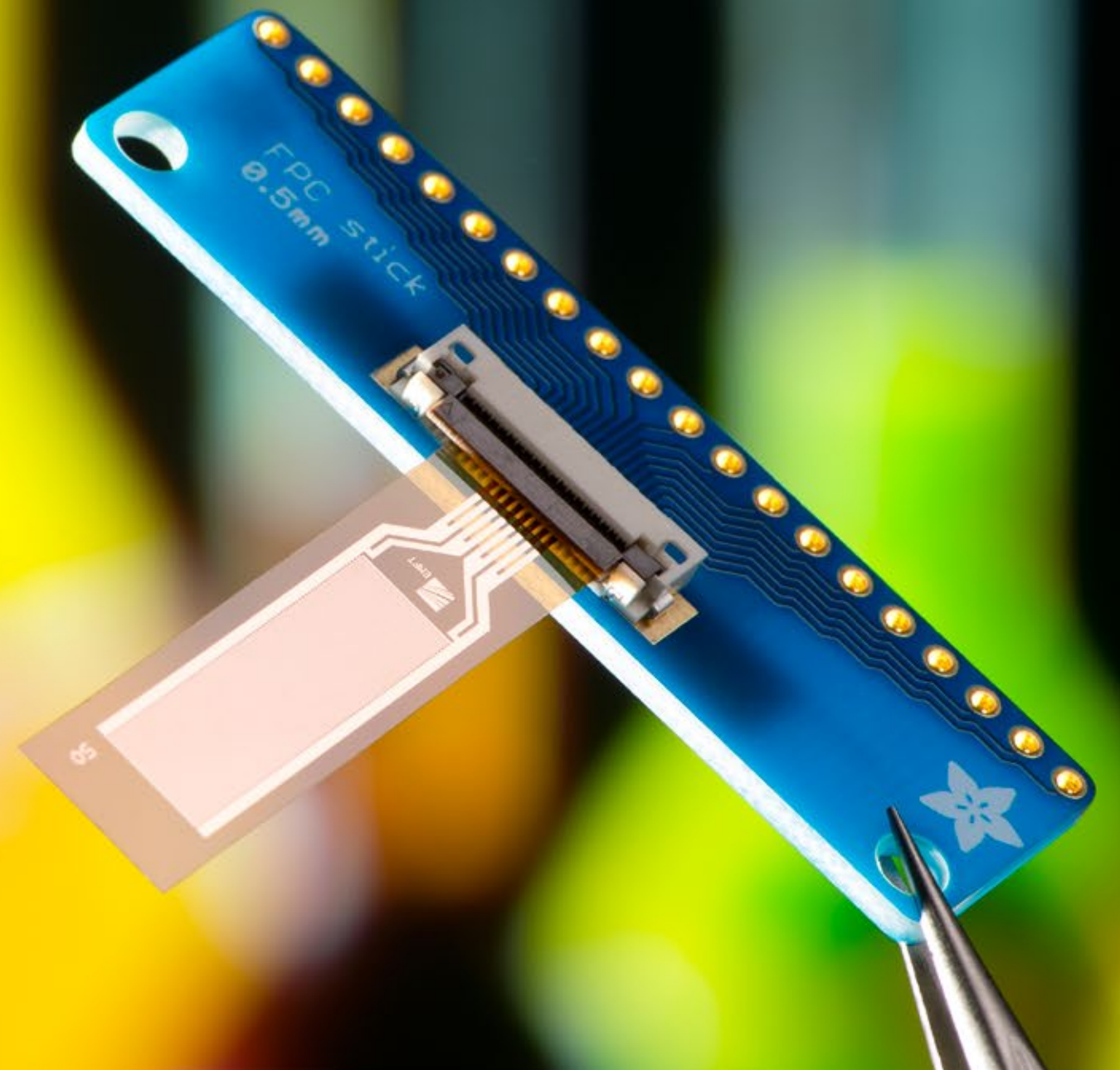
In 2019, the Fraunhofer EMFT team generated added value for society and the economy with a total of 110 projects. Most of the projects (45%) fall under the competence Manufacturing-oriented Microtechnologies, which forms the basis for the other Fraunhofer EMFT competences. The latest findings from semiconductor research are used for innovative sensor solutions, for instance, while advanced micropumps are developed for microdosing solutions in the silicon cleanroom and systems for safe electronics are realized in a roll-to-roll pilot line for flexible electronics. It is precisely the interdisciplinary interaction between these areas of expertise that enables Fraunhofer EMFT to produce forward-looking solutions.



Fraunhofer EMFT's total budget amounted to EUR 16.1 million in 2019, with industrial orders generating a total volume of approx. EUR 4.7 million. This is a 30.7% share of the operating budget.



AREAS OF EXPERTISE



*Capacitive sensor for integration in wound dressings*



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## INNOVATIVE SENSOR SOLUTIONS

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As the »sense organs of things«, sensors have a key role to play in future applications in the area of the Internet of Things (IoT). Yet while their potential uses are diverse, the demands made of these tiny electronic helpers in the various concrete applications are both highly complex and very specific. In many instances, standard solutions commonly available on the market are not able to meet this wide range of needs.

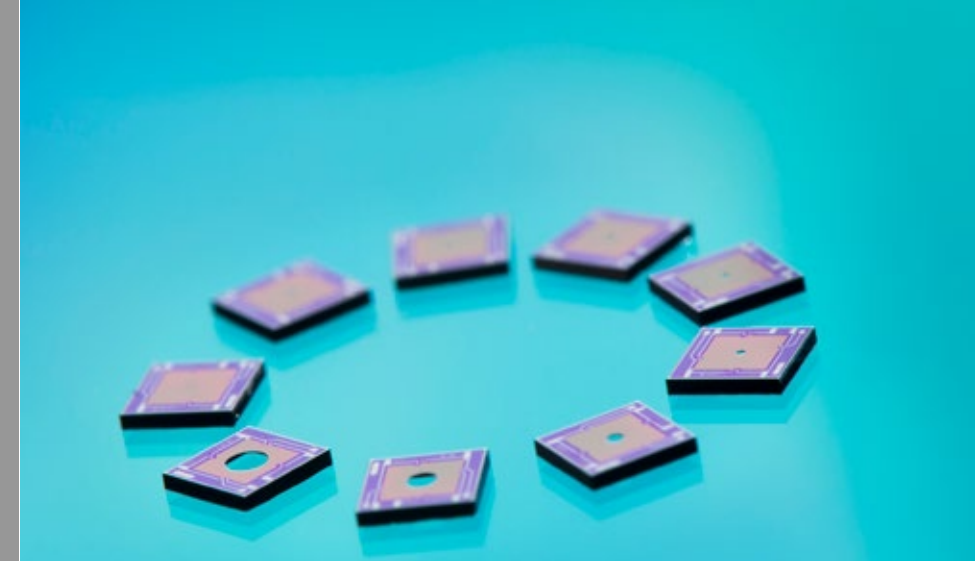
One research focus at Fraunhofer EMFT is innovative sensor solutions that can be individually tailored to our customers' needs and requirements. With their broad technological expertise, Fraunhofer EMFT scientists develop novel, high-performance sensors, design robust, secure and fast sensor networks and create system solutions that enable the sensors to interact perfectly with their environment. In this area, in-house developments are sometimes combined with existing solutions.

R&D focus areas at Fraunhofer EMFT:

- Energy-efficient sensors
- Sensors on flexible substrates
- Flow sensorics
- Chemical sensorics/gas sensorics
- Biosensorics
- Cell-based sensorics
- Characterization and validation
- Combined sensor systems

For more detailed information, see our website:

<https://www.emft.fraunhofer.de/en/competences/innovative-sensor-solutions.html>



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## MICRODOSING

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Precise dosage of gases and liquids to the nearest nanoliter is a central and longstanding area of expertise at Fraunhofer EMFT, covering a broad range of applications – from medical technology through to industrial applications and consumer electronics.

Piezo-electrically powered micropumps are at the heart of microdosing systems. The Fraunhofer EMFT team possesses extensive expertise and practical experience in the design of micropumps. On this basis, it is possible to adapt the technological parameters in terms of dosage precision, counter-pressure resistance, size, energy consumption, particle resistance, bubble tolerance and free-flow protection to the requirements in question.

Fraunhofer EMFT has designed a portfolio of silicon, stainless steel and titanium micropumps for various areas of use. One main focus of R&D activities in the area of silicon micropumps is further miniaturization. The aim here is to significantly reduce production costs, thereby facilitating access to the mass markets. The smallest silicon membrane pump currently available in the world, sized 3.5 x 3.5 x 0.6 mm<sup>3</sup>, was developed at Fraunhofer EMFT. A key focus just now in the area of metal micropumps is designing the pumps and valves. Here Fraunhofer EMFT cooperates closely with industry partners: the aim is for the latter to be able to manufacture the components themselves in high volumes subsequent to technology transfer.

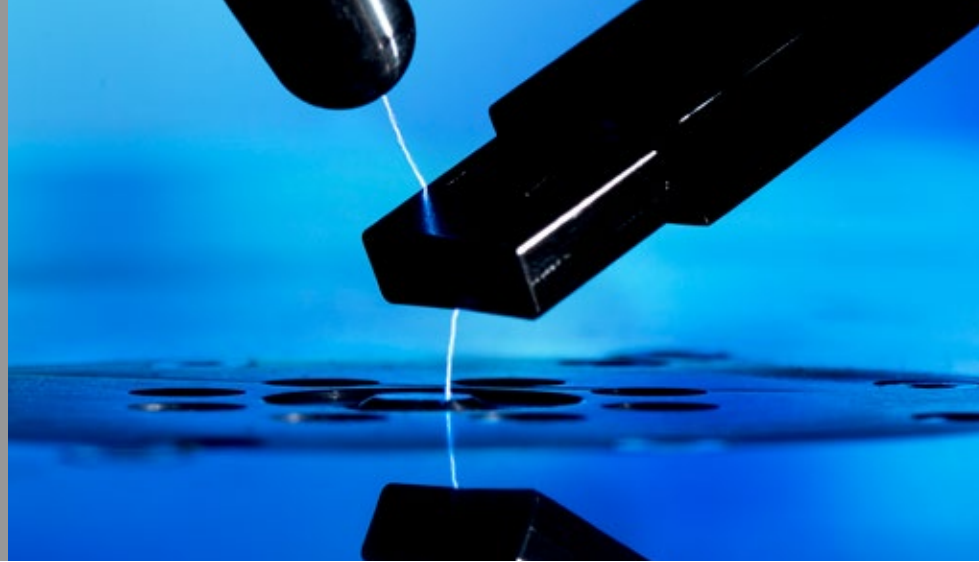
In addition to the micropumps themselves, the Fraunhofer EMFT R&D portfolio also includes a very diverse range of microdosing components in this research area, and the team possesses extensive system expertise, too. Microdosing as an interface technology requires a wide-ranging knowledge of such areas as fluid mechanics, elastomechanics, surface physics, chemistry and phase transformation. Understanding the causal relations between these various factors is essential in order to enable smooth interplay of all components in a microdosing system.

For more detailed information, see our website:

<https://www.emft.fraunhofer.de/en/competences/micro-dosing.html>



ESD system test with broadband measurement of the secondary discharge current



Detailed view of a foil system for temperature measurement during processing

## SAFE AND SECURE ELECTRONICS

Internet of Things, Industry 4.0, Big Data – there is no question that digitization has come to play a role in virtually all areas of our day-to-day lives. Safe and secure electronic systems are required as the »infrastructure« of this interconnected world. This area of expertise has various facets here.

Firstly, electronic systems have to be one hundred percent reliable in the sense of offering fail-safe operation in sensitive areas such as medical technology, the automotive industry and aerospace technology. In its R&D activities, Fraunhofer EMFT pursues the goal of enabling so-called zero-defect systems. Focus areas here include failure analyses and characterization of electronic modules and systems, development of novel ESD test and protection concepts and the monitoring of electrical connections using »intelligent« plugs.

The second aspect of »security« that is becoming increasingly important in the age of digitization is the protection of electronic systems from manipulation and unwanted access. Only when data security is guaranteed will Internet of Things applications become accepted by users on a wide scale. However, software-based solutions are often no longer sufficient to protect sensitive data in electronic systems, e.g. in the field of banking and smart grid/smart metering, or when handling patient data and operating critical infrastructures. Fraunhofer EMFT collaborates with partners and customers on novel protection concepts at hardware level, e.g. based on so-called Physical Unclonable Functions (PUF).

The third aspect of security refers to electronic systems being used to increase the safety of human beings, e.g. in occupational safety, medical applications or the area of Ambient Assisted Living. Fraunhofer EMFT solutions contribute to users' personal safety in the various application areas. In the field of medical technology, for example, the microdosing components and systems developed at Fraunhofer EMFT ensure that solutions for medication dosage function reliably. In the area of occupational safety, Fraunhofer EMFT's sensor solutions can be used to detect hazardous substances in the environment.

For more detailed information, see our website:  
<https://www.emft.fraunhofer.de/en/competences/safe-secure-electronics.html>

## MANUFACTURING-ORIENTED MICROTECHNOLOGIES

Fraunhofer EMFT is equipped with extensive cutting-edge technological facilities in the area of microelectronics and microtechnology that are maintained by experienced researchers and microtechnologists and used to develop customer-specific solutions. These production-oriented microtechnologies provide the basis for the other areas of expertise at Fraunhofer EMFT. Expertise in this area include the following:

**Technology and process analytics:** In the area of technology and process analytics, Fraunhofer EMFT offers an industry-compatible technology platform for testing new process media and optimizing selected process stages, thereby increasing performance and efficiency, for example.

**Development of electrical and optical components:** The optical and electric components developed at Fraunhofer EMFT include complex fluorescence modules, conventional PIN photodiodes, sensitive silicon photomultipliers for individual photo detection and extremely low-noise transistors – something that is unique to Fraunhofer EMFT.

**Foil electronics:** Flexible electronics offers new possibilities for a wide range of »smart« high-performance products. In-house roll-to-roll production systems enable low-cost processing of foils and other flexible substrates to develop bendable, flat and large-area electronic systems. Here, heterointegration of silicon and foil technology has a key technological role to play.

**Thin silicon:** Extremely thin silicon chips are required for heterogeneous 3D integration and chip-in-foil packages. A fundamental requirement here is the technological expertise to produce thin wafers. The Munich site is excellently equipped for the complex processes required for thinning, so the devices produced at wafer level can be as thin as needed.

**IC design:** Very specific applications, the capacity to tap into new functions and areas of use, increased miniaturization, enhanced energy efficiency, low manufacturing costs and greater reliability often require new IC designs that are not available on the market in this form. Here, Fraunhofer EMFT supports its customers in designing complex analog and mixed-signal circuits, focused on novel sensoric concepts and millimeter wave design.

**System integration:** By means of demonstrators, prototypes and systems, Fraunhofer EMFT scientists are able to illustrate potential application scenarios for the technologies and components developed at the institution. For customers, this development expertise is an essential part of the Fraunhofer EMFT service portfolio.

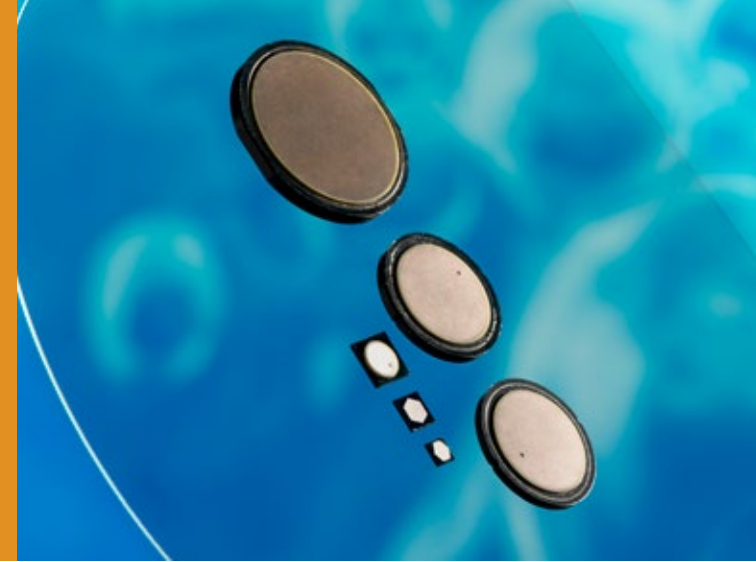
For more detailed information, see our website:  
<https://www.emft.fraunhofer.de/en/competences/manufacturing-oriented-microtechnologies.html>





EXAMPLES OF PROJECTS AND APPLICATIONS





Fraunhofer EMFT pump family (silicon, metal and titanium)

## FRAUNHOFER EMFT FIELDS OF RESEARCH



### Health and Environment

In addition to medical care, nutrition and the environment are crucial factors that impact on human health: these give rise to the most important goals of current Fraunhofer research in the field of environmental and life sciences.



### Security and Protection

The aim of the safety researchers inside and outside the institute is to protect people and the environment as far as possible from hazards. In doing so, they pursue a sustainable approach in order to gain control of all phases of a disaster: the focus is on early detection, prevention, direct protection and the capacity to swiftly overcome the consequences of an incident.



### Mobility and Transport

Mobility of people and goods has become indispensable to the economy and society at large, and it consistently confronts science with fresh challenges – from vehicle development to traffic management, from new safety requirements to efficient transport logistics. Fraunhofer researchers work to make mobility safer, more efficient and more cost-effective.



### Production and Supply of Services

Scarcity of raw materials, the pressure of competition and the shortage of skilled specialists are just some of the many challenges that manufacturing industry has to face. Researchers work to create energy-efficient and resource-friendly processes for the production of the future.



### Communication and Knowledge

As a cross-sectional topic, ICT covers almost all other research fields and sectors – from medicine through to media and manufacturing. Digital technologies open up a whole new range of possibilities for communication. Personalized, interactive and mobile learning methods get us into shape for the future world of work.

## HEALTH AND ENVIRONMENT

### Active implants – reliable and powerful

From drug dosage to artificial sphincters: in the future, micropumps could be used as active implants for a wide range of medical applications. At the High Performance Center for Secure Intelligent Systems (LZSiS), researchers working on the “Active Implants” project are evaluating the risks involved in using micropumps as medical implants. The various applications require very varied pump specifications, but what they all have in common is their extremely rigorous safety requirements.

“Active Implants” focuses on two fundamental safety-related issues. Firstly, interaction between the pump and the medium being supplied (e.g. medication) is investigated in order to ensure long-term dosing stability without micropump failure. Secondly, scientists are investigating the possibility of reducing the pump’s operating voltage. At present it is several hundred volts, which is a very high level. For this purpose, tests are carried out to see whether the actuator – currently a single-layer piezoceramic – can be replaced by a multi-layer drive. This multi-layer technology could potentially enable a substantial reduction of the voltage required to operate the pump. This would make it easier to achieve reliable insulation.

### A highly precise and automated assay for the analysis of wound healing *in vitro*

Coordinated cell migration has a key role to play in physiological and also pathological processes. The most important form of pathological migration is probably that of metastasizing tumor cells. Consequently, a detailed understanding of cell migration, its regulatory mechanisms and potential influencing strategies is of crucial importance in both basic and applied research.

Cell migration is mainly studied in a controlled laboratory environment on cultivated cell models (*in vitro*) using so-called wound healing assays, where the migration of a cell population is observed along its growth substrate, normally microscopically. For this purpose it is necessary to experimentally introduce a defined wound into a continuous cell layer into which the cells from the periphery of the wound can migrate. The existing, established assays are functional but can only be automated to a very limited extent and cannot be run at a high level of throughput. In addition, the reproducibility of the wound applied – often crucial to the reproducibility of the entire assay – has not yet been satisfactorily solved.







Cell and tissue samples in the 37 °C incubator

The project OptoMigration adopts a new approach to the study of cell migration: the focus here is on a composite, polymer-based material that is used for the high-precision optical wounding of cells cultivated on it. A thin, light-sensitive yet biocompatible coating is applied to an inert, transparent carrier material. When exposed to visible light, the light-sensitive layer generates a toxic chemical species that locally kills cells growing on the surface of the substrate. The range of the toxic species is set so that only the cells directly above the site of origin are diffusively reached and killed. The cells then grow from the periphery of the wound into the cleared space, a process that is documented microscopically. The contactless introduction of a defined wound to a cell layer provides the basis for a wound healing migration assay with a high degree of automation and parallelization. In particular, the anticipated precision of the wound introduced and its independence from the influence of the person conducting the experiment will significantly improve the reproducibility of this assay, making automation possible in the first place.

The project is being run jointly with ibidi GmbH and is funded by the Federal Ministry of Education and Research (BMBF) under the funding initiative KMUinnovativ, funding reference 13XP5074B.

### A plaster that gets “under your skin”

“Intelligent plasters” can already do more than just cover up wounds: equipped with the necessary sensors, they are able to monitor body parameters such as temperature, moisture, pH, oxygen saturation and electrical potential. But what goes on beneath the surface of the skin is a closed book to most of the sensor plasters available nowadays.

In the EU project ULIMPIA, Fraunhofer EMFT is collaborating with 17 partners from six countries on a plaster that is also capable of detecting physical processes deep inside the body – even measuring blood pressure or monitoring the bladder. For this purpose, the researchers combine state-of-the-art MEMS ultrasound technology with innovation in compliant patch technology. The aim is to create an open technology platform for diagnostic ultrasound patches.

As part of this project, Fraunhofer EMFT is developing a packaging technology to integrate several sensors and also ultrasound actuators on a foil and textile base. Among other things, the aim is to create a skin-friendly, flexible sensor plaster with the necessary microelectronics components for data logging and transfer. The platform will be accessible to various users and focus on the development of concrete applications.

The project is being funded under the EU PENTA program, funding reference 16ES0815.

### Fabric kit with integrated sensor system

When it comes to developing new pharmaceuticals and assessing biological, chemical or physical risks, 3D fabric models cultivated in the laboratory are becoming increasingly important as compared to the much less realistic 2D cell layers that have mostly been used up until now. In addition to biological fabric models, whose development is already well advanced, there is a demand for analysis methods enabling quantitative measurement of the reaction of the cells to external stimuli. However, the sensory technologies used to read out information from the inside of a tissue in a non-invasive manner have not kept pace with the rapid biological developments. Existing examination methods are invasive or require the tissue model to be dissected (endpoint analysis) in order to obtain data. Continuous, label-free monitoring which includes cells deeper inside the tissue has not yet been established.

The project TissueSense is pursuing a fundamentally new idea: instead of installing sensor functions (electrodes, nano probes) in the model fabric subsequently or dismantling them after a predefined exposure period for the purpose of analysis, the 3D fabric model is made of individual layers based on a kind of modular principle. The cultivation of the individual fabric layers is initially carried out in 2D by means of cell monolayers on thin, porous polymer carriers with integrated signal converters. The fabric layers are then assembled in layers made of up of these 2D constructs. The porosity of the polymer carriers ensures that the individual cell layers come into contact with each other and can exchange substances after being assembled into a 3D construct. By fitting the polymer carriers with signal converters, it is possible to obtain chemical or physical information from each individual cell layer of the 3D fabric model and transfer it in real time. When screening substance libraries on individually tailored organ models in particular, this opens up a whole new range of perspectives in terms of the quality of the biomedical information available as well as from the point for view of economy and testing capacity.

The project is funded under the internal Fraunhofer program Discover.

### Hygiene check

Multi-drug-resistant Gram-negative rod-shaped bacteria (MRGN) have become increasingly widespread in recent years as a cause of nosocomial infections worldwide. Antibiotics used as a standard therapy are largely ineffective in the case of MRGN infections. This is why infections with multi-drug-resistant pathogens have to be identified very early on in order to initiate the right therapy with one of the few reserve antibiotics still available as soon as possible. MRGN bacteria can also survive on inanimate surfaces and spread via contaminated objects. Early





Gas measuring station for the characterization of sensors  
(stainless steel chamber)

detection is important so as to be able to take special hygienic measures and prevent these problematic pathogens from spreading.

A Fraunhofer EMFT research team is collaborating with the SME GBN Systems GmbH, the Institute of Microbiology and Hygiene at Regensburg University Hospital and Asklepios Kliniken GmbH to develop a compact, comprehensive system that will enable rapid on-site detection of MRGN bacteria. The detection system is to be fluorescence-based and capable of being carried out on the sample material without elaborate sample preparation. Smears from potentially contaminated surfaces and objects serve as test material, in addition to human samples. By using a highly sensitive measuring system combined with a fluorescence-based detection reaction, the aim is to achieve an enormous reduction in time between sample collection and test result. Unlike conventional, time-consuming methods using microbiological cultures, rapid on-site detection will provide feedback on the existence of MRGN bacteria in the sample material within a short period of time. In contrast to PCR-based methods, this phenotypic detection will be independent of the genetic variability of the MRGN bacteria, also allowing the pathogens to be detected where PCR-based methods would not be capable of identification. This constitutes a major step forward as compared to the methods currently in use.

This project is funded by the Bavarian Research Foundation (BFS).

#### Integrated optical gas sensors for VOCs

The joint project "Integrated-optical detection of volatile organic compounds using functional polymer coatings (COLODOR)" coordinated by the Austrian Institute of Technology GmbH AIT addresses the need for compact measuring systems for so-called "volatile organic compounds" (VOCs). This is to be achieved by researching a novel optical multi-parameter gas sensor concept using polymers doped with indicator dyes. Quantitative detection of such compounds is of enormous importance in a broad range of applications.

VOCs have key role to play in the food industry in particular. Detection of VOCs during food preparation in combination with the appropriate optimization of the boiling and cooking processes can help avoid the formation of toxic organic products, thereby generally reducing the fat content in food. For this purpose, the VOC measurement systems being developed by the project are to be integrated in food preparation equipment for end consumers.

In addition to its high level of integration, the proposed COLODOR concept allows operation at room temperature with low power consumption, thereby ensuring compatibility with

cost-effective mass production technologies. COLODOR taps into the potential offered by VOC measurement by exploring dye-doped polymers for optical multi-parameter gas sensors. For this purpose, the aim is to investigate novel sensor materials and their local deposition on sensor chips, create compact optical gas sensor chips and demonstrate the function of the new optical VOC measurement principle.

Since three industrial companies are involved – specializing in photonic components, local functionalization and kitchen appliances – the entire value-added chain is covered, so it will be possible to fully exploit the findings at a later stage. The project is funded by the Federal Ministry of Education and Research BMBF under the funding initiative M-ERA.NET 2015, funding reference 13N14242.

#### Intelligent food packaging

Consumers can rarely assess exactly how fresh a food product is with the naked eye. Yet foods with a high degree of freshness such as raw meat and fish products are highly susceptible to microbial decomposition processes.

Since it is very difficult to monitor the freshness of packaged products, Fraunhofer EMFT is collaborating with Fraunhofer IVV and industry partners on the project FRESH to develop a packaging foil which displays the degree of food freshness using color indication. Here, development involves integrating chemical sensor materials in food packaging that are based on color change, enabling reliable determination of a product's quality at a single glance. The integrated sensors respond specifically to gases released when the products perish, triggering an obvious color reaction when a certain threshold is exceeded.

In future, the development of intelligent food packaging will have a very positive general impact: not only is it capable of increasing product safety, it can also contribute to the reduction of food waste at the end of the supply chain. This is because the sensor packaging will reliably detect real-time information relating to the edibility of a food product.

In collaboration with the partners EVONIK Resource Efficiency GmbH, Wipak Walsrode GmbH, Siegwirk Druckfarben AG & Co. KGaA, Albis Plastic GmbH and MuWe Fleischhandels GmbH, the project is well on the way to increasing sustainability in the food industry. The project is funded by the Federal Ministry of Food and Agriculture (BMEL), funding reference 281 A100116.

Gefördert durch:  
  
 aufgrund eines Beschlusses  
 des Deutschen Bundestages





Fraunhofer EMFT researcher working with cell samples

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### MRSA Rapid Test

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Multi-resistant pathogens such as MRSA (multi-resistant *Staphylococcus aureus*) can spread rapidly and become a serious health hazard for already weakened persons, for example in hospitals and nursing homes. Since the methods for detecting MRSA are either very time-consuming (microbiological cultural detection) or very cost-intensive (molecular biological or antibody-based detection), most countries currently do not carry out general initial screening of all patients on admission to hospital.

A research team at Fraunhofer EMFT collaborated with Asklepios Kliniken GmbH and the SME KETEK GmbH to develop a low-cost MRSA Rapid Test which could be used as a potential target application for routine admission checks at hospitals or doctors' surgeries. Early detection of an MRSA infection or colonization and application of the relevant treatment will significantly reduce the risk of transmission of the pathogens to other patients. The rapid test simply requires a nose smear to be taken from the patient. Whether or not MRSA is contained in the sample can be established quickly by using fluorescence indicators with a highly sensitive detection system.

The innovative test for detecting resistant bacteria was set up as a comprehensive system for on-site analytics on a laboratory scale. A study was conducted to test the procedure in a hospital environment and it has been continuously adapted to real-life conditions.

The project was funded by the Bavarian Ministry of Economic Affairs, State Development and Energy as part of the "Microsystems Technology Bavaria" program, funding reference MST-1308-001/BAY 189/001.

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### New method in the fight against viruses

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Testing the effectiveness and efficiency of vaccines is of great importance in terms of providing broad protection for the population against viral infectious diseases. The efficacy of a vaccine is typically tested in the laboratory on cultured cells, analyzing response to a viral infection in the presence of the blood serum of a person who has been vaccinated beforehand. If the vaccination was successful, the serum will contain neutralizing antibodies against the viruses and the virus contact has no consequences. If the vaccination was not effective however, the antibody titers in the serum of the vaccinated individual are not sufficient to completely intercept the viral load and the cells used for the test become infected. So suppression of the cellular viral infection by the neutralizing antibodies is the measure of how effective a vaccine is. The tests

carried out to date for this purpose are currently labor-intensive and cost-intensive: given the enormous number of tests required, this is a limiting factor in terms of vaccine development.

In the ViroSens project, scientists from the Fraunhofer Institute for Biomedical Engineering (IBMT) in Sulzbach/Saar and Fraunhofer EMFT in Regensburg are collaborating with nanoAnalytics GmbH (Münster) and innoMe GmbH (Espelkamp) on a completely new completely new process for measuring antiviral neutralizing antibodies. The aim is to have the test cells grow on multi-electrode arrays that allow fully automated detection of the state of infection using electrochemical measurement methods. This will not only eliminate the time-consuming steps involved in conventional testing, it will also enable the cells to be monitored continuously instead of analyzing them at a specific time only. As well as complete automation of the analysis, the method will also yield additional insights into cell reaction over time. The consortium has set itself the goal of looking into setting up a complete system comprising the hardware, analysis software and electrode arrays required for cell observation, and implementing this in laboratory set-ups that pave the way for a later market launch.

The project is funded by the German Federal Ministry of Education and Research (BMBF) under the KMUinnovativ program, funding reference 13XP5085C.

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### Smart catheter for cell-based heart attack therapy

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About 10% of the population of the western world have to undergo angioplasty surgery at some time, due to cardiac arrhythmia or for a heart valve replacement. These minimally invasive procedures on the heart are supported by numerous intelligent imaging and sensor catheters acting as the surgeon's "eyes and ears". Despite the fact that these intelligent instruments are absolutely indispensable and indeed life-saving, there have been very few innovations in the recent years due to the frequently small production volumes. As a result, the level of demand among hospitals for instruments with improved functionality is very high. The project Position-II offers a unique solution to this problem.

A consortium of 45 partners from 12 countries has set up an open technology platform for miniaturization, in-tip AD conversion, wireless communication, MEMS converter technology and encapsulation. The platform has the advantage that it is open to multiple users. This makes it possible to improve the performance of "smart" catheters at a low cost, thereby enabling the development of entirely new minimally invasive instruments. As part of this project, Fraunhofer EMFT scientists are working on a catheter that transports stem cells to dead myocardial tissue. For this purpose, an appropriate dosing unit has to be found which pumps the cells through





Monitoring of concealed solder connections  
(BGA, PGA, QFN)

the catheter to the heart, without the pressure in the heart and the additional fluidic counter-pressure impairing the accuracy of the dosage.

The project is funded by the ECSEL Joint Undertaking, funding reference Ecsel-783132-Position-II-2017-IA.

## SECURITY AND PROTECTION



### Reliable detection of hardware trojans

In the BMBF-funded project SyPASS (funding reference 16KIS0669), Infineon AG, Raith GmbH and Fraunhofer EMFT are collaborating to develop methods for the retrograde preparation of highly integrated safety circuits up to 40 nm so as to recover layout information. Comparison with design data is to ensure reliable detection of Hardware Trojans. The particular challenges confronting this project are the structures and layer thicknesses of less than 10 nm in the preparation, the stability of the mapping using scanning electron microscopy and finally the synthesis and analysis of huge quantities of data.

In view of the more and more rigorous requirements arising from increased integration density, the BMBF project RESEC (funding reference 16KIS1008) – in the same consortium, with the addition of the Technical University of Munich – also develops methods and systems for the physical analysis of components from technologies below 40 nm and of hetero-integrated modules using Artificial Intelligence, continuing analysis down to the circuit level. The BSI has also certified a laboratory according to Common Criteria EAL6 for the physical analysis of security modules. These services are also offered at the High Performance Center for Secure Intelligent Systems (LZSiS).

### Accelerated model for mechanically caused material damage

In the field of drive systems, press-fit technology is an important alternative to other electrical contacting methods such as solder, screw or crimp connections. The benefits are minimal space requirements, repair capacity and a failure rate which is potentially between ten and hundred times lower. Due to the force applied during press-in, a gas-tight and corrosion-resistant

contact zone is formed between the press-in contact and the printed circuit board after about 24 hours. Inside this zone, the free electrons generate attraction forces that connect the two metal surfaces. In this way, a cold weld zone is formed within a few hours.

However, the process can also involve unintentional damage to the component. For example, microrelative movements between the press-fit contact and the copper sleeve in the circuit board, induced by vibrations, can result in fatigue damage or fatigue failure of the cold weld zone. The cold weld zone then disengages as a result of crack formation and crack growth. As part of the Raffmo II project, researchers at Fraunhofer EMFT are working on a suitable accelerated model to obtain a better understanding of how these undesirable effects occur.

The Fraunhofer EMFT team has a test bench to study the microrelative movements described above. The Munich experts also undertake precise electric characterizations of the contact resistance of the cold weld zone.

The project is funded by AiF Forschungsnetzwerk Mittelstand, funding reference IGF Project No. 19462 N, FVA-Nr. 618 II.

### Securely networked sensors in the healthcare sector

Medical progress in recent decades has significantly reduced the mortality rate while at the same time improving healthcare worldwide on a lasting basis. But the other side of the coin is the enormous increase in cost in healthcare and social systems. To illustrate this point: about 30% of the population in the European Union (EU) will be over 65 by 2030; two out of three people at retirement age will have at least two chronic diseases.

The Internet of Things (IoT) offers huge potential in terms of relieving the burden on social systems while enabling contemporary, high-quality healthcare – from diagnostics and patient safety through to optimized logistics processes. A total of 21 European partners are involved in the project SERENE IoT, which aims to lay the basic foundations for IoT applications in healthcare.

In this project, the German consortium under the coordination of Fraunhofer EMFT is developing an IoT-capable mobile analysis device to detect multi-resistant *Staphylococcus aureus* (MRSA). The detection method (developed in the project MRE Test, funded by the Bavarian Ministry of Economic Affairs and Media, Energy and Technology as part of the Mikrosystemtechnik Bayern program, funding reference MST-1308-0001//BAY189/001) is to



Secured and networked on-site MRSA detector

be transferred to an overall system with connectivity capability which can run on batteries. The basis is provided by new application-specific memory chips with a very low level of energy consumption.

The research project is focusing on the development of a secure software architecture for IoT networking of medical devices and the secure transfer of confidential data. The concept of IoT-networked medical devices is being tested nationally using various demonstrators (mobile MRSA detector, device to detect postoperative infections, food pump, fall detector to identify and prevent falls) by the hospital of Ludwig Maximilian University, Munich.

The project SERENE IoT receives funding from the EUREKA cluster PENTA; 67% of this amount is provided by the Federal Ministry of Education and Research (BMBF).

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#### Test development for ESD safety: controlled lightning

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Electrostatic discharges pose a threat to highly integrated circuits even if they only last a split second. In a US-funded project, researchers at Fraunhofer EMFT were able to show on Cisco Gbit modules that it is determined in a matter of picoseconds whether a telecommunications module will suffer damage even at lower currents. The requirement here was a test set-up for particularly fast, precisely reproducible high-current pulses in conjunction with methods for automatic correction of measurement errors.

The results are to be incorporated in the international standardization of the test method "Capacitively Coupled Transmission Line Pulsing CC-TLP".

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## MOBILITY AND TRANSPORT

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### Failsafe electronics for autonomous driving

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Autonomous driving is an integral part of virtually all future mobility concepts. Since human intervention is not intended in the context of fully automated driving, the relevant sensors and electronic systems have to meet the very highest demands in terms of reliability: the system has to be able to respond to unforeseen events as well as remaining stable in the case of error or functional impairment – as caused by incorrect, delayed or missing information, if a component fails or if the energy supply is lost, for example.

Theoretically, all electronic components could be provided in duplicate: if one component were to fail, an identical one would be available to take its place. However, this solution is neither economically nor technically feasible since it would take up too much installation space inside the car.

Researchers at Fraunhofer EMFT have joined forces with several industry partners to develop a clever alternative with the project AutoKonf: a redundant, generic control unit. If the control device for the steering or brakes fails, the redundant generic control unit takes over the function in question and is able to control the car safely. In order to ensure that the redundant control unit can perform the tasks of both steering and brake control, the project has focused on developing electronic systems which allow dynamic alteration of the signal distribution and power supply, for example.

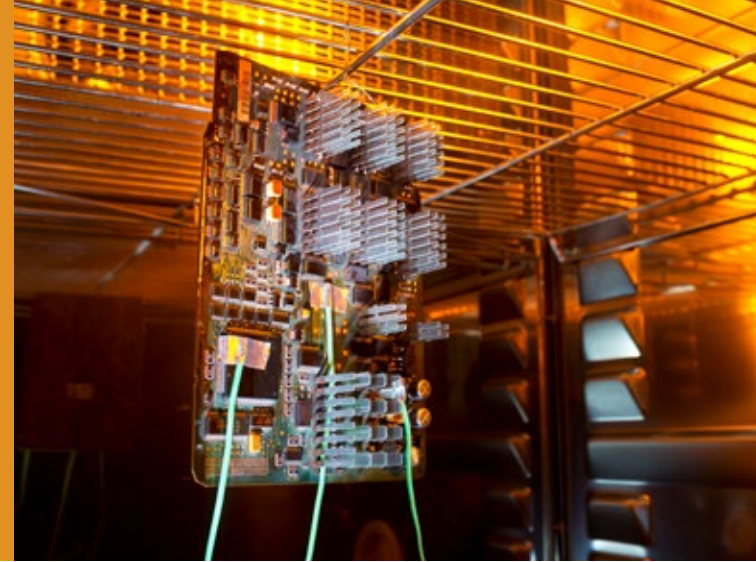
The Fraunhofer EMFT team is looking into the integration of switching capability in plugs and interface modules. Among other things, classic switch matrices and novel techniques are investigated which work within a very small installation space, in particular with regard to reliability. For this purpose, a thermal design is being developed for the necessary assembly and interconnection technology.

By the end of the project, the aim is to develop the effectiveness of the concept in defined test and failure cases: an error is injected into the new system while the stability control is active. Using a vehicle test bench, the project partner and coordinator Intedis will then verify whether and to what extent vehicle stability is still maintained.

The project is being funded by the Federal Ministry of Education and Research (BMBF); subsidy from the Business Plan of the Energy and Climate Fund (EKF), funding reference no.: 16EM00187).







Climatic test of an electronic module

### High-performance components for autonomous traffic

Self-driving cars are one of the key mobility concepts of the future; but urban air traffic also has numerous autonomous applications, including air taxis or drones for the dispatch of time-critical goods and medicines. These require environmental sensors such as cameras, LiDAR or radar systems to capture the vehicle environment. Microprocessors are equally important to convert the acquired data into control commands such as steering and braking.

In the EU research project Ocean12, a Fraunhofer EMFT team is working on future-proof components for autonomous road and air vehicles. In order to ensure these components operate at maximum reliability and energy-efficiency, the researchers are using a manufacturing approach based on FD-SOI technology (Fully Depleted Silicon On Insulator). This involves insertion of an additional wafer-thin insulation layer in the chip so as to reduce the so-called leakage current. As a result, power consumption is reduced by up to 90% while computing speed is enhanced. Furthermore, this technology enables the design of highly compact sensor systems, since sensors with high-performance integrated evaluation circuits can be integrated on a so-called SoC (System on Chip).

A total of 27 European partners from industry and research are contributing their expertise in semiconductor technology, electronics, aerospace and automotive engineering to the project – including Fraunhofer EMFT, Fraunhofer Institute for Integrated Circuits IIS and Fraunhofer Institute for Photonic Microsystems IPMS.

The project runs until 2021 and is funded by the European Union, the Federal Ministry of Education and Research (BMBF) and the state of Saxony, among others.

## PRODUCTION AND SUPPLY OF SERVICES

### European pilot line for multifunctional electronic systems

Europe – and especially Germany – have particular strengths in microelectronics in the areas of automotive, energy, security and industry. In the EU project EuroPAT-MASIP, partners from nine countries are pooling their expertise to lay strategic foundations for the development of innovative and complex electronic systems. The aim here is to secure and significantly increase the competitiveness of Europe's microelectronics industry at the global level. The German consortium is focusing on multifunctional electronic systems, energy-saving power electronics, design of complex systems and innovative production technologies.

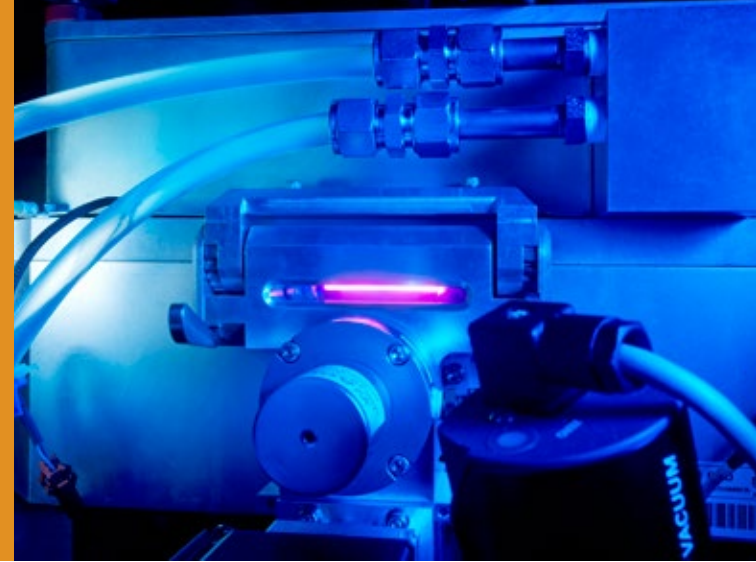
As part of this project, Fraunhofer EMFT is showing how it is possible to performing pick & place processes with self-assembly. For this purpose, the researchers are adapting the wetting properties of surfaces by means of low-pressure plasma: metal surfaces become hydrophilic, while the surrounding areas made of polyimide become hydrophobic. In the production process, the chips are then adjusted to the (metallic) target areas by means of a liquid.

The project is funded by the EU under funding reference 737497 as part of the ECSEL initiative, and by the BMBF under funding reference 16ESE02605.

### Large-area conductor path patterns in a roll-to-roll method

In the LEO project (platform technology for the resource-friendly production of conductor paths on large-area surfaces fitted with electronics), Fraunhofer ISE and Fraunhofer EMFT combine their expertise in fine-line metallization and roll-to-roll processing as well as thin-chip integration in foils. The new process aims to enable the production of very large-area conductor path patterns and simplify the integration of electronic components. Based on the selective structuring of a thin aluminum/copper/polymer layer sequence by means of printing or laser processes and subsequent electroplated copper deposition, the process has the potential to make even traditional processes of printed circuit board manufacture more cost-effective and at the same time more environment-friendly and resource-saving in the medium term.





*PECVD cleaning plasma with environment-friendly and CFC-free fluorine chemistry – Solvaclean@N*

Using an initial PCB design, the newly developed process sequence has made it possible to produce thin, galvanically reinforced conductor paths on 50 µm foil substrates. In coordination with an advisory committee made up of leading representatives of the electronics and electroplating industry, the process sequence is to be stabilized and converted into a cost-effective roll-to-roll process. The aim is also to demonstrate that the process is suitable for production of ultra-thin chip packages that do not require conventional wire bonds. The project is being funded under the internal Fraunhofer program WISA.

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#### **Environment-friendly cleaning gas for the semiconductor industry**

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Many plasma coating systems used in the semiconductor industry have to undergo thorough cleaning on a regular basis after each stage of production. Currently this is mainly carried out using perfluorinated compounds (PFCs) and nitrogen trifluoride (NF<sub>3</sub>) gases, which are up to 17,000 times as damaging to the environment and climate as the greenhouse gas CO<sub>2</sub>.

Solvay, Texas Instruments, Muegge and Fraunhofer EMFT are working on the project ecoFluor to develop an environment-friendly alternative which only has the greenhouse potential of CO<sub>2</sub>: the gas mixture used by the cooperation partners – Solvaclean®, consisting of fluorine, nitrogen and argon – dispenses entirely with the highly environmentally harmful gases PFCs and NF<sub>3</sub>. The project is funded partially under the BMBF program “r+Impuls – Innovative technologies for resource efficiency – Impulses for industrial resource efficiency”, which in turn is embedded in the framework program “Research for Sustainability” (FONA).

In the first year of the project, Fraunhofer EMFT was mainly responsible for optimizing the new gas mixture in terms of etching rate, process stability and particle contamination. In the second year, the process was transferred to Texas Instruments in Freising. A mix ratio of 30% fluorine in nitrogen and argon was established as the best known method. Texas Instruments set up the relevant gas supply and tested the Solvaclean fluorine gas mixture (Solvaclean@N) in production systems. The result was a slightly improved cleaning performance and a reduction in the time required as compared to the standard process using NF<sub>3</sub>.

A pilot production test on an Applied Materials Producer system with more than 70,000 processed wafers – and therefore approx. 70,000 cleaning cycles – showed that the cleaning processes using the Solvaclean@N fluorine gas mixture achieved the same particle levels as with the standard Ar/NF<sub>3</sub> method. The first components containing PECVD-based SiO<sub>2</sub> layers produced using environment-friendly cleaning chemicals have already been supplied to the

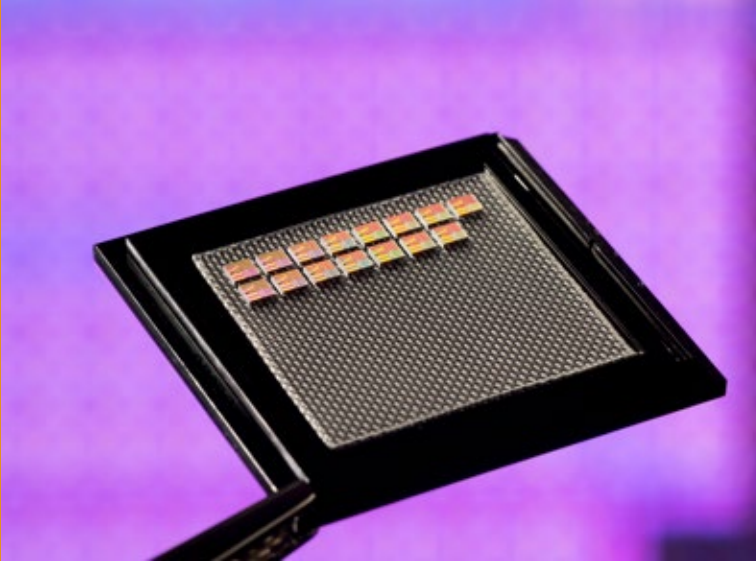
semiconductor market by Texas Instruments. This means that an F<sub>2</sub>-based, climate-friendly cleaning process has been qualified for Ar/NF<sub>3</sub>-based cleaning processes with remote plasma system (RPS).

In a second production test on a LAM Novellus Sequel PECVD system (silane-based oxide/nitride), the standard cleaning process based on C<sub>2</sub>F<sub>6</sub>/O<sub>2</sub> was replaced with an environment-friendly and climate-friendly Solvaclean@NO in-situ plasma cleaning process. This cleaning process was also qualified after processing of more than 25,000 wafers. By comparison with the PFC-based cleaning process, this resulted in fluorine savings of over 80%.

In order to be able to increase efficiency even further in the future, a new type of microwave-based remote plasma source produced by Muegge GmbH will be tested at Texas Instruments. Preliminary development work for this was carried out at Fraunhofer EMFT as part of the ecoFluor project.

Other semiconductor manufacturing sites in Germany are currently investing in their gas and water supply so as to be able to use the Solvaclean@ cleaning system.





Voltage-controlled RF and mm wave oscillators and transmission lines on a 3 x 3 mm<sup>2</sup> integrated circuit board implemented with a 22 nm-FDSOI CMOS technology by GLOBALFOUNDRIES

## COMMUNICATION AND KNOWLEDGE



### Data rates in turbo mode

Data rates up to the TBit/s range – such is the ambitious goal of the internal Fraunhofer project EOS. In order to get within reach of such extremely high data rates, the research team from Fraunhofer HHI, Fraunhofer IIS and Fraunhofer EMFT is seeking to convert several 56 Gbit/s digital-electrical message signals directly and without power-hungry signal processors (DSP) into a multi-stage, optically complex modulation signal.

For this purpose, the scientists are marrying the optical modulator and electrical driver components – previously developed independently of each other – to form a closely dovetailed and precisely tuned functional unit. With indium phosphide (InP) for the photonic IC (PIC) and the 22 nm FDSOI CMOS electronics with lower power dissipation as compared to SiGe, the most efficient and fastest material systems available are heterogeneously combined in a novel modular structure to create a new electro-optical (e/o) subsystem.

The main task of the Fraunhofer EMFT team is to fabricate fine metal structures on very thin, flexible film substrates and integrate the InP and silicon 22nm FDSOI ICs along with several other components at very demanding spacings. The researchers also carried out a detailed analysis of the thermal reliability of the modular integration design using FEM (finite element method) simulations. In addition, analyses of the ESD load and strength were carried out during assembly and testing.

### Low-noise diodes for mobile communication applications

For mobile communication applications such as 5G, resonators of high quality are required in order to transmit and receive the signals with as little interference as possible. In order to be able to adjust the frequencies of the transmitters and receivers, voltage-controlled capacitors are used, which are realized by means of so-called varactor diodes (varicaps). However, commercially available low-noise diodes for oscillators are hardly available today – industrial production is not worthwhile given the small quantities required. In order to continue to serve this important niche market, a research team at Fraunhofer EMFT is currently developing novel varicaps with excellent noise properties.

### Power-saving chips for neuromorphic computing

Neuromorphic computing is considered a key technology for future AI applications. Here, the sophisticated nerve network of the human brain serves as a model. A central challenge facing research is the very high level of power consumption of chips for the complex computing required. In the ECSEL project TEMPO (Technology & Hardware for Neuromorphic Computing), the German consortium with the participation of Fraunhofer EMFT is working on the development and evaluation of power-saving neuromorphic computing chips in the 22 nm FDSOI technology node. The researchers are looking into new integrated memory technologies based on innovative concepts for the realization of analog and digital neuromorphic circuits. Memory and chip development is conducted at all levels of exploitation – from applied research and IP generation through to integrated systems. The chips designed and manufactured in connection with the project are to be used primarily for classification tasks in image recognition systems, e.g. for autonomous driving, as well as for processing other sensor data such as the data generated by radar systems.

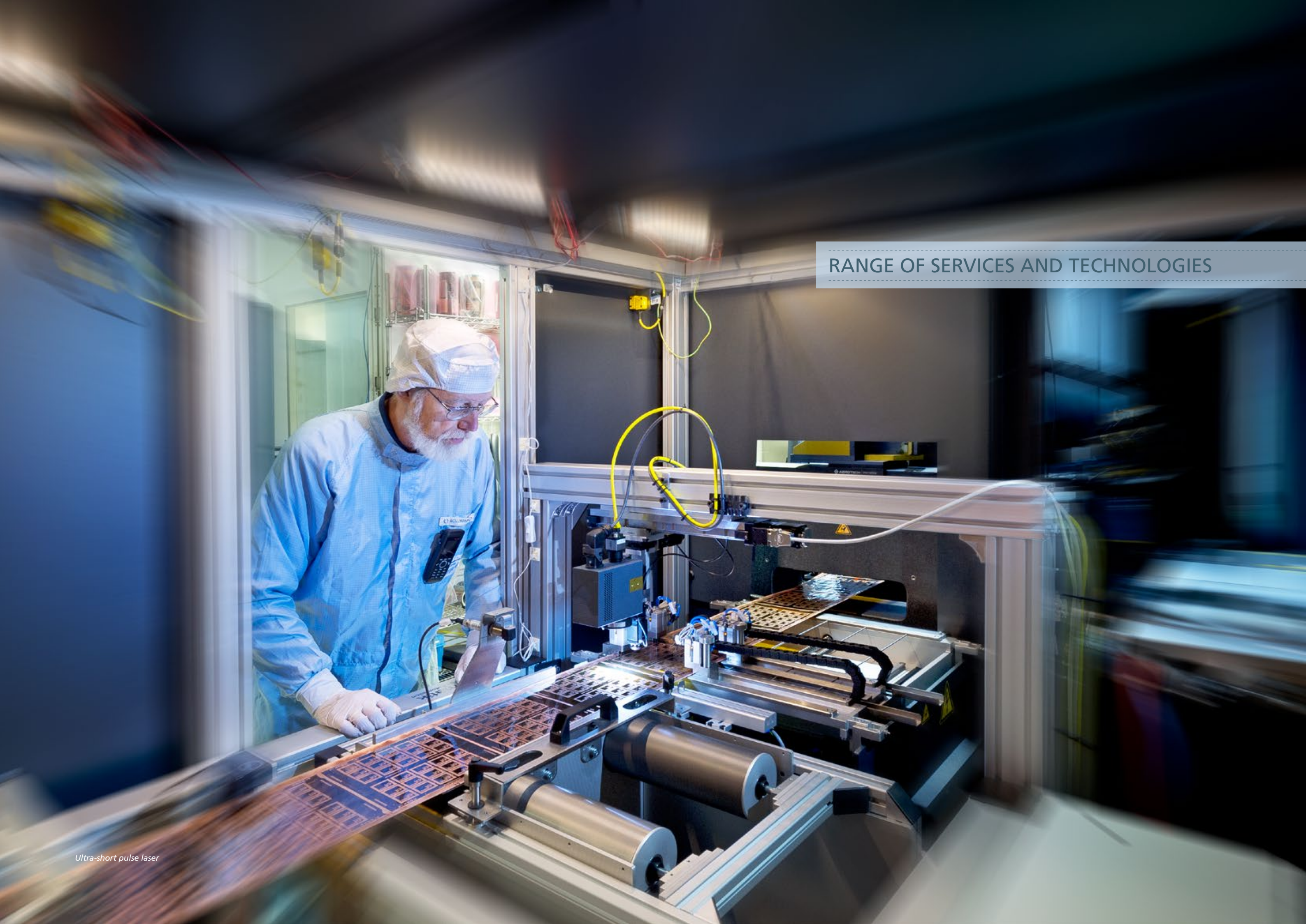
Fraunhofer EMFT's contribution will focus on developing key IPs for analog and mixed-signal signal processing for neuromorphic structures. The goal is to develop signal processing for existing mobile and portable sensor systems, enabling a reduction of power consumption by several orders of magnitude.

The project is funded by the EU under funding reference 826655 as part of the ECSEL initiative and by the BMBF under funding reference 16ESE0407.



RANGE OF SERVICES AND TECHNOLOGIES

Ultra-short pulse laser







## FRAUNHOFER EMFT RANGE OF SERVICES

### Studies

- Technology analyses
- Feasibility studies
- Assessment in the case of damage claims

### Modeling & Simulation

- Whole process
- FEM simulation
- System response

### Customer-Specific Development

- Advance development
- Single process modules and overall process
- ASIC design
- Components and systems

### Prototypes and Small Series Production

- System design
- Layout
- Device design and construction

### Analysis & Test

- Risk and problem analysis
- Development of test methods and equipment

### Professional Development

- Seminars and training programs
- Conferences

### R&D as part of publicly funded projects

- Joint projects funded publicly or by industry, e.g. BMBF, German states, the EU
- Coordination of industrial project consortia
- Consultancy for national and EU research applications

### Start-Ups & Joint Ventures

- Spin-offs for the commoditization of products and systems
- Participation of industrial partners via joint ventures





## FRAUNHOFER EMFT RANGE OF TECHNOLOGIES

### 200 mm – CMOS technology

- Wet chemical cleaning and etching processes
- Photolithography
- Epitaxy (Si, SiGe)
- Ion implantation and annealing
- Dielectric layers (thermal oxidation, LPCVD deposition of SiO<sub>2</sub> and Si<sub>3</sub>N<sub>4</sub>, PECVD of SiO<sub>2</sub> and Si<sub>3</sub>N<sub>4</sub>)
- Highly conductive layers (Al/Si, Ti, W, doped poly-Si)
- Plasma etching processes (Si, SiO<sub>2</sub>, Si<sub>3</sub>N<sub>4</sub>, Al, W)
- Electroplating (Cu, Sn)

### 200 mm lithography cluster

- Proximity exposure
- Double-sided exposure
- Contact exposure
- Electron ray exposure
- Ion beam writing with FIB
- i-line stepper
- Nanoimprint

### Si-MEMS technology

- Cleanroom technology for 150mm wafers (silicon, ceramics, glass)
- Metal coating (Cu, Ti, TiW, Pt, Au, Ni)
- Dielectric layers (Si, SiO<sub>2</sub>, Si<sub>3</sub>N<sub>4</sub>, SiC, polyimide)
- Wafer bonding, bonding techniques by means of adhesion
- Structuring with mask aligner 2 μm

### Substrate processing

- Wafer grinding
- Spin etching
- Chemo-mechanical polishing (CMP)
- Wafer cleaning
- Contactless wafer thickness measurement
- Flexural and breakage test devices for thin substrates and chips

### Analytics and material characterization

- Atomic force microscope (AFM): measurement of surface roughness and step measurements up to max. 6 μm
- Scanning electron microscopy (REM) incl. energy-dispersive x-ray spectroscopy (EDX)
- In-line REM (Schottky emitter) and focused ion beam (Ga-FIB) with EDX and gas injection system (GIS)
- Spectral ellipsometer: measurement of thin layers and transparent materials
- Spectrometer: measurement of layer thickness of silicon (thick layers) and infrared permeable layers
- Target grinding device for sample preparation (grinding accuracy: ±2 μm)
- X-ray diffractometry (XRD): measurement of silicon-germanium content
- CVD epitaxy facility: quality control of high purity gases
- Plasma-supported etching and deposition systems to test gas compounds
- Wafer prober for electrical characterization

### Microbiological laboratory

- Spectral fluorimetry for the qualitative and quantitative analysis of fluorescent samples, kinetic measurements
- Absorption spectroscopy (UV/VIS) for qualitative and quantitative analysis
- Transmitted light and phase-contrast microscope with microscope camera
- Epifluorescence microscope with microscope camera
- Rotational vacuum concentrator for fast and low-impact drying of aqueous, acidic and solvent samples

### Application of large-area electronics and flexible substrates to foil sheets and using the roll-to-roll method

- Hot roll laminator for double-sided lamination
- In-line coating system for liquid coatings such as photoresist, dielectrics and passivation
- Sputter system for double-sided metallization of chrome and copper
- UV lithography with high resolution (5 – 15 μm structure width)
- Wet-chemical etching techniques for structuring metals
- Screen printing on foil sheets
- Screen printing using the roll-to-roll method
- Galvanic deposit of copper on premetallized foils
- Laser processing for cutting, marking and drilling various materials
- Plasma process for surface conditioning and reactive etching of polymers with nitrogen, oxygen and CF<sub>4</sub>
- Foil mounting and bonding technology

### Analysis and testing

- Semi-automatic wafer prober up to 300 mm using thermo chuck (-55 °C–+300 °C) and laser
- Semiconductor parameter analyzers
- Network analyzers in the megahertz range up to 110 gigahertz and Simulator Agilent ADS
- Generation and measurement of high-current pulses in the picosecond and nanosecond range
- 62 gigahertz real-time oscilloscope
- Electrostatic discharge characterization and exposure (automatic 2-pin tester, CDM, HBM, TLP, VF-TLP, CC-TLP)
- Robustness measuring station for EOS/ESD
- Electrochemical impedance spectroscopy
- Environmental test chamber 100 cc – moisture and gases
- Oscilloscope
- Permanent bending tester for flexible and rigid-flex structures
- Physical analysis of integrated circuit boards
- 2D X-ray analytics for circuit boards
- ESA – Accepted Qualification Lab
- Environment simulation laboratory
- Contaminometer to detect ionic contamination
- Friction corrosion tests on soluble compounds
- Zwick universal testing machine with heating and cooling facility

### Studios for advanced training

- Crimping learning lab
- Wiring harness learning lab
- Lab for night work and module repair
- Soldering training center with 20 fully fitted workstations
- ESA STR-258 Skills Training School



## ZVE – CENTER FOR INTERCONNECTION TECHNOLOGIES

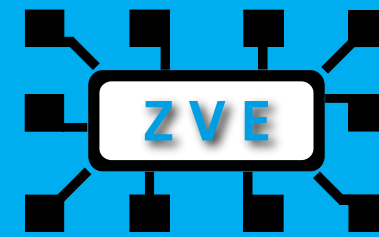


*Fraunhofer EMFT in Oberpfaffenhofen,  
the building that houses the ZVE – Center for Interconnection Technologies*



## Training to the highest standards:

- The ZVE is accredited as an initial training and instruction center by both the European Space Agency ESA and the Association Connecting Electronics Industries IPC.
- In 2019, the training center team passed their regular audit as an ESA-accredited training center with flying colors. Two of the ZVE trainers are certified as Category I instructors – the highest level according to ESA criteria.
- For all training courses offered by the ZVE, the trainers also hold the IPC-recognized qualification as Master Trainer.



ZVE training board for the IPC courses IPC J-STD 001 and IPC-7711/21



## ZVE – CENTER FOR INTERCONNECTION TECHNOLOGIES

**At Fraunhofer EMFT's ZVE (Zentrum für Verbindungstechnik in der Elektronik – Center for Interconnection Technologies) in Oberpfaffenhofen, experts have taught essential know-how relating to electrical connection technology for more than 30 years. The focus here is on professional development for QS coordinators, specialists and manual workers.**

Even in times of Industry 4.0, good manual work is still very much in demand. Soldering, press-fit and crimping are still an integral part of connection technology for electronic modules: these methods guarantee a high level of quality and reliability. With more than 30 years of experience, the ZVE in Oberpfaffenhofen has become established as an important training and professional development center.

The modern training concept used by the team in Oberpfaffenhofen is based on the fact that it is virtually impossible to separate learning and work in the modern working environment. The “knowledge worker” is now long-established at conventional production plants, too: ongoing professional development is required in order to keep up with the state of the art. In order to integrate teaching in day-to-day work in an effective and practically oriented manner, the ZVE training concept supplements conventional seminars with flexible formats such as webinars as well as providing apps that make information accessible according to specific situations and needs. iAcademy learning apps produced by the Fraunhofer Academy are used for seminar preparation and follow-up. The spectrum of course topics ranges from production technologies and information on installation and production to repair and maintenance procedures. The expertise

taught is not just dry theory: it is drawn directly from current R&D activities relating to electronic module production and electrical-mechanical connection technology.

In addition to courses and training programs, the ZVE also offers process qualification, process audits and damage analytics. The equipment available for this purpose includes a 2D and CT x-ray system, a scanning electron microscope, temperature change and climate test consoles and a metallography lab. Longstanding contacts with the aerospace industry mean that the qualification of electronic modules under tough environmental conditions is one of the training center's core areas of expertise.

The ZVE's R&D activities are very much geared towards the Internet of Things (IoT): this is because in networked environments, connectivity and the reliability of the electronic interfaces are an absolute must for the system as a whole to function smoothly – especially in safety-sensitive areas such as autonomous driving. In this context, researchers are working to develop so-called Cyber Physical Connectors, for example: these are plug connectors fitted with sensors and enable continuous monitoring of the connection state. This enables the early detection of impending system failures due to defective contacts.



## COOPERATIONS

Verification of the deep learning algorithm for implementation of a neuromorphic hardware





Prof. Christoph Kutter  
Director of Fraunhofer EMFT

## FMD – RESEARCH FAB MICROELECTRONICS GERMANY

### **One-stop shop: from the basics to pilot production of microelectronic components**

Since April 2017, the Fraunhofer EMFT has been part of the nationally coordinated Research Fab Microelectronics Germany (FMD) – Europe’s biggest R&D microelectronics and nanoelectronics network with 13 members and more than 2,000 scientists.

### **Investment in FMD pays off**

Last year, several successful project involvements were established and order contracts concluded in collaboration with the FMD. In 2019, projects worth a total of EUR 66.8 million were in progress based on FMD investments. The share of purely industrial projects in 2019 was 17 percent, underscoring the importance of this unique cooperation in German microelectronics research from the industrial perspective.

### **FMD – future model for large-scale projects**

The Research Fab Microelectronics Germany is due to enter its final phase of development in 2020. The success of this novel collaborative cross-site approach has already been demonstrated by miniLiDAR, for example, a large-scale project launched at the end of 2019 and supported by the FMD office with a budget of EUR 5.65 million. It will involve the development of components for a miniaturized LiDAR for robotics in collaboration with an industrial partner actively approached by the FMD office. Four FMD institutes are involved: the Ferdinand-Braun-Institut FBH in Berlin, the Fraunhofer Institute for Microelectronic Circuits and Systems IMS in Duisburg, the Fraunhofer Institute for Photonic Microsystems IPMS in Dresden and the Fraunhofer Institute for Reliability and Microintegration IZM in Berlin.

### **FMD-Space turns start-up ideas into reality**

FMD-Space is a support scheme for start-ups: developed in the first set-up phase of the research fab, it was further implemented in 2019 and successfully tested in several pilot projects. In this way it has been possible to make the institutes’ technologies and the facilities available to technologically oriented start-ups in a very efficient way. The start-ups join forces with institute researchers to develop demonstrators for their product ideas.

FMD-Space was used by the founders of “Ghost – feel it”, “OQmented GmbH” and “nxtbase technologies GmbH”, for example. Another two project ideas secured a place at FMD-Space at the end of 2019: “Quantune Technologies” and “Twenty-One Semiconductors”.

### **Modernization of plant technology in full swing**

The idea of productive research and development across several sites is supported by the Federal Ministry of Education and Research (BMBF) with funding of EUR 350 million up until the end of 2020 – an investment that lays the foundation for the future viability of applied microelectronics research in Germany. The main aim is to modernize research facilities at the 13 participating Fraunhofer Society and Leibniz Association institutes. By the end of 2019, 157 installations had been delivered and most of them are now ready for operation – a great accomplishment that is already substantially expanding the institutes’ technological potential.



LZSiS showroom opening on July 11, 2019

## LZSiS – HIGH PERFORMANCE CENTER FOR »SECURE INTELLIGENT SYSTEMS«

Clustered competences and versatile know-how for secure intelligent systems: that's what the LZSiS is all about! As a joint initiative involving six Fraunhofer institutes (AISEC, EMFT, IBP, IGCV, IKS, IVV), the Technical University of Munich, the Bundeswehr University and Munich University of Applied Sciences, LZSiS brings together university and non-university research from the relevant subject areas in order to make digitization available to customers from a wide range of industries.

LZSiS supports transformation processes in all phases – from conception through to the implementation of digital process chains and new business models. Particular attention is paid to the comprehensive security of the system solutions: a secure path from sensor to cloud. The overriding objective is to identify digitization potential in the various sectors in collaboration with partners and customers and translate this potential securely into practice. Individually tailored, secure system solutions are provided through synergetic, cross-disciplinary and cross-industry cooperation and a powerful network. Cooperation with LZSiS as a neutral and manufacturer-independent partner institution enables companies – from start-ups and SMEs through to large-scale corporations – to identify digitization potential within the framework of funding initiatives or direct orders and implement this securely in accordance with their own requirements. The services offered range from innovative, intelligent sensor system solutions to company-wide cyber security concepts and customer-specific workshops or training courses. The High Performance Center offers extensive technological expertise in the areas of cyber and hardware security, innovative sensor technology, intelligent networking and AI. In addition, a unique research infrastructure (e.g. cyber security laboratory, clean room environment etc.) is available for project participants. In combination with outstanding industry expertise in such application fields as food and packaging, foundry and construction, the center is a powerful partner when it comes to digitization.

Dr. Sabine Trupp is Director of the High Performance Center for Secure Intelligent Systems. Sponsorship and funding for the center comes from the Bavarian Ministry of Economic Affairs, Regional Development and Energy, the Fraunhofer Society and various industry partners who are involved in joint projects.

### The competence portfolio of the research platform covers the following:

- Conception, development and assembly of networked sensor nodes for data logging to serve customer-specific applications
- Networking of embedded systems such as sensor nodes and control units by means of wireless and wired communication systems
- Establishment of secure cloud-based data and control solutions
- Conception and establishment of real-time communication systems in an industrial setting
- Concept, evaluation and validation of new communication architectures and technologies for the real-time-capable, reliable and secure vehicle environment networking
- Testing conformity, performance and security in dedicated test environments and customer scenarios





*CitizenSensor team testing the nitrate measurement kit*

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## INTERVIEW »NEW OPTION IN TERMS OF COLLABORATIVE APPROACHES«

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**Co-creation with citizen scientists and open licensing of project results: a team at Fraunhofer EMFT broke new ground with its CitizenSensor project.**

***CitizenSensor is regarded as rather an unusual project at Fraunhofer EMFT. What exactly is it all about?***

**Tina Möbius:** The technological goal of CitizenSensor was to develop an electrochemical nitrate measuring device that can also be used by non-experts such as gardening enthusiasts and farmers. But the “unusual” nature of the project has more to do with the project team: we developed the measuring kit together with members of FabLab Munich, which was a completely new type of collaborative venture for us. Institutionalized research and the maker scene are two extremely distinct worlds! And many of our well-established approaches to project management and exploitation can’t simply be transferred to this type of constellation. New methods are required, along with an outside-the-box perspective.

**Matthias Steinmaßl:** The project was fascinating from a technical perspective, too: as a research institution, we have an interest in ensuring our components are used in applications. Confronting citizen scientists directly with this idea and being able to get their ideas and input generated an exciting dynamic. Our demonstrator is not just a measuring device consisting of 3D printed parts and a single-board computer: the way it is operated shows that it was born out of the aim to make expensive and complex scientific methods accessible to non-experts.

***What are the challenges involved in such an unusual form of collaboration?***

**Tina Möbius:** Both sides had to put aside their customary work perspective and approach: after all, each was confronted with perceptions that were – and still are – quite contradictory in some cases. Take the example of IP. For FabLab enthusiasts, the motto here is: Make. Learn. Share. The motivation to find and implement new technical solutions is not to earn money but to enrich the community with knowledge. From this point of view, it is undesirable to classify knowledge as “property”. Things are very different at Fraunhofer, of course: if we weren’t making money, we wouldn’t be able to go on funding our research – it’s that simple!

But when you start to move towards each other despite these differences, exciting new perspectives can open up on both sides. For Fraunhofer EMFT it was a big step to delve into the world of open licenses. But FabLab also accepted the fact that we need opportunities to exploit our IP commercially. Based on the experience gained in this project, I would say that CitizenScience cooperations are not only a chance to broaden your own horizon but also an exciting opportunity to engage in development in a context where you really are up close to future users. Of course you can’t simply apply this one-on-one to all fields of research. But it should definitely be included as an option in terms of potential collaborative approaches moving forward.

***Where is CitizenSensor today and what contribution can the project results make in the future?***

**Tina Möbius:** Our demonstrator is already working very well in the laboratory environment, so in this respect the project goal per se was achieved. But we’re not about to have two years’ work disappear into a drawer just because the funding has expired. We’ve been both encouraged and surprised by the initial feedback from users regarding our demonstrator. Last autumn we held a workshop with Green City Munich: at the end, participants asked whether we could provide them with enough devices next season to equip the various gardens in Munich. We hadn’t been thinking on this scale – so now the next challenge lies in store for us ...

**Matthias Steinmaßl:** From the researcher’s perspective, this raises exciting questions: how do our ideas and approaches stand their ground in practice? Are sensitive electrochemical sensors ready for use in the agricultural industry or in hobby gardens? Nitrate is an explosive issue. Over-fertilized fields pollute our groundwater – this applies to agriculture as it does to allotment gardens, where gardening enthusiasts can sometimes get a little carried away with their plants. Simple but effective measuring methods could potentially make a sound contribution to educating people, encouraging them to take on responsibility and so ultimately resulting in enhanced environmental protection. This is why the validity of the measured data is extremely important. Our demonstrator doesn’t do badly in this respect, but we can only improve on it if our device is now used and tested. So it’s definitely worth getting involved.

*The interview was conducted by Sophia Drimmel.*

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## UNIVERSITIES

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Prof. Marc Tornow

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### Technical University of Munich (TUM)

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In the spring of 2016 it was possible to gain the services of Prof. Marc Tornow to head up the Silicon Technologies and Devices department together with Prof. Ignaz Eisele. Marc Tornow holds the Professorship in Molecular Electronics at Technical University of Munich and is involved in research into nanoscale components in molecular electronics and biosensorics.

Through the Chair for Technical Electrophysics there is also close collaboration with Dr. Gabriele Schrag and Prof. Gerhard Wachutka. Research there focuses on physically based modeling, numerical simulation and the characterization and diagnosis of production processes and the operating response of microstructured components. Collaborative research aims to further strengthen Fraunhofer EMFT expertise in this area. Joint doctoral dissertations on various preliminary research topics further enrich collaboration.



Prof. Joachim Wegener

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### University of Regensburg

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Fraunhofer EMFT has engaged in longstanding collaboration with the Institute for Analytical Chemistry, Chemo- and Biosensors at the University of Regensburg. Since January 1, 2017, Prof. Joachim Wegener has been in charge of the Fraunhofer EMFT group Cell-Based Sensors (ZBS) in Regensburg. Joachim Wegener is Professor of Bioanalytics and Biosensors, and the work he does with his group mainly focuses on developing physical sensors that allow living cells to be examined on a non-invasive, label-free basis. The aim of this new initiative is to harness Fraunhofer EMFT expertise in the areas of microelectronics and polymer electronics for cell-based sensors, thereby penetrating new areas of application in bioanalytics and biotechnology.

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### Technical University of Dresden

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Technical University of Dresden has been one of Germany's eleven Universities of Excellence since 2013. The honorary professorship of Prof. Peter Kücher at the Faculty of Electrical Engineering forms the basis for cooperation with Fraunhofer EMFT.

In his courses at the Institute for Semiconductors and Microsystems Technologies (IHM), Prof. Peter Kücher focuses mainly on the connection between technological and economic challenges, since globalized competition has led to changes such as specialization and resegmentation of the supply chain. This requires manufacturers of materials, production facilities and chips to adopt new strategic approaches. For this reason, current trends in microelectronics/nanoelectronics – from "More Moore" to "More than Moore" – need to be viewed from the perspective of the overall economic context. Fraunhofer EMFT also cooperates closely with the Electronics Packaging Laboratory (IAVT) on scientific topics.



Prof. Dr. Peter Kücher

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### Universität der Bundeswehr München

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There is a close link between the Faculty of Electrical Engineering and Information Technology at Universität der Bundeswehr München and Fraunhofer EMFT, not least as a result of staffing connections: Prof. Linus Maurer (Professorship for Integrated Circuits and Electronic Components) has taught at the university since 2012, along with Prof. Christoph Kutter (Professorship for Polytronics). The cooperation originated under Prof. Ignaz Eisele, who was appointed the university's first Emeritus of Excellence and today heads up the business area Silicon Technologies and Devices at Fraunhofer EMFT.

Fraunhofer EMFT and Universität der Bundeswehr München complement each other ideally due to the nature of their respective cleanroom facilities. The close connection between the university and Fraunhofer EMFT is also reflected in their collaboration on the integration of new, innovative functionalities and components in existing silicon standard technologies. Here, Fraunhofer EMFT contributes its expertise in the area of add-on technologies and their combination with standard technologies. The goal of the project is to collaborate with industry partners so as to advance new developments – from high-risk research through to product maturity and implementation.



Prof. Christoph Kutter



Prof. Ignaz Eisele



Prof. Linus Maurer



HIGHLIGHTS







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## HIGHLIGHTS

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### NEWCAS Conference

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From June 23 – 26, Munich was the venue of the 17th IEEE International NEWCAS Conference under the direction of Dr. Erkan Isa (Fraunhofer EMFT) together with Professor Mohamad Sawan (Westlake University, China). As the local organizer, Fraunhofer EMFT was responsible for the planning and implementation of the event.

On June 23, several tutorial sessions at Fraunhofer EMFT gave participants the opportunity to engage in in-depth technical discussion with renowned international experts. The subsequent conference with 85 papers and accompanying poster session (13 papers) at the Munich Hilton Park from June 24 – 26 was attended by some 200 participants. The conference program covered a wide range of current topics in the fields of circuits, systems and microsystems, allowing researchers and industrial partners to exchange ideas and results. Sessions on neural networks, reliability, 5G and video processing were just a few of the highlights of what was a fascinating program. Top-level keynote speakers from science and industry inspired participants to debate trend topics such as quantum computing, machine learning and AI in sensor technology.

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### LZSiS showroom opening

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Under the motto “Hands-on digitization”, the showroom at the High Performance Center for Secure Intelligent Systems (LZSiS) was opened at Fraunhofer EMFT on July 11, 2019 by Roland Weigert, Secretary of State at the Bavarian State Ministry of Economic Affairs, Regional Development and Energy.

The demonstrators in the newly opened showroom reflect a very broad spectrum of new technologies in the most diverse application scenarios. In addition to Industry 4.0 projects, the range of topics includes Smart Health and Automotive. Organized in cooperation with Center Digitization Bavaria (ZD.B), the opening featured a top-class lecture program with Fraunhofer Society experts and industry representatives (Linde AG, PROCON IT AG) giving fascinating keynote talks on the topic of digitization.

The new showroom gives partners and customers from industry and science on-site access to live demonstrators that illustrate the synergetic interaction between the institutions involved in LZSiS. Innovative, interdisciplinary technology developments are demonstrated here through concrete application examples. “It’s a great opportunity to see what LZSiS can do for companies when it comes to digitization,” says Dr. Sabine Trupp, Director of LZSiS.



*Fraunhofer Head of Human Resources Prof. Alexander Kurz was clearly delighted to be able to welcome Joseph von Fraunhofer himself to the Fraunhofer Society anniversary*

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### 70 years of Fraunhofer – #WHATSNEXT

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The Fraunhofer Society was founded in Munich on March 26, 1949, with the aim of rebuilding the local economy. It celebrated its 70th anniversary in 2019 – along with the Federal Republic of Germany and the post-war German constitution. The numerous activities in the anniversary year were all focused on the question/statement: “What’s next”?!

On the occasion of the 70th anniversary of its foundation, a festive event at the Bavarian Ministry of Economic Affairs commemorated the Fraunhofer Society success story, at the same time looking ahead to the future with the theme “Research for Europe”. Attendees included high-ranking guests from politics, business and science, including Bavaria’s state premier Dr. Markus Söder, Minister of State Hubert Aiwanger, German Minister of Education Anja Karliczek, CEO of the Dutch research organization TNO Paul de Krom, Infineon AG CEO Dr. Reinhard Ploss, and Prof. Heinz Jörg Fuhrmann, Salzgitter AG CEO and Chairman of the Fraunhofer Society Senate.

Some 300 people attended the opening reception of “Lichtfelder” at STATE Studio Berlin on November 1. The exhibition focused on the works of the Berlin-based artist duo Charlotte Dachroth and Ole Jeschonnek, who received funding through the Fraunhofer Residency Program “Artist in Lab”.

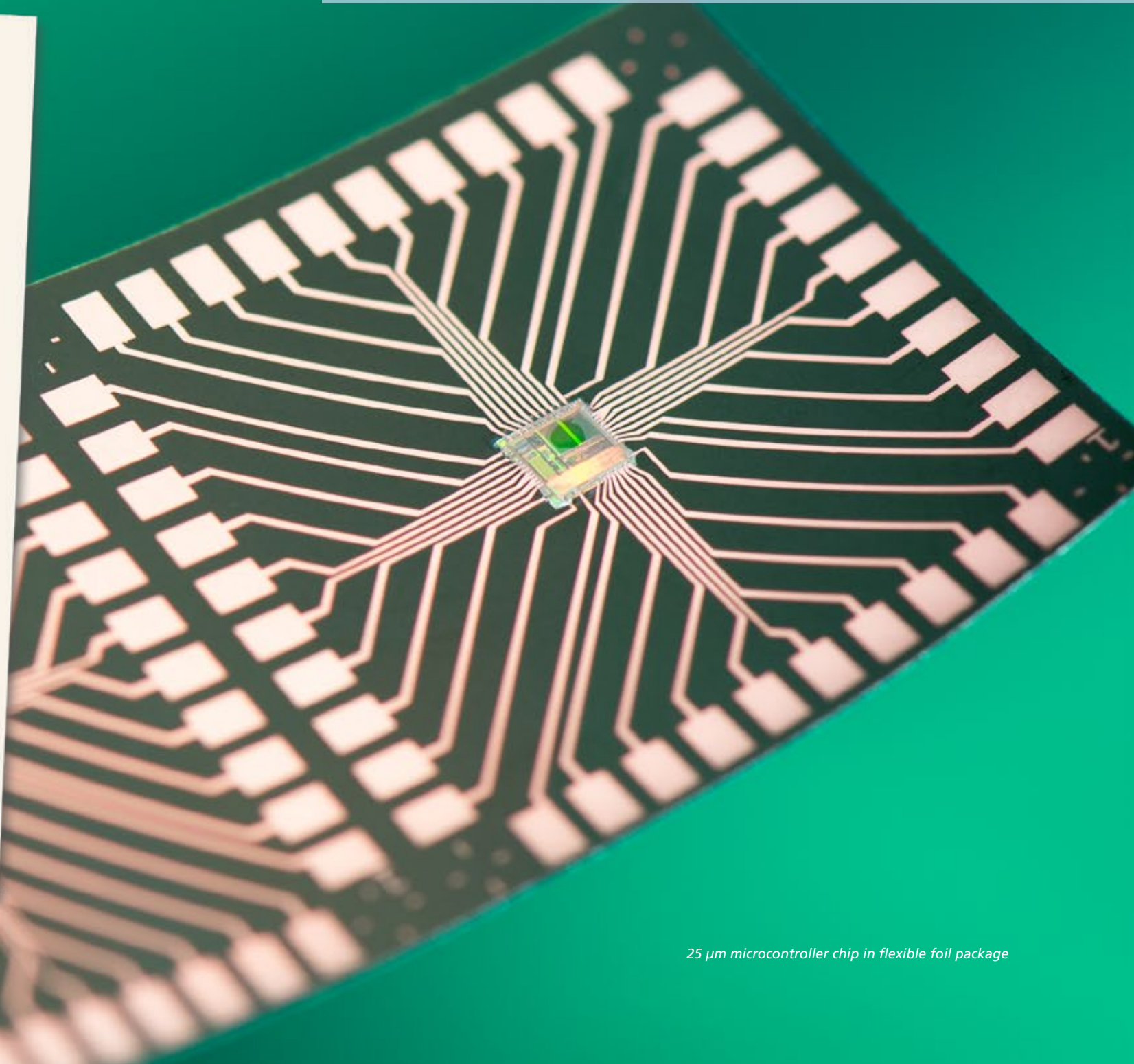
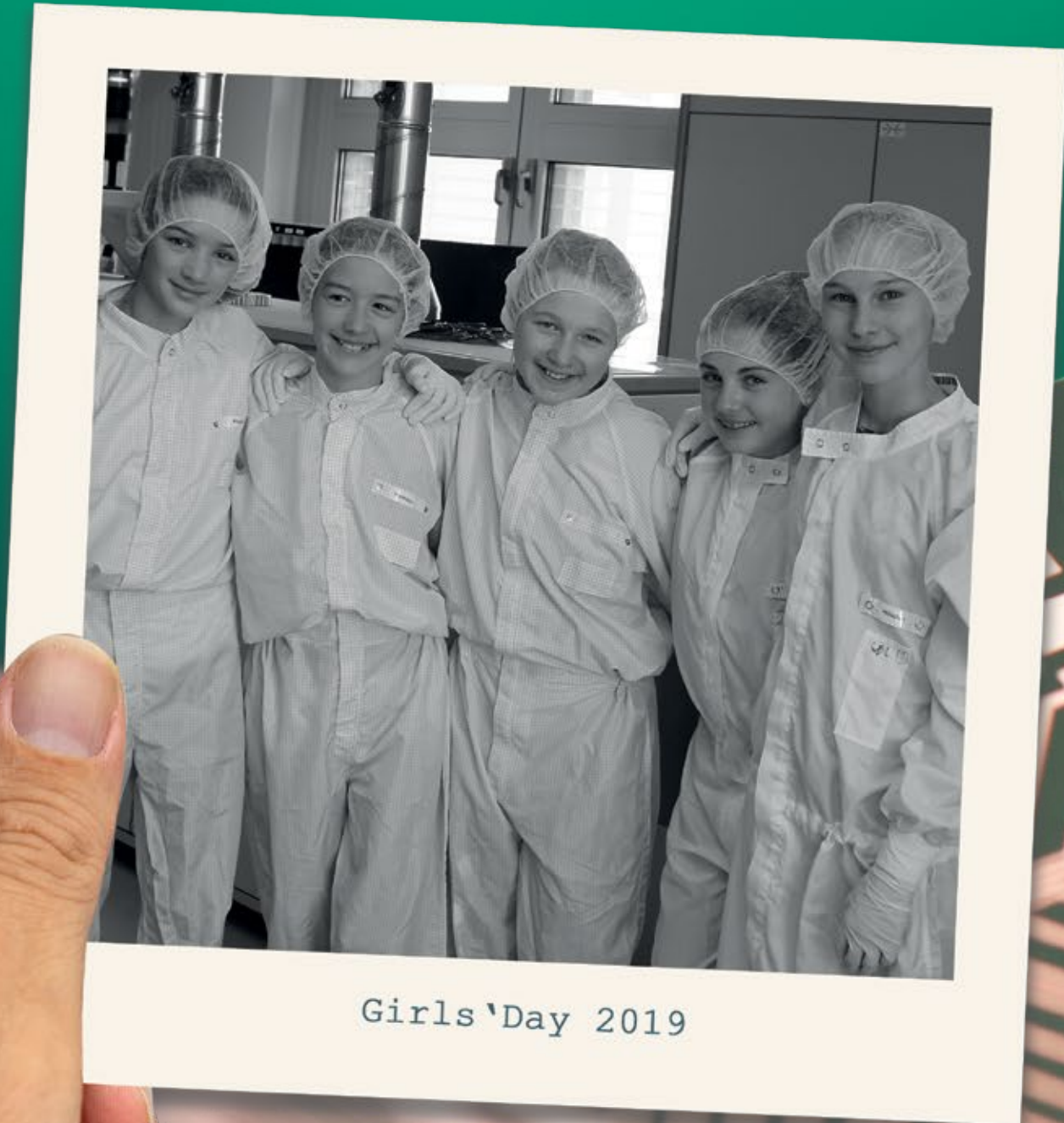
Throughout the anniversary year, Joseph von Fraunhofer himself accompanied the research organization that bears his name: just in time for his 232nd birthday on March 6, 2019, he made his first contact via the WhatsApp and Apple Business Chat messenger services, then regularly sent messages to his messenger contacts from March 26, 2019 onwards.

Fraunhofer is diversity. Fraunhofer is the future. Fraunhofer is excellence. This was conveyed very clearly once again in the project “70 Years. 70 Heads”: it focused on Fraunhofer employees – those who work and conduct research for the future, in all their diversity and diverse excellence. In videos, interviews and texts, the 70 different Fraunhofer heads talked about their day-to-day research, their motivation and their visions for the future – entirely in keeping with the motto of the anniversary year: #WHATSNEXT





PROMOTING YOUNG TALENTS



25  $\mu\text{m}$  microcontroller chip in flexible foil package



## CAREERS AT FRAUNHOFER EMFT



As part of my studies, I initially worked as a placement student at the department of Microdosing Systems department of Fraunhofer EMFT, starting on March 1, 2019. I have since become a master's degree student in the Silicon Technologies and Devices department and my main focus has been on the SmartVista project, which aims to develop an electrochemical microsensor for monitoring biomarkers in welding. I decided to do a master's degree thesis at the Fraunhofer EMFT because here you have the research aspect combined with an economic/industrial perspective. I also find it very exciting to be part of an EU project with lots of international partners. And of course I like the friendly working atmosphere, the central location and the opportunity to try out lots of things for myself. As a further career step after completing my master's degree, I'm considering doing a doctorate.

*Eva-Maria Korek*



Since May 2019 I've been working in the department of microdosing systems at Fraunhofer EMFT. I started out as a placement student and now I'm pursuing a master's degree. During my time as a student trainee my work was focused on software development for the automated measurement of pump parameters. I also developed a measuring station for the incoming inspection of the piezoceramics needed to drive the micro-pumps. In my master's degree thesis I'm looking into a new approach to make the micropump an intelligent, self-monitoring dosing system by using machine learning algorithms. The work at Fraunhofer EMFT is very varied, and a lot of importance is attached to adopting an independent approach. But colleagues are always very considerate and you can consistently rely on their advice and support. The Fraunhofer EMFT has an open-minded, friendly atmosphere and there's a great mixture of young and experienced employees. My immediate career goal is to complete my master's degree. After that I want to look for an exciting job in the R&D area of microelectronics.

*Mauriz Trautmann*



Since October 1, 2019 I've been working at Fraunhofer EMFT as an intern in the department of Microdosing Systems. During my internship I'm getting to know the numerous different fields in which my department is involved. In the laboratory, for example, I'm responsible for the incoming goods inspection of microdosing system components. I also carry out various measurements myself such as array measurements, stroke and flow measurements. In addition to doing lab work, my colleagues and I also assist in writing reports and evaluating measurement results. Recently I got the opportunity to travel with the team to Erlangen to learn more about laser welding. Even after this short time, I've found my internship to be highly enriching, and I've been able to strike just the right balance between theory and practice. What is more, I can work independently while at the same time being very well supervised, so I learn a lot. The work here at Fraunhofer EMFT is extremely varied and my colleagues are very helpful and friendly. The next step in my career will be to obtain my bachelor's degree.

*Sophia Güntner*



I started working at Fraunhofer EMFT in April. After finishing my master thesis, I'm now working as a PHD candidate in the Circuit Design department. I mainly deal with the development of a new charge pump (CP). It is used to convert the output signal of the phase-frequency detector into the loop filter and to generate a control voltage for a voltage-controlled oscillator in a PLL based frequency synthesizer. Therefore, my main tasks include the evaluation of different design concepts for the PLL charge pump, implementing the preferred concepts and the verification of the design. Additionally, I'm responsible for the documentation and presentation of our results. In the future, I will focus primarily on the Development of Neuromorphic (AI) Hardware. What I like most about working at Fraunhofer EMFT are the friendly and warm-hearted colleagues. I get a lot of support and help from my colleagues and benefit a lot from their experience. I enjoy working on very interesting projects and, on top of this, in a beautiful location – the heart of Munich.

*Lei Zhang*





I started at Fraunhofer EMFT in October 2018, first of all as a master's degree student in the department Circuit Design. I've since moved on to become a research associate and doctoral candidate, focusing mainly on the development of integrated analog circuits. My field of work includes developing concepts and circuits as well as circuit simulation, circuit testing and validation. The best thing about my job? The varied and fascinating activities that lie in store for me every day. I have lots of young, motivated colleagues and I'm grateful for their unreserved cooperation and helpfulness. I also particularly like the fact that I've had direct project responsibility and was given the opportunity to work independently. My upcoming goals for the future are to write my dissertation and then take over leadership of a project or group.

*Oleg Sakolski*



I've only been working as a research assistant in the Flexible Systems department since mid-November 2019 so I'm still fairly new here at Fraunhofer EMFT. Nonetheless, my first impression has been great! The areas of work are fascinating, and I can combine my theoretical knowledge from university with applied research, working in a modern, well-equipped environment. Having participated in a Fraunhofer Talent School in 2013 when I was still a student, I always had Fraunhofer at the back of my mind during my studies, so now I'm very glad to be employed at Fraunhofer EMFT. I was especially excited when I realized that the Fraunhofer EMFT research areas exactly match my current field of interest and are even related in some ways to the topics I covered in my bachelor's degree thesis. I'm looking forward to the rest of my time here at Fraunhofer EMFT because I'll be able to learn a lot from the experienced employees here and take on a varied range of tasks. I can even join one project almost from the very beginning and follow it through the various stages of development. My next goal is to complete my master's degree in physics.

*Zoë Siebers*



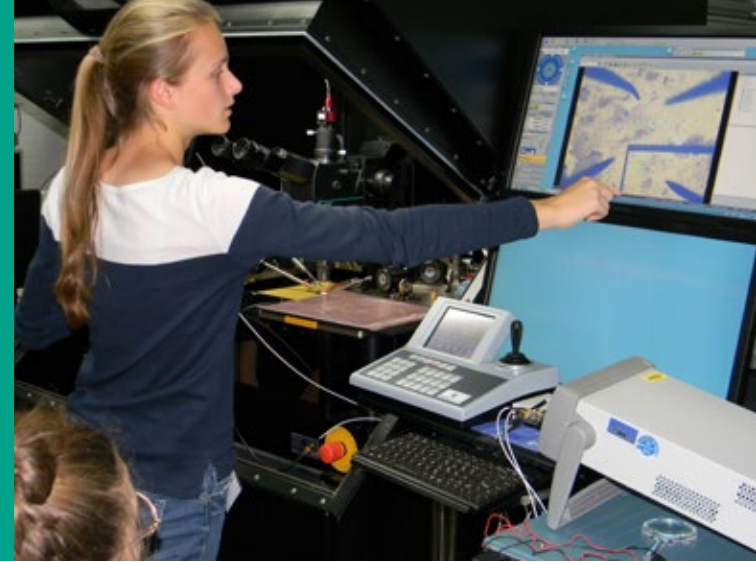
I've been working in the Department of Silicon Technologies and Devices at Fraunhofer EMFT since August 19, 2019, doing a mandatory internship for my physics degree (B.Sc.) at the University of Tübingen. My field of activity includes software maintenance and development, technical implementation and testing of new devices as well as firmware development. I also test sensor materials under laboratory conditions for the projects BioPat and CitizenSensor. I am supervised by Matthias Steinmaßl. I enjoy working at Fraunhofer EMFT very much because they have great confidence in my newly acquired skills and I have a lot of creative freedom. I also particularly like the excellent support, as well as the motivating and welcoming work environment. My tasks are very varied – nothing is too taxing or too easy, so my internship has already been very enriching, even in this short time. Moving forward, I would like to obtain my Bachelor of Science degree in physics.

*Aaron Steel*

At the beginning of 2019, after having completed my Master's degree in Marketing Management, I actually had the intention to leave Fraunhofer EMFT. And so I did – at least temporarily. First, I went abroad for a while. At that time, I thought my first proper fulltime job is going to be in a marketing agency, in order to gain as much experience as possible, working on lots of various projects in a relatively short time period. In the end it turned out quite differently. Already during my stay abroad, I took the chance to start working fulltime at the Fraunhofer EMFT at my return. What made me change my original plan? Probably the combination of my future tasks and the team. Turns out, my gut feeling was right – I couldn't have wished for a better start into my professional life. Since I had already worked with the same team as a student, my colleagues were well aware of my strengths and abilities and which skills I wanted to develop, so they were able to give me exactly the right amount of support I needed. In addition, Fraunhofer EMFT provides many opportunities for trainings according to individual interests and needs. Today, my work routine consists of both strategic and operational activities, and is therefore fully in line with my striving for analytical and creative work. I mainly deal with topics related to online presence (website and social media), the creation of print media and content in general (copywriting, photo shoots and video shootings). Since my team's responsible is very broad, my to-do list also includes public relations, promotion of young talents, events or trade fairs – it definitely never gets boring!

*Johanna Markl*





Fraunhofer EMFT Talent School 2019 participant

## PROGRAMS FOR SCHOOL STUDENTS

### Career orientation weeks

Career Orientation Week for school students took place at Fraunhofer EMFT in 2019 as it does every year – in fact the event was held on two occasions. The aim of the cooperation with various upper secondary schools, lower secondary schools and comprehensive schools is to give young participants an insight into the world of microsystems and show them something of the day-to-day working life of scientists at Fraunhofer EMFT. Once again this year, school students – of whom there were three girls and three boys in total – were exposed to fascinating topics and issues in the course of the career orientation weeks:

- What do we need microelectronics for?
- Small, smaller, smallest – tiny pumps for microdosing
- What does plastic have to do with electronics?
- Flexible systems need thin chips
- Working in the cleanroom – why cleanliness is crucial
- Who checks to make sure everything works and what is the service life of a microchip?
- Crimping, soldering – how do you connect electronic systems?

In addition, Fraunhofer EMFT was able to offer five more individual students the opportunity of a one-week internship in 2019.

### Girls' Day on Thursday, March 28, 2019

“Working in the lab – what does a scientist do?” – this was the motto of Girls' Day at Fraunhofer EMFT in 2019. Five girls from Gymnasium Kirchem were treated to their very first taste of lab work. The participants enjoyed a day full of new impressions. The program included workshops in the cleanroom and electronics lab. The girls were instantly transformed into ‘real’ researchers when they put on cleanroom clothing. At the end of the day, everyone agreed that in addition to gaining fascinating insights into day-to-day working life at a research institution, the girls had had a lot of fun, too!

There was also plenty of positive feedback in other respects: “I think it's really cool that there's such a thing as a Girls' Day because you can find out what you might want to be when you grow up.” “I found the day very interesting from start to finish and it was pleasant surprise for me to find out about the research being done at this institute.” “I'd like to thank everyone who showed us something on Girls' Day. It was great!”



### Fraunhofer Talent School

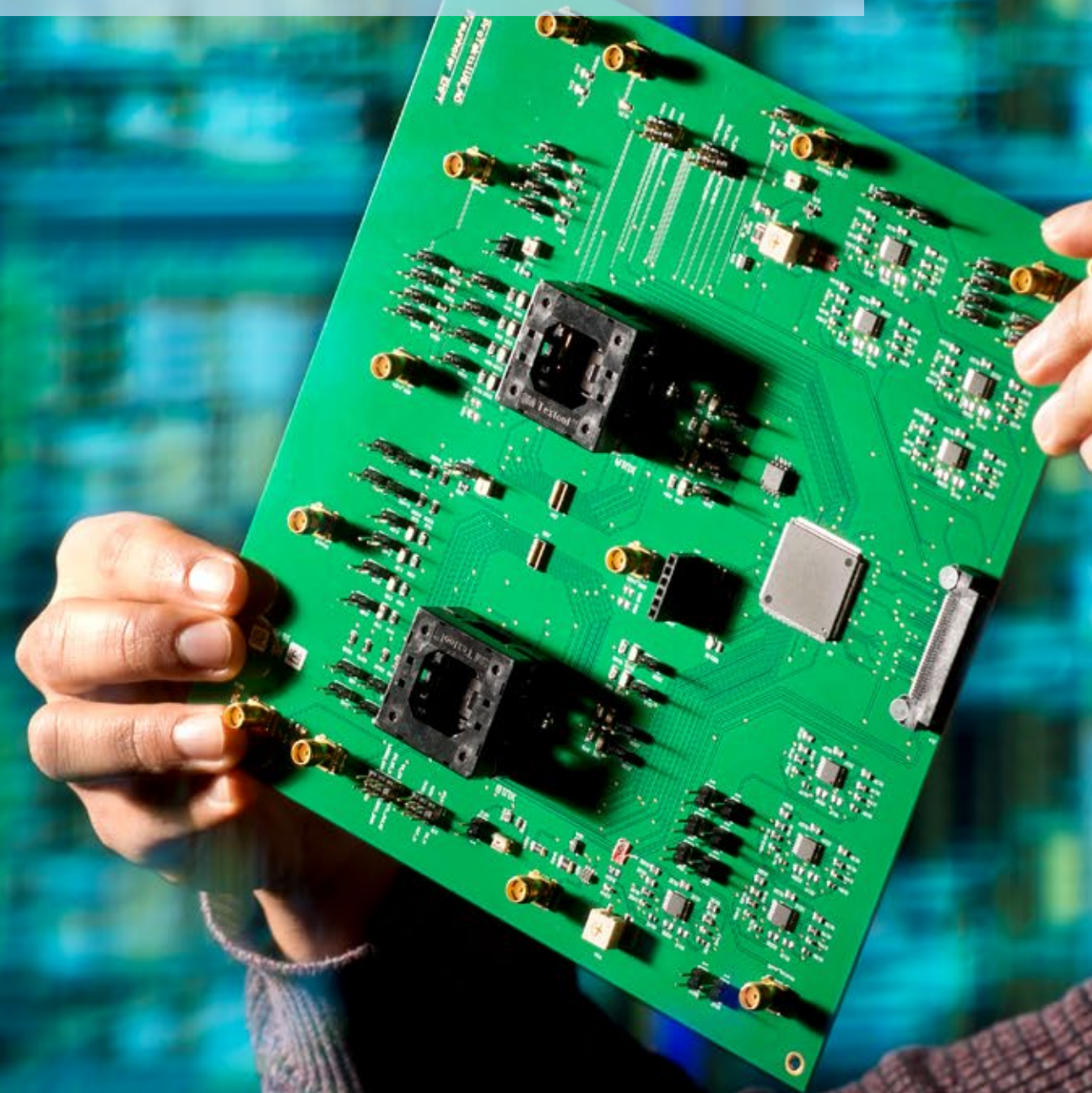
One especially popular Fraunhofer program to support youngsters is the Fraunhofer Talent School. This gives young people from the age of approx. 15 the opportunity to gain interesting insights into the world of research.

Fraunhofer EMFT offers this program on a regular basis, too: this year, two girls and nine boys visited the institution's facilities from October 25 to 27, 2019. Their experience included fascinating workshops giving them a first-hand experience of “Flexible Electronics for the Electronics of the Future”. Working with experienced Fraunhofer EMFT scientists, the youngsters were able to get involved in engaging research projects. And they weren't just there to stand by and watch: all of them got to work independently on the equipment. The youngsters gained in-depth insights into screen printing, lithography, electrical measuring technology and scanning electron microscopy, learning how to measure layers of just a few micrometers, for example, and finding out how these layers are used in sensors. The electronics involved was an important aspect too, of course: a microcomputer was used to show how measurements are digitalized, enabling the electrical signals emitted by the sensors to be converted into measurement data.

Displaying an obvious interest in technology, the students were fully engaged and highly motivated. Proactive involvement and questioning on the individual topics enabled them to satisfy their curiosity and take away fresh impressions from the world of research.



SCIENTIFIC ACTIVITIES



*Test board for an eight-channel ultrasonic transceiver chip*





## ACADEMIC PUBLICATIONS AND TALKS

### Publications

G. Acri, F. Podevin, E. Pistono, L. Boccia, N. Corrao, T. Lim, E. N. Isa, and P. Ferrari

#### **A Millimeter-Wave Miniature Branch-Line Coupler in 22-nm CMOS Technology**

IEEE Solid-State Circuits Letters, Vol. 2, no. 6, June 2019; DOI 10.1109/LSSC.2019.2930197

G. Acri, L. Boccia, N. Corrao, F. Podevin, E. Pistono, T. Lim, E. N. Isa, P. Ferrari

#### **Compact and performing transmission lines for mm-wave circuits design in advanced CMOS technology**

In Proc. European Microwave Week 2019, September 29 – October 4, 2019, Paris, France

M. Ammer, Y. Cao, A. Rupp, M. Sauter, L. Maurer

#### **Bringing the SEED Approach to the Next Level: Generating IC Models for System ESD and Electrical Stress Simulation out of Design Data**

IEEE Transactions on Electromagnetic Compatibility, Pages: 1 – 11, 2019

M. Ammer, S. Miropolskiy, A. Rupp, F. zur Nieden, M. Sauter, L. Maurer

#### **Characterizing and Modelling Common Mode Inductors at high Current Levels for System ESD Simulations**

41st Annual EOS/ESD Symposium (EOS/ESD), 2019

M. Ammer, A. Rupp, U. Glaser, Y. Cao, M. Sauter, L. Maurer

#### **Application Example of a Novel Methodology to Generate IC Models for System ESD and Electrical Stress Simulation out of the Design Data**

41st Annual EOS/ESD Symposium (EOS/ESD), 2019

J.D. Bartl, P. Scarbolo, D. Brandalise, M. Stutzmann, M. Tornow, L. Selmi, A. Cattani-Scholz

#### **Role of Different Receptor-Surface Binding Modes in the Morphological and Electrochemical Properties of Peptide-Nucleic-Acid-Based Sensing Platforms**

Langmuir 35, 3272, 2019

P. P. Bora, D. Borggreve, F. Vanselow, E. Isa, L. Maurer

#### **A 0.8 V Low-Power 3rd order Sigma-Delta Modulator in 22 nm FDSOI CMOS Process for Sensor Interfaces**

In Proc. 17th IEEE NEWCAS Conference, June 23 – 26, 2019, Munich, Germany

P. Bora, D. Borggreve, F. Vanselow, E. Isa, L. Maurer

#### **A low power Sigma-Delta Modulator in an advanced 22 nm FD SOI CMOS Process for sensor applications**

13th International Conference and Exhibition on Integration Issues of Miniaturized Systems, Pages: 1 – 7, 2019

J. Boudaden, A. Klumpp, H.-E. Endres, I. Eisele

#### **Towards Low Cost and Low Temperature Capacitive CO<sub>2</sub> Sensors Based on Amine Functionalized Silica Nanoparticles**

Nanomaterials 2019, 9, 1097; July 31, 2019, Basel, Switzerland; DOI 10.3390/nano9081097

C. Bscheid, C. R. Engst, I. Eisele, C. Kutter

#### **Minority Carrier Lifetime Measurements for Contactless Oxidation Process Characterization and Furnace Profiling**

Materials 2019, 12, 190

T. Diederichs, G. Pugh, A. Dorey, Y. Xing, J.R. Burns, Q.H. Nguyen, M. Tornow, R. Tampé, S. Howorka

#### **Synthetic protein-conductive membrane nanopores built with DNA**

Nature Communications 10, 5018 2019

P. D. Franzon, E. J. Marinissen, M. S. Bakir, P. Garrou, M. Koyanagi, P. Ramm

#### **Handbook of 3D Integration: Vol. 4 - Design, Test and Thermal Management of 3D Integrated Circuits**

ISBN 978-3-527-33855-9, Wiley, March 2019, Weinheim, New York

P. Garrou, M. Koyanagi, P. Ramm

#### **Introduction to Design, Test and Thermal Management of 3D Integrated Circuits**

Handbook of 3D Integration. Design, Test, and Thermal Management. Vol.4 Design, Test and Thermal Management of 3D Integrated Circuits, Weinheim: WILEY VCH, 2019, p. XV-XVII

H. Hoffmeister, A. Fuchs, L. Strobl, F. Sprenger, R. Gröbner-Ferreira, S. Michaelis, P. Hoffmann, J. Nazet, R. Merkl, G. Längst

#### **Elucidation of the functional role of the Q- and I-motif in the human chromatin remodeling enzyme BRG1**

Journal of Biological Chemistry, The American Society for Biochemistry and Molecular Biology, Inc., January 15, 2019, Rockville, Maryland, USA, DOI 10.1074/jbc.RA118.005685

S. Koch, B. Orr, H. Gossner, H. Gieser, L. Maurer

#### **Identification of Soft Failure Mechanisms Triggered by ESD Stress on a Powered USB 3.0 Interface**

IEEE Transactions on Electromagnetic Compatibility, Pages: 20 – 28, 2019

P. Kumar, J. Al-Eryani, B. Taş Ulaşlı, E. Böhme, F. Vanselow, E. N. Isa, L. Maurer

#### **A 400 mV, widest-tuning-band-VCO with a central Frequency of 10.5 GHz and FTR of 2.5 GHz, designed in 22 nm FDSOI CMOS technology**

In Proc. EUROSOCI – ULIS 2019 Conference, April 1 – 3, 2019, Grenoble, France

P. Kumar, J. Al-Eryani, D. Borggreve, E. Böhme, P. P. Bora, E. N. Isa, L. Maurer

#### **A 23 GHz VCO with 13% FTR in 22 nm FDSOI**

S3S CONFERENCE 2019 October 14 – 17, 2019, San Jose, California, USA

P. Kumar, E. Böhme, J. Al-Eryani, P. P. Bora, D. Borggreve, L. Maurer

#### **A 300mV, low power VCO with the central frequency of 4.89 GHz in 22nm FDSOI**

2019 Asia-Pacific Microwave Conference (APMC) December 10 – 13, 2019, Marina Bay Sands, Singapore

S. Michaelis, J. Wegener

#### **Zellen als Sensoren, Effekt- statt Konzentrationsanalytik**

Biologische Transformation, Springer Vieweg, Berlin, Heidelberg, Germany, 2019  
DOI 10.1007/978-3-662-58243-5\_7

N. Palavesam, W. Hell, A. Drost, C. Landesberger, C. Kutter, K. Bock

#### **A novel low cost roll-to-roll manufacturing compatible ultra-thin chip integration and direct metal interconnection process for flexible hybrid electronics**

NordPac 2019, The Nordic Conference on Microelectronics Packaging, June 11 – 13, 2019, Lyngby, Denmark  
DOI 10.23919/NORDPAC.2019.8760350





S. Pfaehler, A. Angi, D. Chryssikos, A. Cattani-Scholz, B. Rieger, M. Tornow

**Space charge-limited current transport in thin films of alkyl-functionalized silicon nanocrystals**  
Nanotechnology 30, 395201, 2019

S. Ruckdäschel, C. Kade, J. Wegener

**Quartz Crystal Microbalance: Basics and Applications in Biology**  
eLS, John Wiley & Sons, Ltd., January 16, 2019, Chichester, UK, DOI 10.1002/9780470015902.a0028178

K.B. Saller, H. Riedl, P. Lugli, G. Koblmüller, M. Tornow

**One-step transfer printing of patterned nanogap electrodes**  
Journal of Vacuum Science and Technology B 37, 040602, 2019

C. Schmittlein, R. J. Meier, L. Sauer, G. Liebsch, J. Wegener

**Image-Based Monitoring of Oxygenation in Microfluidic Cell Culture**  
Genetic Engineering & Biotechnology News, Mary Ann Liebert, Inc., January 25, 2019, New Rochelle, New York, USA, DOI 10.1089/gen.39.01.18

M. Speckbacher, M. Rinderle, W. Kaiser, E.A. Osman, D. Chryssikos, A. Cattani-Scholz, J.M. Gibbs, A. Gagliardi, M. Tornow

**Directed Assembly of Nanoparticle Threshold-Selector Arrays**  
Advanced Electronic Materials 5, 1900098, 2019

J. A. Stolwijk, M. Skiba, C. Kade, G. Bernhardt, A. Buschauer, H. Hübner, P. Gmeiner, J. Wegener

**Increasing the throughput of label-free cell assays to study the activation of G-protein-coupled receptors by using a serial agonist exposure protocol**  
Integrative Biology, Volume 11, Pages 99 - 108, 2019, Oxford University Press, Oxford, UK, DOI 10.1093/intbio/zyz010

J. A. Stolwijk, J. Wegener

**Impedance-based assays along the life span of adherent mammalian cells in vitro: from initial adhesion to cell death**  
Label-free monitoring of cells in vitro, Bioanalytical Reviews 2, p. 1 – 76, 2019, Springer Nature Switzerland AG, Cham, Switzerland, ISBN 978-3-030-32432-2  
DOI 10.1007/11663\_2019\_7

J. Weber, R. Fung, R. Wong, H. Wolf, H. A. Gieser, L. Maurer

**Stress current slew rate sensitivity of an ultra-high-speed interface IC**  
IEEE Transactions on Device and Materials Reliability, Vol. 19, Issue: November 4, 2019

J. Wegener

**Measuring the Permeability of Endothelial Cell Monolayers: Teaching New Tricks to an Old Dog**  
Biophysical Journal, Elsevier B.V., April 23, 2019, Amsterdam, the Netherlands, DOI 10.1016/j.bpj.2019.03.018

J. Wegener

**Label-free Monitoring of Cells in Vitro**  
Bioanalytical Reviews, vol. 2, 2019, Springer Nature Switzerland AG, Cham, Switzerland, ISBN 978-3-030-32432-2

H. Wolf, J. Weber, H. Gieser

**Secondary Discharge during System Level ESD Tests**  
16th ESD Forum 2019, Tagungsband, October 21 – 23, Dresden Nördlingen, Germany, 2019; ISBN 978-3-9813357-3-5, p.147-153

M. Zinkl, J. Wegener

**Using animal cells as sensors for xenobiotics: Monitoring phenotypic changes by multimodal impedance assays**  
Current Opinion in Environmental Science & Health, Elsevier B.V., Amsterdam, the Netherlands, August 2019  
DOI 10.1016/j.coesh.2019.08.007

#### Talks

F. Ansorge, T. Kiesling, C. Landesberger, C. Kutter  
**Intelligenz im Steckverbinder für Anwendungen im Automobil und der Automatisierungstechnik – aus Sicht der Aufbau- und Verbindungstechnik für hochintegrierte Elektroniksysteme**

Bordnetz Kongress Landshut 2019, September 29, 2019, Landshut, Germany

R. Arntzen, F. Ansorge, O. Grünberg, M. Herrmann, I. É. E.Ilosvay, J.S. Michels, S. Nolte

**Intelligente Steckverbinder als zentraler Baustein der Infrastruktur für die Industrie 4.0**  
7th Symposium Connectors, March 19 – 20, 2019, Lemgo, Germany

J. Boudaden, A. Klumpp

**A Novel Photoelectrochemical Biosensor to detect Catechol**  
Sensor+Test 2019, June 25 – 27, 2019, Nurember, Germany

A. Bußmann, L. Grünerbel

**Increasing piezo micro diaphragm pump performance by optimizing piezo actuation**  
Smart Systems Integration, April 10 – 11, 2019, Barcelona, Spain

A. Dahiya, B. Charlot, M. Dhifallah, T. Gil, N. Azémard, A. Todri-Sanial, J. Thireau, A. Phymedexp, J. Boudaden, P. Ramm, T. Kießling, A. Klumpp, S. Lal, C. O'Murchu, K. Razeeb, U. Gulzar, Y. Zhang, C. O'Dwyer

**SmartVista: Smart Autonomous Multi Modal Sensors for Vital Signs Monitoring**  
Smart Bioelectronic and Wearable Systems, October 22, 2019, Brussels, Belgium

C. Durasiewicz, T. Thalhofer

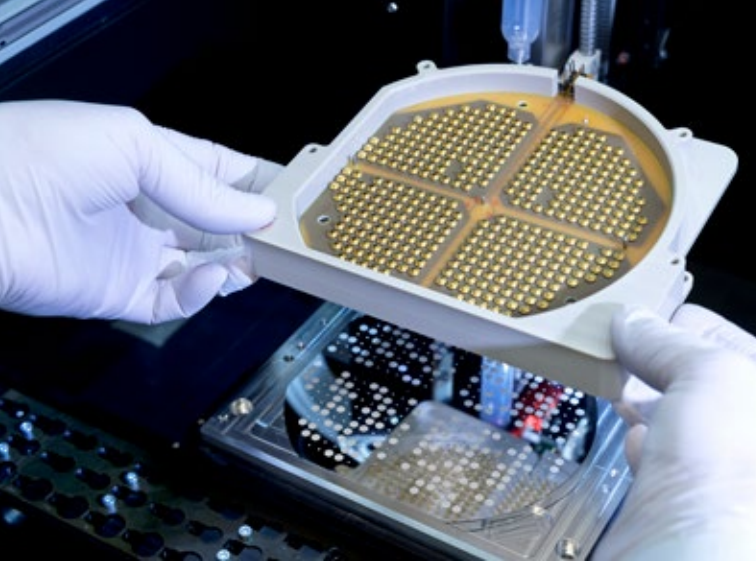
**Hochdynamische Druckpulsanalyse einer Mikromembranpumpe mittels in-line MEMS-Sensor**  
MikroSystemTechnik Kongress, October 28 – 30, 2019, Berlin, Germany

L. Govoni, T. Perekhodko, Piyush.k, L. Maurer, D. Schupke, T. Meyerhoff, E. Böhme, M. Kreissig, F. Protze, S. Damjanovic  
**REFERENCE (ECSEL JU) Project, Aeronautic WAIC hotspot: wireless video transmission using an SOI RF front-end**  
In Proc. 17th IEEE NEWCAS Conference, June 23 – 26, 2019, Munich, Germany

L. Grünerbel, A. Bußmann, O. Zett

**Hochflussoptimierung von Mikromembranpumpen durch phasengesteuerte Kopplung**  
MikroSystemTechnik Kongress, October 28 – 30, 2019, Berlin, Germany





Spezielles Kontaktierungstool für Piezomontage auf Waferlevel

J. Häfner, C. Durasiewicz, T. Thalhofer, S. Kibler, C. Kutter  
**Smart Sensor System for Constant Dosing with Micro Diaphragm Pumps**

Smart Systems Integration, April 10 – 11, 2019, Barcelona, Spain

L. Meixner, F. Ansorge, C. Kutter  
**Raffungsmodelle II (FVA 618 II), Teilprojekt Fraunhofer EMFT**

FVA-Informationstagung December 4– 5, 2019, Würzburg, Germany

L. Nebrich  
**Sensors & Aktuators**

BITCOM IoT – Auf der Suche nach Mehrwerten zwischen Milliarden von Sensoren, Technologie, Security und Business Cases im Internet der Dinge werden ausgetestet – ist die Umsetzung einer großen Vision nur noch Routine?  
 Expert Round Table, January 30, 2019, Cologne, Germany

P. Ramm, A. Klumpp, C. Landesberger, J. Weber, A. Heinig, P. Schneider, G. Elst, M. Engelhardt

**Fraunhofer's Initial and Ongoing Contributions in 3D IC Integration**

Invited Talk, IEEE 3DIC, October 8 – 10, 2019, Sendai, Japan

S. Scherbaum, C. Landesberger, B. Auer, H. Klingler, B. Brandstätter, E. Brandl, J. Bravin

**Toward improved FOWLP manufacturing by using self-alignment process**

Smart Systems Integration, April 10 – 11, 2019, Barcelona, Spain

R. Schönmann  
**Simulation of time-dependent molecular transport in vacuum systems**

Third European Contamination Modelling Workshop September 10 – 11, 2019, Friedrichshafen, Germany

M. Steinmaßl, J. Boudaden, H.-E. Endres, D. Reiser, M. Heigl, K. Neumeier, I. Eisele, C. Kutter

**Mikroanalysesystem auf Basis eines ladungs-empfindlichen Fluidsensors mit Rückseitenkontakten**

20th GMA/ITG Conference, Sensors and Measurement Systems 2019, June 25 and 26, 2019, Nuremberg, Germany

J. Weber  
**Technologies for 3D Heterogeneous System Integration**

Sinano Workshop "Heterogeneous Integration of Nanomaterials and Innovative Devices", ESSDERC/ESSCIRC 2019, September 23, 2019, Krakau, Poland

J. Wegener  
**Analytical Microtechniques to monitor cell and tissue phenotypes**

SEMICON 2019 November 12 – 16, 2019, Munich, Germany

J. Wegener  
**Profiling the pharmacology of G-Protein coupled receptors using label-free physical sensors**

Indian Analytical Conference December 12 – 14, 2019, Delhi, India

J. Wegener  
**Things you always wanted to know about the bioelectricity of living cells and their marriage with electronics – but never dared to study**

In Proc. 17th IEEE NEWCAS Conference, June 23 – 26, 2019, Munich, Germany

E. Yacoub-George, N. Palavesam, W. Hell, M. König, R. Faul, C. Landesberger, C. Kutter

**Ultra-thin flexible interposer – a flexible hybrid integration approach to replace wire bonds**

Smart Systems Integration April 10 – 11, 2019, Barcelona, Spain

## BACHELOR THESES

Maximilian Baringer  
**Untersuchungen zum Einfluss von Histaminika auf die Proliferation von Zelllinien mit endogener Histamin-Rezeptorausstattung**  
 Bachelor thesis, University of Regensburg  
 Supervisor: Prof. Joachim Wegener

Sophia Baumann  
**Entwicklung eines mikrogravimetrischen Wassertransportassays**  
 Bachelor thesis, University of Regensburg  
 Supervisor: Dr. Stefanie Michaelis

William Bittner  
**Untersuchung der Flussparameter von Membranpumpen für den Einsatz in der Zellkultur**  
 Bachelor thesis, Technical University Munich  
 Supervisor: Agnes Bußmann

Eduard Frank  
**Impedimetrische Untersuchungen zur GPCR-Aktivierung am Beispiel der humanen Histamin-1 und -2 Rezeptoren**  
 Bachelor thesis, University of Regensburg  
 Supervisor: Prof. Joachim Wegener

Linda Frank  
**Optimierung und Bewertung eines Impedanz-basierten Assays zur Untersuchung des transepithelialen Wasserflusses**  
 Bachelor thesis, University of Regensburg  
 Supervisor: Prof. Joachim Wegener

Richard Ganser  
**Entwicklung eines Messaufbaus zur Charakterisierung piezoelektrischer Keramiken**  
 Bachelor thesis, Munich University of Applied Sciences  
 Supervisor: Agnes Bußmann

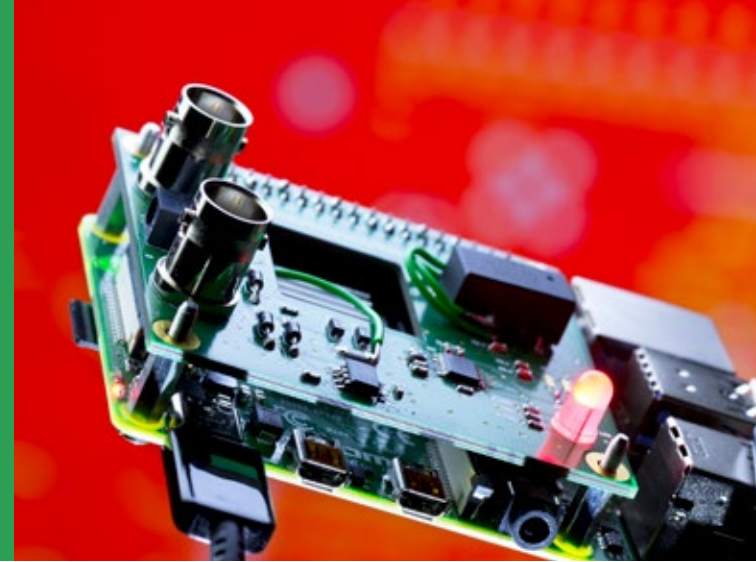
Judith Kraus  
**Impedimetric Analysis of Tissue Models**  
 Bachelor thesis, University of Regensburg  
 Supervisor: Pierre Pütz

Azer Ben Mahmoud  
**Evaluation of a Human Body Model (HBM) Two-Pin Tester**  
 Bachelor thesis, Technical University Munich  
 Supervisor: Dr. Johannes Weber

Shawn Tian U Qi  
**Detection Methods of Nitrate**  
 Bachelor thesis, Technical University Munich  
 Supervisor: Jamila Boudaden

Oliver Zett  
**Hochfluss- und Hochdruckoptimierung von Mikromembranpumpen**  
 Bachelor thesis, Technical University Munich  
 Supervisor: Lorenz Grünerbel





Messschaltung für Mikromembranpumpen

## MASTER THESES

Saphia Azzam

**Entwicklung und Anwendung eines photochemischen Wundheilungssassays**

Master thesis, University of Regensburg  
Supervisor: Dr. Stefanie Michaelis

Stephan Böck

**Design and Realization of a Measuring Circuit for Self-Sensing Micropumps**

Master thesis, Technical University Munich  
Supervisor: Johannes Häfner

Jakob Eppinger

**Entwicklung und Test einer Messschaltung zur Extraktion fluidischer Parameter in piezoelektrischen Mikromembranpumpen**

Master thesis, Technical University Munich  
Supervisor: Johannes Häfner

Florens Welf Fraidling

**Anomaly Detection in Time Series Data with Neural Networks**

Master thesis, Munich University of Applied Sciences  
Supervisor: Franz Wenninger

Shivananda Halladamath

**Design methodology of a low power MEMS- Particulate Matter capacitive sensor for real-time sensing platform**

Master thesis, University of Siegen  
Supervisor: Prof. Linus Maurer, David Borggreve, Frank Vanselow

Xinrui Ji

**Memristive Phenomena in Nanoparticle-based Devices**

Master thesis, Technical University Munich  
Supervisor: Prof. Marc Tornow

Yitao Jin

**Classification of Water and Materials Using Short Near-Infrared Image Based on Support Vector Machine**

Master thesis, Technical University Munich  
Supervisor: Dietrich Dumler

Mohamed Lamin Kanu

**An Empirical Study on Project Control: Applying Earned Value Management and Risk Monitoring at Fraunhofer EMFT**

Master thesis, FOM University of Applied Sciences for Economics and Management  
Supervisor: Andrea Keill

Johanna Markl

**Old but Gold? Who Cares? Wie können Pflegekräfte in ihrer Arbeit unterstützt werden?**

Master thesis, Hof University of Applied Sciences  
Supervisor: Pirjo Larima-Bellinghoven, Dr. Sabine Trupp

Gagandeep Singh Matharoo

**Dip-coating versus spin-coating: Different methods for forming organophosphonate self-assembled monolayers on titanium nitride**

Master thesis, Technical University Munich  
Supervisor: Prof. Marc Tornow

Florian Pommerening

**Entwicklung und Evaluierung eines Dosiersystems zur indirekten Förderung von partikelbeladenen Flüssigkeiten mit integrierter Volumenkontrolle und Partikelzählung**

Master thesis, University of Stuttgart  
Supervisor: Agnes Bußmann

Kiran Vani Himaja Sarma Ravada

**Investigation of Shear Forces using Coupled ANSYS Simulation of Micro Diaphragm Pump Dynamics**

Master thesis, University of Rostock  
Supervisor: Claudia Durasiewicz

Catherine-Christiane Scholtes

**In vitro quantification of epithelial barrier function: sensitivity enhancement of impedance-based transfilter measurements**

Master thesis, University of Regensburg  
Supervisor: Prof. Joachim Wegener

Oleg Sakolski

**Design of a High Voltage Linear Regulator with Current Sinking Capability for Capacitive Micromachined Ultrasonic Transducer Driver Circuit**

Master thesis, Technical University Munich  
Supervisor: Frank Vanselow, Prajith Kumar Poongodan

Olfa Sayadi

**Simulation assisted development of photomasks for grayscale lithography**

Master thesis, Technical University Munich  
Supervisor: Bassem Badawi

Simone Schafhauser

**Wet-chemical process for delayering Microchips**

Master thesis, University of Regensburg  
Supervisor: Nicola Kovač, Dr. Horst Gieser

Andrej Seb

**DNA Fokussierung in folienbasierter Mikrofluidik**

Master thesis, Munich University of Applied Sciences  
Supervisor: Dr. Anna Ohlander, Dr. Indranil Ronnie Bose

Kiran Krishna Tunuguntla

**Detection and Classification of Semiconductor Processes using Deep Learning Neural Networks**

Master thesis, Technical University Munich  
Supervisor: Bassem Badawi

Akshay Wankhade

**Investigation of Transient Micro Diaphragm Pump Dynamics**

Master thesis, Technical University Chemnitz  
Supervisor: Claudia Durasiewicz

Lei Zhang

**Design of a Charge Pump for a 4.3GHz Frequency Synthesizer in 22nm FD-SOI CMOS Technology**

Master thesis, Technical University Munich  
Supervisor: Büşra Taş Ulaşlı, Enno Böhme





CDM Bausteintest mit dem ATIS MCDM3

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## DOCTORATES

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Florian Urban

**Impedance-based Analysis of Epithelial Barrier Function: New Assays and Devices**

Doctoral dissertation

(Dr. rer. nat.) at the Faculty of Chemistry and Pharmacy, University of Regensburg.

The doctoral dissertation was completed from 2016 to 2019 as part of a cooperation between Fraunhofer EMFT (Cell-Based Sensors) and the University of Regensburg. The dissertation was submitted to the University of Regensburg on September 12, 2019 and successfully defended on November 8, 2019.

The dissertation was supervised by Prof. Joachim Wegener.

Johannes Weber

**Pulsed High Current Characterization of Highly Integrated Circuits and Systems**

Doctoral dissertation (Dr.-Ing.) at the Faculty of Electrical Engineering and IT, Bundeswehr University Munich.

The doctoral dissertation was completed from 2016 to 2019 at Fraunhofer EMFT in Munich. The dissertation was submitted to the Bundeswehr University Munich on April 8, 2019 and successfully defended on July 25, 2019.

The dissertation was supervised by Prof. Linus Maurer.

In addition, the following doctoral dissertations were supervised by Fraunhofer EMFT professors in 2019:

Vincent Immler

**Higher-Order Alphabet Physical Unclonable Functions**

Technical University Munich, Prof. Christoph Kutter

Zlatko Paric

**Development of a Dual ECIS-SPR Sensor Platform for Cell-Based Assays: Label-Free Analysis of G-Protein Coupled Receptor Signal Transduction**

University of Regensburg, Prof. Joachim Wegener

Simon Pfähler

**Electronic Transport Studies on Hybrid Organic-Inorganic Semiconductor Devices on the Nanoscale**

Technical University Munich, Prof. Marc Tornow

Kai Saller

**Direct Printing of Large Area Metal Thin Film Electrode Pairs with Nanometer Spacing onto Organic Thin Films Using Molecular Beam Epitaxy Based Stamps**

Technical University Munich, Prof. Marc Tornow





Zuverlässigkeitsprüfung von dünnen Chip-Folienpackages

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## PATENTS

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### **Ein Verfahren zur Ermöglichung planarer dünner Packaging für MEMS Sensoren**

Ronnie Bose, Christof Landesberger  
EP 3 480 164 A1

### **Verstärkung der Empfindlichkeit und Erhöhung der Selektivität für Fluid Sensoren durch Sensorgeometrie**

Ignaz Eisele, Karl Neumeier, Martin Heigl, Daniel Reiser  
WO 2019 063 650

### **PUF-Film and Method for Producing the same**

Martin König  
EP 3550623 A1

### **Wafer-Kassette mit elektrischen Kontaktflächen für die beladenen Wafersubstrate**

Christof Landesberger  
DE 10 2009 025 681.4

### **Mobilgerät zum Bestimmen eines Bestandteils in Umgebungsluft**

Martin Richter, Christof Jenke, Siegfried Röhl, Christoph Kutter  
US 10/386,350

### **Verfahren und Haltevorrichtung zum Herstellen einer Mikropumpe mit mechanisch vorgespanntem Membranaktor**

Martin Richter, Christoph Kutter, Siegfried Röhl, Yücel Congar, Martin Wackerle  
WO 2019/219600 A1

### **Vorrichtung und Verfahren zur Detektion von Gasen**

Sabine Trupp, Michael Henfling, Dieter Hemmetzberger  
DE 10 2018 206 917.4

### **Halbleitervorrichtung und Verfahren zur Herstellung einer Halbleitervorrichtung**

Sabine Trupp, Michael Henfling, Karl Neumeier  
DE 102017 200 952

### **Semiconductor device and method of producing a semiconductor device**

Sabine Trupp, Michael Henfling, Karl Neumeier  
US 10/519,034

### **Verfahren zur Herstellung einer Vorrichtung zur sensorbasierten Untersuchung biologischer Zellen, hergestellte Vorrichtung und Verwendungen hiervon**

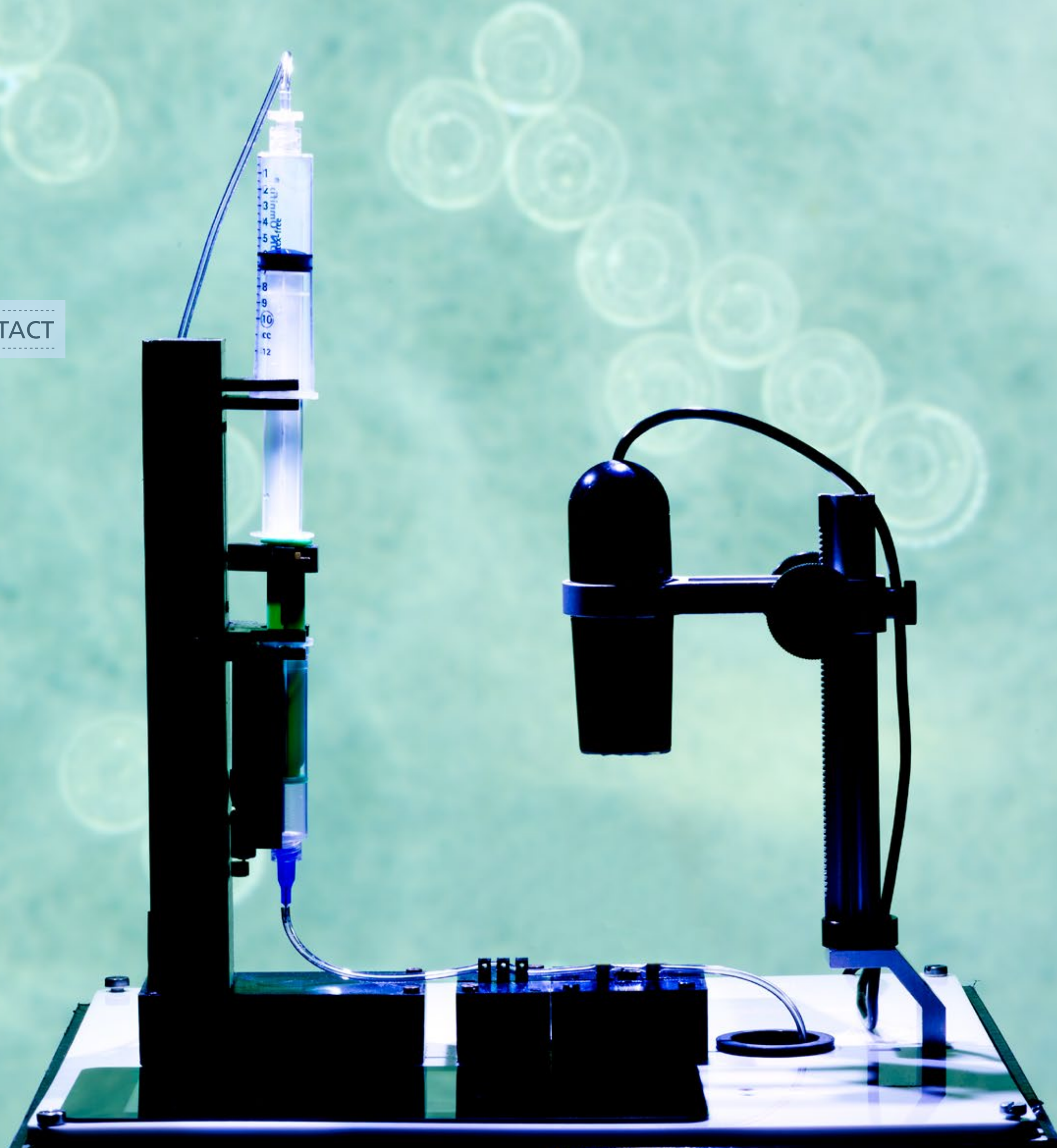
Joachim Wegener, Stefanie Michaelis  
WO 2019/072588 A1

### **Vorrichtung zur Kultivierung und strahlungsinduzierten Abtötung von Zellen und Verfahren zur Untersuchung einer Migration und/oder Wundheilung**

Joachim Wegener, Carina Schmittlein, Michael Skiba  
WO 2019/091939 A1

## CONTACT

*Measurement system for the automated examination of indirect pumping of particle-laden liquids*





## CONTACT

### Fraunhofer Research Institution for Microsystems and Solid State Technologies EMFT

Hansastraße 27 d  
80686 München  
Phone: +49 89 54 75 90  
Fax: +49 89 54 75 95 50

[www.emft.fraunhofer.de](http://www.emft.fraunhofer.de)

#### Director



Prof. Dr. Christoph Kutter  
Tel.: +49 89 54 75 95 00  
Christoph.Kutter@  
emft.fraunhofer.de

#### Marketing, Communications and Strategy



Pirjo Larima-Bellinghoven  
Tel.: +49 89 54 75 95 42  
Pirjo.Larima-Bellinghoven@  
emft.fraunhofer.de

#### Business Development



Prof. Dr. Peter Kücher  
Tel.: +49 89 54 75 92 41  
Peter.Kuecher@  
emft.fraunhofer.de

#### Strategic Projects



Dr. Peter Ramm  
Tel.: +49 89 54 75 95 39  
Peter.Ramm@  
emft.fraunhofer.de

#### Analytics and Technologies



Karl Ring  
Argelsrieder Feld 6  
82234 Weßling  
Tel.: +49 8153 4 03 20  
Karl.Ring@  
emft.fraunhofer.de

#### Circuits & Systems



Prof. Dr. Linus Maurer  
Tel.: +49 89 54 75 93 30  
Linus.Maurer@  
emft.fraunhofer.de

#### Microdosing Systems



Dr. Martin Richter  
Tel.: +49 89 54 75 94 55  
Martin.Richter@  
emft.fraunhofer.de

#### Sensor Materials



Dr. Sabine Trupp  
Tel.: +49 89 54 75 95 61  
Sabine.Trupp@  
emft.fraunhofer.de

#### Cell-Based Sensorics



Prof. Dr. Joachim Wegener  
Universitätsstr. 31  
93053 Regensburg  
Tel.: +49 941 9 43 45 46  
Joachim.Wegener@  
emft.fraunhofer.de

#### Flexible Systems



Christof Landesberger  
Tel.: +49 89 54 75 92 95  
Christof.Landesberger@  
emft.fraunhofer.de



Dr. Alexey Yakushenko  
Tel.: +49 89 54 75 92 11  
Alexey.Yakushenko@  
emft.fraunhofer.de

#### Silicon Technologies and Devices



until January 31, 2020:  
Prof. Dr. Ignaz Eisele  
Tel.: +49 89 54 75 91 89  
Ignaz.Eisele@  
emft.fraunhofer.de



from February 1, 2020:  
Dr. Wilfried Lerch  
Tel.: +49 89 54 75 91 90  
Wilfried.Lerch@  
emft.fraunhofer.de



Prof. Dr. Marc Tornow  
Tel.: +49 89 54 75 95 51  
Marc.Tornow@  
emft.fraunhofer.de

---

## CONTACT

---

ZVE – Center for Interconnection Technologies

Oberpfaffenhofen  
Argelsrieder Feld 6  
82234 Weßling

Tel.: +49 89 54759-440  
Fax: +49 89 54759-515

[www.zve-kurse.de](http://www.zve-kurse.de)



Dr. -Ing. Frank Ansorge  
Tel.: +49 89 54 75 94 56  
Frank.Ansorge@  
emft.fraunhofer.de



Günter Paul  
Tel.: +49 89 54 75 94 18  
Guenter.Paul@  
emft.fraunhofer.de



Silke Paul  
Tel.: +49 89 54 75 94 40  
Anmeldung@  
emft.fraunhofer.de



Dirk Schröder  
Tel.: +49 89 54 75 94 17  
Dirk.Schroeder@  
emft.fraunhofer.de



Monika Schmidt  
Tel.: +49 89 54 75 94 00  
Anmeldung@  
emft.fraunhofer.de



Jürgen Weise  
Tel.: +49 89 54 75 94 10  
Juergen.Weise@  
emft.fraunhofer.de

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## PUBLISHING NOTES

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Fraunhofer EMFT Annual Report 2019

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Fraunhofer EMFT  
Hansastraße 27d  
80686 München  
Tel.: +49 89 54 75 90  
Fax.: +49 89 54 75 95 50

**Director of the Research Institution**

Prof. Christoph Kutter  
Tel.: +49 89 54 75 95 00

**Editors:**

Pirjo Larima-Bellinghoven  
Tina Möbius  
Sophia Drimmel  
Regina Böckler  
Johanna Markl

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**Cover photograph:**

4.3 GHz fractional-N frequency synthesizer IC in 22nm FDSOI technology on the evaluation circuit board

**Picture on intermediate page (p. 2/3):**

Capacitive sensor for integration in wound dressings

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