Annual Report

2014
Annual Report 2014
FOREWORD
Dear friends and partners of the Fraunhofer Research Institution for Microsystems and Solid State Technologies EMFT, dear reader,

In 2014 we set ourselves the aim of further extending our customer relations. This we have been successful in doing: as a result of intense exchange with both new and existing customers, we have been able to transfer several of our research topics to industrial projects. Particular interest was shown in our microdosage systems and talks in this area have been very successful. As a result, our micropumps will soon be found in products for a range of different applications. In the field of sensorics, too, our research has achieved excellent results – such as our extremely low-noise components for sensor applications, for example.

Fraunhofer EMFT was an active participant in scientific dialog throughout 2014, too: we organized the important Trillion Sensors Summit for Europe, bringing together high-ranking experts from research and industry to discuss sensor technologies and new sensor applications. The summit demonstrated especially clearly the enormous extent to which sensors will simplify and impact on our lives in the years to come.

Other highlights were the Sensor Roadmap Workshop which we organized in collaboration with Yole Developpement and also our traditional „Be Flexible“ forum – both of which attracted great interest.

Meanwhile we have undertaken internal restructuring, in particular in the areas of quality management and project management. The aim here is to enhance our performance capacity vis-à-vis our industry partners so as to become the partner of preference for applied sensor development. Optimizing these two processes will remain a key focus for us in the coming years.

I am especially pleased to see how Fraunhofer EMFT has become increasingly popular among scientists and students. In 2014 a large number of students completed internships with us as well as bachelor’s and master’s degree assignments in various areas. In the area of ESD and 3D integration we also welcomed two renowned guest scientists as visiting professors who contributed fresh ideas and stimuli.

Another highlight of the year was of course our 40-year anniversary celebration at which we took a look back over the history of the Fraunhofer microelectronics site in Munich and discussed future challenges and visions with some 170 invited guests from the fields of science, business and politics. Many former employees, longstanding partners and friends came together and much enjoyed sharing stories from the past. Our doctoral candidates gave presentations to show where our present journey is taking us and what innovative new ideas we are currently researching and working on: research into innovative sensor and actuator systems for people and the environment.

Dear reader, all that remains is for me to hope very much that you enjoy reading our 2014 annual report.

Yours sincerely

Prof. Dr. Christoph Kutter
Director of the Fraunhofer Research Institution for Microsystems and Solid State Technologies EMFT
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FRAUNHOFER EMFT
Fraunhofer EMFT is engaged in top-level applied research into sensors and actuators for people and the environment.

History

Fraunhofer EMFT was formed from the Fraunhofer Institute for Solid State Technology IFT, which was founded in 1974. Here, technologies were developed for the manufacture of semiconductors. Other areas of activity were sensor technology, communication technology and microstructure technology.

In 1999 the Fraunhofer IFT was dissolved and split into three independent sections. The section located in Hansastrasse, Munich – today’s Fraunhofer EMFT – initially became part of the Berlin-based Fraunhofer Institute for Reliability and Microintegration IZM. Fraunhofer EMFT itself was founded on July 1, 2010, as an independent institution once again, created from the Munich branch of the Fraunhofer IZM.

Profile

In its research and development work, Fraunhofer EMFT focuses on sensors and actuators for people and the environment. Sensors already have a key role to play in our digitized world and will become increasingly important in the years to come as a result of the interconnection of devices („Internet of Things“). People may not actually notice sensors, but the latter will make a significant contribution to improving the quality of living in areas such as health and nutrition, mobility and material analysis. Fraunhofer EMFT actuators will be used in micropumps and microvalves in medicine and industry, for example.

In defining its research fields, Fraunhofer EMFT always attaches priority to practical application. The institution gets together with customers to assess areas which are important for the market and where Fraunhofer EMFT can make a significant contribution with its expertise. The aim of applied research is to create added value for society and for the economy. This added value consists of transferable work results, operational components and systems and qualifiable prototypes. Cutting-edge research means occupying a leading position in global competition. Fraunhofer EMFT is a sought-after guest on the relevant committees, conventions and conferences and is proactively involved in organizing such forums itself. The results of Fraunhofer EMFT’s work appear in a wide range of academic publications and attract a high level of interest in the world of science.

Fraunhofer EMFT’s most important asset is its highly-qualified staff. The institution trains young scientists working on bachelor’s, master’s and doctoral assignments and attaches great importance to the ongoing professional development of its permanent employees. Due to the institution’s long history, the Fraunhofer EMFT team has a very broad background and experience as well as excellent familiarity with the world of microelectronics and microsystem technology. The staff’s high level of motivation and the satisfaction they derive from their work result in exceptional commitment and dedication, ultimately producing good results.
The institution in figures

Total budget

Fraunhofer EMFT performed successfully in fiscal year 2014. The institution’s total budget amounted to approximately 11 million euros in 2014. Industry contracts generated a total volume of 2.8 million euros, accounting for approx. 26.5% of the total. Ongoing expansion of the institution is planned for 2015, involving a further increase in industrial revenue.

Personnel development

Fraunhofer EMFT currently employs a staff of 91. Of these, 67 work in the scientific area and another 24 in the areas of administration, marketing, IT and technology. On average there are also 21 students and research assistants from a wide range of institutions working on their doctoral thesis, dissertation or master’s assignment at any given time, who are involved in the various research areas at Fraunhofer EMFT.

Infrastructure

The Fraunhofer EMFT building consists of the following infrastructure:

Cleanrooms (640 m²):
- according to DIN EN ISO 14644-1, ISO class 5 (previously 100 US FED standard) and 4 (previously 10 US FED standard)
  - 200 mm line with complete range of standard silicon CMOS equipment
  - 150 mm line with complete range of standard silicon MEMS equipment

Laboratories (1600 m²):
- polytronics, microfluidics, bioanalytics, analysis and testing (ATIS), guest companies

Office areas and meeting rooms (2760 m²):
  - Offices (1520 m²)
  - 3 seminar rooms (50 m², 55 m² and 80 m²)
  - 4 meeting rooms (190 m²)
  - 1 video conference room for 15 people (50 m²)
Advisory Board

The Fraunhofer EMFT Advisory Board is a consultative and supervisory body. It consists of a number of distinguished representatives from the areas of science and business. Members of the Fraunhofer EMFT Advisory Board advise the institution management and Fraunhofer board on issues relating to the specialist orientation and structural development of the institution.

Chair:
Dr. Hans-Jürgen Bigus
Hirschmann Laborgeräte
GmbH & Co. KG

Deputy chair:
Prof. Dr. phil. Merith Niehus
Universität der Bundeswehr
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Siemens AG,
Corporate Technologies

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Infineon Technologies AG

Member:
Dr. Stefan Wimbauer
Bavarian Ministry of Economic Affairs and Media, Energy and Technology, Munich
BUSINESS AREAS WITH EXAMPLES OF PROJECTS
Fraunhofer EMFT has grouped its research and development programs into five business areas geared towards optimizing human living space and the natural environment. The fields of application for the technologies developed are highly varied, ranging from mechanical engineering and automotive electronics to medical technology and chemical engineering. The research and development services provided by Fraunhofer EMFT include strategic preliminary research, bilateral industry projects and the coordination of industrial project consortiums. All development is consistently focused primarily on practical, customer-oriented solutions.

1. Sensor Materials
   - Sensor foil to secure system integrity

2. Sensors and Actuators
   - Lab-on-Chip in use in the field

3. Microdosage Systems

4. Flexible Systems

5. Design and Test
At Fraunhofer EMFT, sensor materials are developed for applications in the field of chemosensorics and biosensorics. The focus is on solutions which deliver results quickly and reliably, make do with simple (mobile) analysis devices and in some cases do not even require a power supply.

Even today, sensors already perform the function of a „sixth sense“: they detect parameters not accessible to human perception such as toxic or irritant substances, germs or radiation. Examples of their application include early diagnosis of certain illnesses, effective occupational safety measures in laboratory environments and quality control in the area of foodstuffs, drinking water and production processes.

In its Sensor Materials business unit, Fraunhofer EMFT develops sensor materials that indicate the presence of certain substances or bacteria. For this purpose, Fraunhofer EMFT scientists apply the relevant receptor groups to the sensor molecules, and these react selectively and sensitively with defined analytes. This reaction changes the properties of the sensor molecules, either producing a different color or fluorescence or else resulting in a change in electrical parameters. The intensity of the change depends on analyte concentration. The best detection method is selected depending on the concrete requirements of the application (electrical or visual) and the sensor molecule is adapted to the target analyte.

Integration of this type of sensor material in polymers, foils and textiles opens up a wide range of applications. These can be integrated as non-electrical color-change materials in food packaging and serve as a freshness indicator, for example. As a component of protective clothing they can warn laboratory staff in the event of contamination with hazardous substances. Another area of use of sensor materials are gas detection systems, where concentration is identified based on a change in electrical parameters.

Fluorescence-based sensor materials enable rapid detection of bacteria. In combination with highly sensitive detectors developed by Fraunhofer EMFT, for example, sensor materials provide the basis for measuring devices used for online monitoring of CO₂ content and point-of-care diagnostics.

Based on this extensive expertise, Fraunhofer EMFT offers its customers individually tailored solutions geared precisely to the specific area of application in question.
Project: PROWEAR – Development of intelligent protective clothing as a warning system for those working in potentially harmful environments

Project partners: IAB Weimar GmbH, Spengler & Fürst GmbH & Co. KG, Beb Carl O. Liebetruth GmbH

Funding program: Central Innovation Program SME – German Ministry for Economic Affairs

What is protective clothing with sensor materials needed for?

In the drainage and treatment of sewage, employees come into contact with chemical and biological substances which are potentially harmful. In the project PROWEAR, we develop intelligent protective clothing that changes color as soon as it comes into contact with harmful substances. The intensity of the color change will depend on the concentration of the contaminant. This is a very effective way of warning employees of contaminations early on and therefore protecting them.

How does it work?

The clothing is fitted with sensor dyes that react chemically with certain substances such as carbon dioxide. As a result, properties of the sensor dye are modified and we see this as a change in color.

When the sensor dye in the protective clothing clearly changes color, this is directly linked to the hazardous substance, thereby performing a warning function.

What are your concrete focus areas in this project?

We start by identifying the relevant hazardous substances and then we develop the appropriate sensor dyes with which to detect them. Our work also involves characterizing the materials in the lab, as well as producing the protective clothing itself under normal conditions – which we do in collaboration with our partners. The consortium also carries out studies to test the reliability and stability of the clothing. The final stage is to run small-scale field tests using prototypes.

What are the benefits of this protective clothing as compared to existing solutions?

Protective clothing that changes color to warn its wearer of hazardous substances has not existed before, whether as a product or a prototype. The advantage is that the sensor materials used can be adapted specifically to the requirements of the application area. Another important point is that this type of sensor-based protective clothing has to do without electric power and other aids such as measuring devices to analyze the information. In this way it provides an effective supplement to regular occupational safety measures and improves the safety of employees.
This business area targets the development of new types of sensor for parameters not yet addressed by the market, with the potential of opening up whole new markets. The institution also offers its customers a wide range of different services such as process development, small batch production of sensors and actuators and qualification of process media.

Another aim is to enable objects to network with one another. The Sensors and Actuators business unit acts as a central hub, allowing visions such as the „Internet of Things“ to take shape. For this to happen, the intelligent helpers have to be more refined, more functional and more robust – as well as allowing for low-cost production.

Fraunhofer EMFT offers its customers a universal portfolio of services: from process development through to the design and production of components and even the creation of sensor nodes for complex systems.

In process development for silicon-based sensors, for example, the institution has a technology platform closely based on actual production conditions which allows testing and optimization of new process media or process stages so as to increase performance and efficiency. Existing equipment also allows small batch production in cases where small quantities are not available on the global market, for example.

The set-up available includes a 200 mm CMOS/MEMS line (where all processes comply with the CMOS standard) and a MEMS line for non-CMOS compatible materials. Tools for mask layout and process characterization are also available.

In developing sensors and actuators, the institution is geared towards market needs: while elaborate concepts already exist for measuring physical parameters, for example, there are very few established solutions in the area of chemical and biological parameters. For this reason, research in the area of physical sensors targets the aspects of cost reduction and enhanced performance. New overall concepts need to be developed for chemical and biological transducers. Here Fraunhofer EMFT is working on projects to develop sensors which measure the CO₂ level in the environment, for example. Another market is specialized electronics: this provides the interface between sensors and the digital world. In this context, Fraunhofer EMFT researchers develop highly sensitive, low-noise amplifiers to detect the very smallest signals.

In future, however, sensors will operate less and less on a standalone basis. The idea is to connect them with their environment: solutions currently available on the market do not yet meet all the requirements here. For this reason, scientists at Fraunhofer EMFT are currently working on two new concepts to create sensor nodes. The first approach involves subsequently modifying fully processed wafers with complete sensor system electronics by means of add-on processes, thereby incorporating the required functions. These techniques were introduced and successfully implemented at the institution under the name of MOTT (Multifunctional On-Top Technologies), one example being a cooperative venture with industry to produce moisture sensors in mobile phones. The second approach involves integrating passive components such as antennas or coils and active components such as sensors and actuators in a smart substrate. The various chips for signal analysis and data management are then connected to the substrate by means of heterogeneous system integration. The aim is to establish a universal, modular technology set-up at the institution so as to allow fast and low-cost creation of sensor node system solutions for the industry.
Project: Impedance spectroscopy for condition monitoring – sensor platform as an example of a room climate sensor

Project partners: Kaufbeurer Mikrosysteme Wiedemann GmbH (KMW), Tapko Technologies GmbH, IS-LINE GmbH

Funding program: Mikrosystemtechnik Bayern

What is the project about?

Our aim is to establish a modular sensor platform to act as a basis for low-cost condition monitoring systems using impedimetric sensors. As an exemplary application we are developing an HVAC sensor module – HVAC stands for heating, ventilation and air conditioning. Nowadays, ventilators and humidifiers often run continuously, even though a room may not be used for many hours. On the other hand, an air conditioning system set to permanent operation may often be insufficient if a room is full of people. Our system of integrated sensors for temperature, humidity and CO₂ aims to achieve an optimum room climate and improve energy efficiency by coordinating the three parameters and regulating air conditioning according to needs.

What is the advantage of this system as compared to existing solutions?

Up to now, sensor systems have been based on a range of individual sensors which is ultimately a rather expensive approach. Only sensor fusion enables low-cost serial manufacture as required for mass implementation.

What are the focus areas from the Fraunhofer EMFT perspective?

A sensor platform is required so as to integrate the sensors in the electronic system to create a low-cost module. We develop such a platform for a range of capacitive, resistive sensors as well as for sensors which are based on frequency. We also design the low-cost electronic module with standard interface. Another point is optimization of the sensor elements: Our humidity and CO₂ sensors currently have a sensitive organic layer which still has rather a short service life.

What other areas of application are there for this type of low-cost sensor module?

CO₂ detectors could make smoke alarms more effective and reliable, for example – conventional devices are only triggered by dust particles in the air. Other areas of use include improved control or monitoring of the combustion process in small-scale power stations and domestic heating systems or optimizing air conditioning systems in vehicles.

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Dosage of minute quantities of liquids or gases is crucial to a wide array of sectors nowadays. Microdosage systems are used in tool and mold making as well as in medical technology. The various applications give rise to widely varying and very specific requirements of micropumps and dosage systems, and it is impossible for suppliers of standard commercial products to meet such diverse demands.

For this reason, Fraunhofer EMFT offers its customers individually tailored microdosage solutions for the most varied applications. These range from the design of individual parts and systems through to component development and the realization of entire microdosage systems including transfer to products suitable for industrial production. Our scientists focus on the optimum interplay of all components even during the planning and conception phase, taking into account the entire system to be developed and designing the various components with this in mind. The design expertise of Fraunhofer EMFT scientists includes fluid actuators (pumps, valves), electronic monitoring systems (e.g. flow sensors) and control mechanisms for the management of disturbance variables (such as safety valves, bubble-tolerant filters, degassers, bubble separators).

There are currently two technology platforms available for the development and production of microfluid actuators: one for silicon and one for high-grade steel (currently being set up). Finally, the technology portfolio also includes special piezo assembly techniques and automated tests for pump wafers at wafer level. If required, Fraunhofer EMFT is also able to offer its customers support in transfer to the market: here the institution has access to a broad network of partner companies such as subcomponent suppliers. Robust, precise and yet miniaturized microdosage systems offer considerable application potential: in the area of medication dosage, externally portable microdosage systems could be used for pain therapy, treatment of tinnitus, hormone therapy, tumor therapy and diabetes therapy.

All these applications require precise dosage of the minutest quantities. At the same time, the disposable dosage components used have to be very low-cost. Micropumps can also provide valuable services in the area of vacuum therapy, for example when treating chronic wounds. In tumor therapy, implantable microdosage systems made of silicon could be used to target tumor cells directly with very small amounts of a highly concentrated cytotoxin. In the field of mechanical engineering and plant construction, microlubrication systems will make it possible to apply tiny quantities of lubrication oil to bearings, thereby saving 98% of lubricant consumption.

Meanwhile, there is still a range of interesting challenges in the field of microdosage: these include the management of bubbles, particles and back pressure, monitoring the dosage of minute quantities and also chemical resilience.

Fraunhofer EMFT works on all these issues so as to be able to develop robust products on behalf of and in collaboration with its customers.
what is the role of the micropump you are developing?

Conventional fire detectors do not respond until smoke penetrates the casing, whether by means of diffusion or thermal lift. What is more, they only measure every 20 seconds. Our micropump is a low-cost 20 mm steel pump with flow rates of up to 100 ml/min, and it actively draws in air, thereby ensuring that “fresh” outside air is fed to the sensor second by second. Miniaturization is important here as our customer does not want these new fire alarm systems to be installed in ceilings only: eventually the aim is to make them suitable for integration as micromodules in virtually all electronic devices and systems – such as washing machines, power generators, servers, vacuum cleaners and industrial plants. The idea is to make fire detection considerably more reliable and fast due to the large number of sensors and their proximity to potential fire sources. We also hope to make significant progress in early fire detection.

What is the „SMOKESENSE“ project about?

In collaboration with our partners, we are developing a novel „intelligent“ fire alarm system. The core components are a multi-gas sensor and a micropump – we are responsible for the latter.

What are the benefits of the new system as compared to existing solutions?

Conventional fire alarms are generally quite high-maintenance and tend to have a long response time, depending on how far they are from the source of the fire. False alarms occur frequently, too. In our system, the multi-gas sensor detects specific gases before a fire breaks out, acting as a kind of „electronic sniffer“: before the fire starts, the material heats up and lets off typical odors which are registered by the sensor. So ideally, the SMOKESENSE system is able to sound the alarm before a fire actually starts in the first place. The system also means that false alarms are virtually impossible. Installation is very straightforward, too: one of our project partners has integrated a power-line communication function in the system via the power cable. This enables sensor networks to be installed via existing power lines without additional wiring.
The business area “Flexible Systems” produces ultrathin components such as sensors and integrated circuits and incorporates these in entire systems on foil. The development portfolio ranges from large-area, flexible wiring systems, three-dimensional assembly and connection systems through to printed circuits and systems.

In order to provide a networked environment geared towards human needs, electronic systems are required which blend into our everyday lives inconspicuously. Recent years have seen increasingly miniaturized electronic components and systems being developed in this field. Today the focus is primarily on their flexibility as an enabling technology: only flexible electronics provides shapes and designs that are no longer constrained by rigid structures, thereby laying the foundation for new applications and products.

The possibilities range from intelligent packaging that tells us about what the contents to sensor systems for the purpose of driver assistance – directly integrated in an automobile windscreen – and disposable medical diagnosis systems on foil.

Bendable substrates are what make the systems flexible, and these are also suitable for the production of large-area systems. They include plastic foils, paper, textiles and even laminated substrates specific to particular applications such as thin glass or metals. Production makes use of printing technologies in conjunction with conventional technologies and processes including silicon, MEMS and circuit board technology. The Fraunhofer EMFT development team has also developed new manufacturing and handling techniques for very thin silicon wafers, as well as the patented chip separation technique known as “dicing-by-thinning”. These techniques can be used to create ultrathin flexible silicon components with a thickness of 10-30 µm.

In addition to its development skills, Fraunhofer EMFT has longstanding expertise and the necessary laboratory facilities to be able to produce this type of multifunctional electronic systems efficiently and cost-effectively on foil using roll-to-roll methods. This is of particular interest for products in the field of FOLAE (Flexible Organic and Large Area Electronics) such as electronic paper, rollable displays and “intelligent” floors, and it can also be applied to disposable sensors in such areas as medical technology.

The Bavarian Polytronic Demonstration Center (BDP) has been in operation at Fraunhofer EMFT since 2002. The technology cluster offers cutting-edge, production-like equipment such as machines for modular processing of foil sheets and rolls which are 210 mm wide. So Fraunhofer EMFT customers and development partners have access not just to staff expertise but also an excellent infrastructure.
**Project: Inno(vation) Flex**

**Project partners:** Several industrial partners in the areas of healthcare, lighting and secure information systems

**Funding program:** InnovationFlex – Program of Bavarian Ministry of Economic Affairs and Media, Energy and Technology and Fraunhofer EMFT

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**What is the InnoFlex project about?**

Essentially, InnoFlex might be described as a kind of future workshop: it is a research program that offers customers and partners from industry the opportunity to create and test new technologies, processes and demonstrators for various areas of application in the field of flexible electronics. Our aim is to promote process transfer to industry.

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**Why is this kind of „catalyst“ so important?**

In industry, efficiency has top priority: the user has to be able to assess total costs, performance capacity and yield before investing in a new product. In the young technology of Flexible Electronics, however, this is still rather difficult. As a result, many companies hesitate to invest in development projects even though the level of interest is actually very high.

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**How is InnoFlex able to help remove obstacles to innovation?**

InnoFlex provides a framework for expanding the knowledge base relating to materials, processes and equipment, thereby making investments more calculable. It gives project partners access to our cutting-edge roll-to-roll infrastructure and they get support from our experienced and highly qualified specialists.

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**What are the long-term goals of the project?**

We hope the program will lead to long-term cooperation with various industry partners. Bearing this in mind, we are seeking to develop a self-contained pilot line for preliminary production stages and a ramp-up for flexible electronic components and systems in the foreseeable future.
The business area „Design and Test“ offers customers individually tailored services of widely differing types. These range from developing circuits and integrated components or complete systems or subsystems (devices) through to multiparametric characterization of such systems and reliability forecasts for planned applications.

Every product innovation starts with an idea, but from here it is a long way to go until implementation is achieved, and technological expertise is usually required from widely differing fields. For this development process, Fraunhofer EMFT offers its customers comprehensive support in its business area Design and Test – from realization of specific integrated circuits and components through to prototype development and reliability assessment. The guiding principle is the duality of simulation and experiment.

Microchips are at the heart of countless products: They cluster numerous functions within a minute space. However, very specific applications or 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 not available on the market in this form. Here, Fraunhofer EMFT supports its customers in the design of complex digital and mixed-signal circuits. If necessary, Fraunhofer EMFT scientists also develop customer-specific sensor- and microcontroller-based electronics as well as complete prototypes.

The service portfolio also includes extensive performance and reliability tests for electronic components. Based on multiparametric characterization, it is possible to simulate physical input variables such as voltage, current, temperature, light, moisture, gases etc. under laboratory conditions, determine the response of the component to these variables on its own and collectively and adjust the simulation accordingly.

The results serve as a basis for gathering evidence on measurement accuracy and reproducibility. By applying suitable load tests to address the relevant error mechanisms, it is also possible to determine anticipated reliability and service life. Finally, services include systematic analysis of the causes of complex errors and reliability problems in electronic components and systems, reproduction of these under laboratory conditions, and identification of falsifications.
What is the i-Tex project about?

In collaboration with our partners we develop large-area, energy-efficient lighting systems. To this end we integrate LEDs in textiles featuring fine conductor paths. In addition, the aim is to develop a low-cost and reliable roll-to-roll manufacturing process which integrates sensor and lighting systems in coated textiles.

Where will these „illuminated fabrics“ be used and what benefits do they offer?

Light has a major impact on our mood and our performance capabilities, so it is a key factor in the design of any living or working environment. Fortunately, lighting is no longer simply a matter of hanging a lamp from the ceiling. Textiles as light sources open up a whole new range of possibilities for aesthetic and functional lighting, both indoors and outdoors. For example, curtains could act as a light source in the evening. In high-quality tents, illuminated textiles could obviate the need for a torch.

What are the focus areas from the Fraunhofer EMFT perspective?

We are responsible for characterization and reliability. This means that we investigate visual properties, the conductivity of the electrical connections and the insulation between the conductors under the influence of temperature and moisture as well as the tensile and flexural stress applied to the textiles. We also look very closely at electrostatic discharge during the manufacturing process and develop appropriate protective measures. Otherwise the highly sensitive LEDs would be exposed to dangerous high-voltage static even during production.
OVERVIEW OF CORE COMPETENCES
Fraunhofer EMFT clusters its research and development activities into four core competences which are interlinked and mutually supportive where appropriate. Interdisciplinary collaboration between the four areas gives rise to novel sensor solutions. In this way, Fraunhofer EMFT expertise feeds into the entire value creation chain – “from the molecule to the system”.

**Functional Molecules and Surfaces**

In the Functional Molecules and Surfaces area, the aim is to develop molecules and particles with new properties and extended functionalities and then integrate them into various substances. These novel sensor materials are both sensitive and selective, offering enormous potential for the detection of chemical and biological parameters. Research into precise and reliable detection methods is much needed in these areas. What is more, measurement systems based on sensor materials offer the advantage of not requiring electric power. This means they are well suited to application areas where there is no infrastructure or difficult access, e.g. portable handheld devices in medical technology and environmental analytics.

Fraunhofer EMFT staff focus on the selective synthesis of indicator dyes, their integration in polymer systems or bonding with nanoparticles and the creation of functional polymers and surfaces by means of chemical modifications. In order to produce indicator dyes, Fraunhofer EMFT scientists apply suitable colorants with the relevant receptor groups, and these react selectively and sensitively with a defined analyte (synthesis). As a result, the visual properties of the dye are altered, which is reflected in a change of color or fluorescence.

This type of indicator dye can be used to make a whole range of sensor materials such as sensor particles which can be used as nanosensors for cell analytics. Where such sensor particles are synthetically structured, core-shell systems can be used to combine multiple functions and control properties such as hydrophilicity, hydrophobia or polarity. Fluorescence sensor particles can carry a reference dye at their core and an indicator in their outer cover or on their surface, for example. This type of system allows ratiometric fluorescence measurements to be carried out without the need for an appliance.

The indicator dyes can also be applied to surfaces by means of coating or printing techniques. In this way, researchers develop sensor foils, sensor textiles and even liquid sensor materials such as paints. In combination with Fraunhofer EMFT expertise in the area of semiconductor technology, indicator molecules of this kind can be used to create new sensor systems.

**Silicon Processes, Device and 3D Integration**

In future, sensor systems will be used more and more frequently in applications with particularly demanding requirements in terms of size, performance capacity and reliability. In the area Silicon Processes, Device and 3D Integration, the main focus is therefore on making sensor systems smaller, more efficient and more multifunctional so as to enable new areas of use. In addition to classic CMOS technologies, the relevant expertise breaks down into the areas of 3D integration/MEMS technology, Multifunctional On-Top Technologies, wafer thinning and epitaxy.

Fraunhofer EMFT has an industrially compatible in-house CMOS line for 200 mm slice production. The 0.65 μm CMOS process is used to make test circuits to assess new semiconductor processes, materials and system integration techniques, for example. Twin-well CMOS technology also allows modular integration of special components if required – such as N-channel JFETS and vertical npn-transistors. A particular
focus in the area of **CMOS technologies** is creating low-noise components and circuits.

Other focus areas are **silicon epitaxy** for high-impedance intrinsic layers and **silicon-germanium epitaxy (SiGe epitaxy)** for selectively strained layers or sacrificial layers. Combining silicon and SiGe epitaxy it is possible to make new components for microsystems engineering such as NEMS (Nano Electro Mechanical Systems with nanogaps). A low-temperature epitaxy system for silicon and SiGe is currently being created in order to extend expertise in this area. Depositions are to be carried out at temperatures as low as 450 °C, thereby allowing further handling of ready-processed CMOS circuits.

The technological expertise for producing **thin wafers** is an important basis for system integration. 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. Fraunhofer EMFT offers its patented “dicing by thinning” technique for the purpose of chip separation for very thin semiconductor wafers. These technologies can be used to create thin and flexible silicon chips with a thickness of 10 µm - 30 µm.

**3D Integration** is a key technology in creating miniaturized, multifunctional and high-capacity microelectronic components. Here, Fraunhofer EMFT staff have many years of experience with silicon through-platings (Through Silicon Vias; TSV). A key feature of this is the combination of tungsten vias with the structuring of subsystems based on intermetallic connections made of copper and tin. Vertical integration of the subsystems is carried out by means of standard CMOS-compatible slice production processes. An extensive technology portfolio is available, allowing flexible handling solutions for the most diverse components as supplied by the customer. Depending on the specific requirements, various process modules can be applied (etching, through-plating, low-temperature processes, SLID bond).

In the area of **MEMS technology** (Micro Electro Mechanical Systems), Fraunhofer EMFT has an extensive range of process modules for structuring and processing that enable individualized solutions to be realized even for small wafer quantities as well as the creation of complex MEMS components. Miniaturized components and highly integrated systems of this kind enable new potential applications as well as making numerous products more reliable, multifunctional and intelligent.

As a supplement to MEMS technology, Fraunhofer EMFT researchers are also active in the field of **Multifunctional On-Top Technologies (MOTT)**, looking at modular integration of new functionalities and components in existing standard silicon technologies. Here they are able to draw on extensive expertise from existing research results from work on CMOS circuits and 3D integration.

**Foil Technologies and Heterointegration**

Flexible, multifunctional electronics offer new possibilities for a range of smart, high-capacity products – in the context of the „Internet of Things“ vision, for instance. Here, **heterointegration of silicon and foil technology** has a key technological role to play: while silicon technology allows extremely miniaturized components to be realized, foil technology offers greater scope for design, enabling flexible, flat and biocompatible electronics.

With its laboratory facilities and technological experience in the area of **foil technologies** (polytronics) – especially roll-to-roll manufacturing technology – Fraunhofer EMFT has at its disposal a unique technology platform for the development of flexible electronics.

Production facilities offer an extensive portfolio of processes for coating, structuring and handling foils, right through to automated testing of flexible circuits. These make it possible to produce multiple, application-specific layer systems by
means of both screen printing and thin film technology. The equipment is essentially geared towards roll-to-roll production in order to ensure that developments in this field are as close as possible to real production environment.

Another focus of system integration on foil is heterointegration, which enables the combination of various technology worlds to provide effective solutions for the production of foil systems. In this connection, foil processes developed at Fraunhofer EMFT are combined with techniques drawn from various conventional technological fields (e.g. silicon, MEMS or circuit board technology). These technologies can be varied and supplemented as needed. What is more, the interfaces between the technologies can be adapted to the application in question. And last but not least, the processes can also be transferred to large-area and high-volume production techniques for system integration and product manufacture on flexible substrates.

Systems and Prototypes

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: especially SMEs often require complete solutions rather than individual components. In particular, extensive expertise in system development provides an essential basis for translating innovative technologies and solutions (such as energy harvesting and ultra-low power consumption) quickly and successfully into applications to create future-oriented products.

The development expertise of our experienced interdisciplinary team covers hardware and software, electronics, mechanics, optics and also fluidics with micropumps and microvalves. Our services in the area of system development range from drafting initial concepts through to feasibility demonstrators, prototypes and complete systems, depending on needs.

Systems and prototypes have been developed and produced in small series in various areas of application such as medical technology, bioanalytics, sensorics and wafer level testers for the semiconductor industry. When it comes to system design, modern tools are available for simulation, layout and construction which ensure a high level of sophistication. Fraunhofer EMFT also offers various manufacturing processes and technologies that make innovative approaches possible in the first place.

In sensitive areas such as medical technology in particular, legal requirements applying to new products are very demanding. The Fraunhofer EMFT team takes strict care to ensure that their customer-specific developments comply with these regulations: after all, this is crucial for a smooth and successful market launch.
RANGE OF SERVICES OFFERED BY FRAUNHOFER EMFT
Microelectronics and microsystems engineering are key innovation drivers in virtually all product areas and sectors of the economy. Companies benefit from collaborating with Fraunhofer EMFT in that they are able to draw on the very latest research insights and innovations for their product development. Here, Fraunhofer EMFT supports its customers throughout the entire development process – from the idea through to implementation. Fraunhofer EMFT offers its customers and partners the following services:

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

### Modeling & simulation
- Manufacturing processes
- Whole process
- System response

### Customer-specific development
- Advance development
- Processes
- Components and systems

### Prototypes and small batch production
- Simulation
- Layout
- Construction

### Analysis & test
- Risk and problem analysis
- Development of test methods and equipment

### R&D in publicly funded projects
- Joint projects funded publicly or by industry, e.g. BMBF, German federal 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

### Seminars and training programs
- Orientation talks
- Customer-specific workshops
As a partner for SMEs and industry, Fraunhofer EMFT develops innovative solutions, for instance for the “Internet of Things”. Prof. Peter Kücher, Head of Business Development, ensures important new topics are integrated in the Fraunhofer EMFT business areas and expertise is transferred to the market.

Prof. Kücher, what kind of things does business development and technology transfer involve?

I keep an eye on what aspects are emerging in research and industry so as to penetrate new business areas. If there is something that matches our competence portfolio well, I consider how we can integrate it effectively in our business unit structure and who the potential customers or partners might be. The aim is to establish long-term strategic partnerships with industry and actually define new products.

We have various business models available to us here. The simplest of these is passive transfer: we supply the expertise and receive a fee in return. What we prefer is active transfer, in other words long-term collaboration with one or more partner companies. The framework for this is provided by industrial projects as well as funding projects at state, national or EU level. I particular like the Open Innovation approach: it offers both sides much more added value and it will become increasingly important in the future.

How do you develop a good „nose“ for technological trends?

In fact it has more to do with hard work than some kind of magical instinct. In addition to conventional research into specialist topics, this includes attending scientific forums such as conferences and conventions, where you can make contacts and gather information. I always motivate my colleagues to make the most of these kinds of opportunities. What is more, staff who have become „old hands“ in their field have a lot of contacts with experts in research and industry: this is another information channel that allows us to pick up on trends early on. And of course most „hot topics“ don’t just appear of their own accord: to some extent you can set the agenda yourself by getting involved in the relevant bodies.

Research and industry are two very different worlds. What kind of impact does this have when it comes to negotiations on collaborative projects?

Sometimes there are differing expectations, for example in terms of how suitable a demonstrator is for production or how quickly things can get done. From the point of view of a partner company, such issues understandably have priority but they do require solid development work too, of course. In addition to the quality of the outcomes and adherence to deadlines, this is what ultimately determines the kind of reputation a Fraunhofer institute has in the business world – and rightly so. But generally speaking there are no problems involved in getting together and arriving at an agreement.

Sometimes the most difficult discussions arise in the area of IP (intellectual property) and licenses – especially with companies who are up against international competition. As a publicly funded research institute, our IP should not be exclusively available to one company alone. The company may see this differently of course: after all, an exclusive license represents a huge competitive advantage. Here the aim is to arrive at individual solutions that secure our so-called background expertise and do justice to the parties involved, also in connection with publicly funded projects. So far we have always managed to find a solution that is satisfactory to everyone involved.
What are the differences between cooperating with an SME and with a large corporation?

The term SME is fairly broad and covers companies with between 10 and 200 employees. Nonetheless, I believe SMEs do have certain typical features: their financial resources are usually significantly more limited than those of large corporations. Their business tends to be based on a concrete product idea and they have a high level of specialist expertise. However, these companies often lack the expertise and infrastructure when it comes to moving into new areas of application or combining their idea with other technologies. Research institutions such as ourselves are able to fill this gap. SMEs are generally very flexible and have short decision-making processes, which is a great advantage. You might say that large corporations are the very opposite: they are financially strong and usually have a broad-based R&D operation. Their interest in cooperating with research institutions is geared more towards providing input for their own development departments and implementing innovative solutions in their products. However, the decision-making processes are more complex and time-consuming, and contract negotiations can often be complex, as I mentioned just now.

Incidentally, most of our industrial partnerships are with SMEs – they account for around 80 per cent in terms of Fraunhofer as a whole. This is in line with our political mandate, which is mainly to support SMEs during their intermediate growth phase.

What does Fraunhofer EMFT offer SMEs?

Fraunhofer EMFT is excellently placed to help SMEs achieve a leading market position in key future areas such as the „Internet of Things“. In addition to sensor and actuator components, whose functionality goes far beyond that of standard products, we can also offer system components covering all the development phases of an entire system, from design right through to the characterization methods and reliability tests. This is of particular interest to SMEs since they are more focused on complete system solutions than on individual components. Also, our interdisciplinary expertise dovetails perfectly with the specialized knowhow of SMEs – together this produces novel solutions and products that offer high innovation potential.

We can also provide sound support for SMEs in the so-called „demonstrator plus“ situation – a stage at which medium-sized companies are typically slowed down in their development: at this point they generally just have an initial prototype and need an environment in which they can at least produce a pilot series. We have the infrastructure required for this with our CMOS, MEMS and flexible substrate lines and also the expertise to go with it – a unique combination.

Prof. Kücher, many thanks for the interview.
RANGE OF TECHNOLOGIES OFFERED BY FRAUNHOFER EMFT

Cutting-edge infrastructure, a broad range of technologies and a well-developed network of partners in industry as well as among research institutes, universities and public authorities make Fraunhofer EMFT an attractive partner in research and development. This is of interest to small and medium-sized companies as well as larger-scale industrial enterprises. Marketing the results of research is generally the responsibility of the corporate partner. Since 2007, Fraunhofer EMFT has also offered high-tech companies the opportunity to hire and utilize its high-quality facilities (such as cleanrooms, laboratories, workshops and equipment). Several companies have entered into strategic cooperation with Fraunhofer EMFT – including Ketek GmbH, Panasonic, Siemens AG, Süss MicroTec GmbH, Thin Materials and OHB System AG. Framework contracts are being prepared with a number of others. Here is a selection of the technological possibilities available at Fraunhofer EMFT:

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 SiO₂ and Si₃N₄, PECVD of SiO₂ and Si₃N₄)
- Highly conductive layers (Al/Si, Ti, W, doped Poly-Si)
- Plasma etching processes (Si, SiO₂, Si₃N₄, Al, W)
- Electroplating (Cu, Sn)

200 mm – lithography cluster

- Proximity exposure
- Double-sided exposure
- Contact exposure
- Electron ray exposure
- Ion ray exposure
- i-line Stepper
- Nanoimprint

Si-MEMS technology

- Cleanroom technology for 150 mm wafers (silicon, ceramics, glass)
- Metal coating (Cu, Ti, TiW, Pt, Au, Ni)
- Dielectric layers (SiO₂, Si₃N₄, SiC, Polyimid)
- Wafer bonding, adhesion bonding techniques
- 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
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 CF₄
- Foil mounting and bonding technology

Analytics and material characterization

- Atomic force microscope (AFM): Measurement of surface roughness and step measurements up to max. 6 µm
- Scanning electron microscopy (SEM) incl. energy-dispersive x-ray spectroscopy (EDX)
- In-line SEM (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

Analysis and testing

- Semi-automatic wafer prober up to 300 mm using thermo chuck (-55°C to +300°C) and laser
- Semiconductor parameter analyzers
- Network analyzers in the megahertz range up to 110 GHz and Simulator Agilent ADS
- Generation and measurement of high-current pulses in the picosecond and nanosecond range
- Electrostatic discharge characterization and load (CDM, HBM, TLP, VF-TLP, CC-TLP)
- 160 cc climate chamber for chemical and biochemical sensors: gases and liquids
- Electrochemical impedance spectroscopy
- Environmental test chamber 100 cc – moisture and gases
- Oscilloscope
TECHNOLOGY NETWORKS
In order to enable efficient and effective collaboration with industry and develop product ideas into concrete applications more swiftly, Fraunhofer EMFT has established three technology networks for specific themes and research areas. These are aimed at longstanding customers and development partners as well as new customers who wish to draw on expert support to put their innovative product ideas into practice.

**Multifunctional On-Top Technologies (MOTT)**

The development center for Multifunctional On-Top Technologies (MOTT) for standard silicon and CMOS processes was founded in 2009. Building on the results of previous research into CMOS circuits and 3D system integration, the infrastructure combined with the Munich-based Fraunhofer EMFT expertise provides a technology platform enabling industry to carry out rapid system development that is closely geared towards end products in the area of semiconductor technology. The platform supports modular integration of new functions and components in existing silicon standard technologies, resulting in cost-effective solutions even for medium-sized companies.

**Bavarian Polytronic Demonstration Center (BDP)**

The Bavarian Polytronic Demonstration Center was founded to facilitate low-cost production of electronic systems in substantial quantities on large-area substrates. A wide range of coating and structuring processes for foils is developed in collaboration with industry as part of research projects and development activities for flexible, organic and large-area electronics (FOLAE). The equipment used is consistently designed to process rolls of foil. Current focus areas include the functional integration of organic materials, the assembly of sensors in polymer technology and the creation of large-area, flexible wiring systems.

**Center for Microsystem Integration Munich (CMM)**

Fraunhofer EMFT initiated the founding of the Center for Microsystem Integration Munich (CMM) in 2010 in collaboration with leading Bavarian companies. By pooling the extensive expertise of prestigious partners in the field of technology and product development, the CMM provides a high-performance and efficient technology network in the field of microsystems engineering. The CMM acts as the nucleus for a microsystems engineering center and is looking forward to ongoing expansion as it is joined by further experts.
The success of Fraunhofer EMFT is founded upon powerful industry and project partnerships and an above-average level of customer satisfaction.
Dear project partner: this double page only shows certain selected partner logos. If you are a customer and you do not see your logo here but would like to be included in the next annual report, please let us know!

Fraunhofer EMFT staff members talking to customers
Fraunhofer EMFT is involved in a number of joint European projects, collaborating with companies from science and industry to engage in research and development of future-oriented solutions aimed at tackling major challenges facing society today.

**COLAE**

Commercialization Clusters of OLAE (Organic and Large Area Electronics) (COLAE) is a European initiative which promotes the commercial use of organic and large-area electronics. OLAE technology provides opportunities for energy efficiency as well as environment-friendly materials and processes. Since this is a young technology, there are currently very few companies in Europe who are active in the field and working on product development. COLAE therefore aims to raise the profile of OLAE among potential end users in Europe and point the way forward to innovative product developments. In order to achieve this aim, demonstrators are developed and training programs organized for potential industrial clients. COLAE also seeks to open up new areas of application for OLAE as well as identifying the main needs and challenges relating to research and development.

**CONTEST**

The FP7 ITN Marie Curie project CONTEST involves research and development of technologies for the so-called electronic skin – a synonym for flexible, compliant electronic systems. The focus is on multifunctional electronics, pliable and flexible large-area electronics and the combination of organic and silicon-based solutions. The electronic skin will simultaneously capture sensoric information over large areas, significantly enhancing the cognitive abilities of robots and man-machine interfaces. 14 scientists are involved along with eight companies and research institutes who are leaders in this field.

**COSMIC**

The project COSMIC has set itself the aim of developing the electrical properties of organic thin-film transistors to achieve a performance range required for application in ID tags, display drivers and other integrated circuits. A key element of the project is the development of a complementary and significantly more robust circuit technology with p-type and n-type conductive organic materials. Development is carried out on various production platforms so as to cover the different fields – from applications with a high degree of integration density through to low-cost mass products. The results of the project can be deployed in a diverse range of application areas such as medical technology, environment, energy, leisure, security and mobility.
e-BRAINS

The Fraunhofer EMFT is involved in the large-scale integrated project e-BRAINS being run by the European Commission. e-BRAINS stands for „Best-Reliable Ambient Intelligent Nanosensor Systems by Heterogeneous Integration”. The aim is to provide technologies for future applications in the field of Ambient Assisted Living which require integration of heterogeneous technologies. One of the main tasks here is to develop suitable and reliable 3D integration technologies for future MEMS/IC products. The e-BRAINS project also involves selective evaluation of medical applications (DNA sensors and active implants) and safety applications. The project partners are Infineon Technologies (Project Coordinator), eesy-ID, ELA Medical, IQE, Magna Diagnostics, SensoNor, Siemens, Vermon, DMSC (majority owned by Intel Mobile Communications), CEA, EPFL, IMEC, ITE, SINTEF, TUC, TUG, Fraunhofer IIS-EAS and Fraunhofer EMFT (Technical Manager).

i-Tex

The FP7 project i-Tex – „Intelligent and luminous textiles“ (www.i-tex.nl) – researches and develops energy-efficient, large-area lighting systems based on inorganic light-emitting diodes (LED). Coated textiles with reliable integrated electronics including LED, sensors and drivers open up a whole new range of application scenarios in architecture, both indoors and outdoors, also including user interaction facilities. The aim is to develop robust assembly and interconnection techniques for commercial components and scale these to the roll-to-roll processes and standards commonly applied in the textile industry. This also includes demonstrating reliability.

MANpower

As part of the 7th Framework Programme of the European Commission, Fraunhofer EMFT is involved in the NMP (Nanosciences, Nanotechnologies and New Production Technologies) project MANpower, „Energy Harvesting and Storage for Low Frequency Vibrations”. This project targets the development of a self-sustaining energy harvesting system that operates at extremely low frequencies within the range of just a few hertz. The future user of this innovative technology and project partner is the French company SORIN, Europe’s leading manufacturer of pacemakers. Run in collaboration with the partners Tyndall National Institute, University College Cork, Cork Institute of Technology, TU Eindhoven, KU Leuven, Paris University South, 3D-Plus and SORIN CRM, the project involves the development of suitable materials and components for this new type of harvesting as well as set-up and testing of an ultra-miniaturized pacemaker as an integrated system. Here, particular importance is attached to tests looking at the reliability and biocompatibility of system components and integration techniques. Fraunhofer EMFT contributes its core competence in the area of „Silicon Processes, Device and 3D Integration” and is responsible for the work package „System Integration”. The particular focus here is on developing heterogeneous 3D integration technologies, which are evaluated in terms of reliability in collaboration with the project partners. Solid Liquid Interdiffusion (SLID) bonding and the Fraunhofer EMFT TSV technology is used for vertical integration of extremely thin (< 50 μm) chip components. With the support of the project partner Communicraft Limited, great importance is attached to efficient internal project communication and public presentation of results.
**NanoMend**

The project NanoMend is dedicated to the development of new technologies to reduce microdefects and nanodefects on thin, coated, large-area foil substrates. Surface defects can arise in various phases of the manufacturing process and have a negative impact on the efficiency and yield of the process as well as on product quality and service life. Conventional methods are not able to detect and repair such defects on a micrometer and nanometer scale. For this reason, the project focuses on developing methods and technologies for identifying and characterizing these kinds of defects as well as eliminating and repairing them. They are used in manufacturing such items as flexible illuminants, flexible photovoltaics, coated packaging materials, billboards and screens.

**NAWADES**

The project NAWADES (Nanotechnological Application in Water Desalination) investigates, develops, produces and tests novel filter technologies used for seawater desalination. The technologies are integrated in a module that offers a long service life, low energy consumption and a high level of efficiency. Ultrafiltration (UF) membranes are used to purify the seawater and reverse osmosis (RO) membranes for desalination. In terms of the UF membrane system, the project is looking into methods which allow monitoring and reduction of contamination and growth during the filtration process. Monitoring uses electrodes that are applied to the membrane directly by means of a method suitable for roll-to-roll techniques. The project investigates nanotechnological surface treatments as a way of reducing growth, as well as the integration of glass fibers to distribute UV light.

**POLARIC**

The aim of this project is to create high-performance, organically integrated circuitry on large substrate areas. This means increasing switching frequency into the megahertz range, for instance, and reducing the supply voltage to battery level, as well as reducing power consumption and increasing production yield. A key development here is the miniaturization of organic circuits into the sub-micrometer structure range using new structuring methods such as nanoimprint. At the same time, the manufacturing process is optimized with a view to achieving higher throughput with roll-to-roll methods and large-area substrates.

**SMART-EC**

The aim of the SMART-EC project is to develop energy-autonomous (EC) components. For this purpose, thin foil-based EC transistors are integrated on flexible substrates with functionalities for energy harvesting and storage. The primary goal is to improve the energy efficiency of the components so as to make the various applications more convenient and reliable. The results of the project can be used in such areas as automotive, ID cards and smart packaging. On this project, Fraunhofer EMFT is developing assembly methods for foil subsystems on foil substrates. The aim will be automation using a pick-and-place machine and optical quality control. What is more, a new method is being investigated to integrate ICs on foil.
SMOKESENSE

The aim of the EU project SMOKESENSE is to bring about a radical change in fire detection technology by developing a smart, miniaturized fire detector. Conventional sensors are limited in terms of their performance capacity. They require a high level of maintenance and are generally at a disadvantage when it comes to speed of response because they are positioned a long way from the source of the fire. The core components of the SMOKESENSE fire detection system are a multi-gas sensor and a micropump. The so-called electronic nose is capable of virtually eliminating false alarms by detecting specific combinations of gases (“fire-gas fingerprints”). The SMOKESENSE fire detection system is also able to trigger an alarm before a fire actually starts. The use of an air feed micropump being developed for this purpose by a Fraunhofer EMFT team enables a compact structure and the incorporation of a fire detector in the immediate vicinity of potential safety hazards.

THINGS2DO

Nanotechnology and microsystems engineering have been singled out in the Federal German government’s high-tech strategy as two of the key interface technologies for innovative German products. FD-SOI technology allows the development of extremely miniaturized, energy-saving and yet very high-performance circuits. Circuits with these properties are especially in demand for many applications in the fields of medical technology, environment monitoring, traffic technology and communication technologies.

The project THINGS2DO involves 25 partners from research and industry working under the coordination of the French semiconductor manufacturer STMicroelectronics to establish a sustainable European and German ecosystem for the creation of FD-SOI semiconductor components.
In order to pursue its research goals consistently, Fraunhofer EMFT engages in collaborative research and projects with a number of universities in Germany and elsewhere in Europe.

**Universität der Bundeswehr München**

There is a close link between Fraunhofer EMFT and the UniBwM Faculty of Electrical Engineering and Information Technology, not least as a result of staffing connections. Prof. Maurer (Professorship for Integrated Circuits and Electronic Components) has been teaching at UniBwM since 2012, along with Fraunhofer EMFT Director Prof. Kutter (Professorship for Solid State Technologies). The cooperation originated under Prof. Eisele, who was appointed UniBwM’s first Emeritus of Excellence and today heads up the business area „Sensors and Actuators“ at Fraunhofer EMFT. The close links between the university and Fraunhofer EMFT are also reflected regionally in the establishment of the development center for „Multifunctional On-Top Technologies for Standard Silicon and CMOS“ (MOTT), which is involved in the modular integration of innovative and new functionalities and components in existing standard silicon 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.

**Technische Universität München**

It was in 2011 that Fraunhofer EMFT laid the foundations for collaboration with the Chair for Technical Electrophysics held by Prof. Wachutka. Research there focuses on physically based modeling, numerical simulation and the characterization and diagnosis of production processes and operating response of microstructured components. Collaborative research aims to further strengthen Fraunhofer EMFT expertise in this area. There are plans for joint doctoral dissertations on various preliminary research topics. Meanwhile, talks are also in progress concerning collaboration with other chairs.

**Universität Regensburg**

Ever since it was founded in 2009, the Fraunhofer EMFT group Sensor Materials has worked closely with the Chair for Analytical Chemistry, Chemosensors and Biosensors at the University of Regensburg. Scientists at both institutions collaborate on developing fundamental opto-sensoric techniques and transferring these to applications in the areas of healthcare, life sciences and environmental analytics. The chair possesses considerable expertise in the field of biosensors using physical transducers, e.g. plasmon resonance (SPR) and impedimetry. Cooperation between the Sensor Materials group and the University of Regensburg is expanded continuously through the joint acquisition of funded projects, participation in university teaching and the supervision of students.
Technische Universität Berlin

Technische Universität Berlin and Fraunhofer EMFT are linked through the Professorship for Polytronic Microsystems under Prof. Bock. This department is dedicated to research into polymers, low-cost coating technologies and the characterization and control of polymeric surfaces and boundary layers in polymeric material composites as well as in hybrid multilayer technologies. Other research topics are in the areas of adhesion, interdiffusion barriers, electrical contacting of polymers and the self-arrangement and selective electronic alignment of semiconducting polymers. The more stable and more powerful layer systems thereby created serve to enhance the stability and reliability of the components of which they form a part – after all, many problems of reliability can be traced back to uncontrolled or impaired boundary layers within the synthetic composite.

Technische Universität Dresden

TU 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 future cooperation with Fraunhofer EMFT: in his courses at the Institute for Semiconductors and Microsystems Technologies (IHM), the longstanding head of the Fraunhofer Center Nanoelectronic Technologies CNT focuses mainly on the connection between technological and economic challenges, since globalized competition entails changes such as specialization and resegmentation of the supply chain, which requires manufacturers of material, equipment and chips to adopt new strategic approaches.

Polytechnische Universität Bukarest, (Universitateat Politehnica Bucuresti, UPB), Romania

Universitateat POLITEHNICA of Bucharest developed from a polytechnic school dating back to 1864 and is now the most important technical university in Romania. There are longstanding collaborative links between Fraunhofer EMFT and the university’s Faculty of Electronics, Telecommunications and Information Technology (ETTI) as well as its Department of Electronic Technology and Reliability (TEF). This cooperation allows several staff of the TEF department to undertake scientific internships at Fraunhofer EMFT. A number of doctoral students from the TEF department also use the experimental facilities at Fraunhofer EMFT. The collaboration between the two institutions has resulted in joint conference presentations and publications.
The Bavarian government runs a cluster offensive to support the competitive capacity of Bavarian companies in 19 key sectors. For this purpose it has set up cluster platforms throughout Bavaria to promote networking among companies and research institutions. The clusters help companies become involved in joint product development, optimize internal processes and jointly penetrate markets. Fraunhofer EMFT is closely involved in the following clusters:

Sensorics Cluster

The partnership organization Strategische Partnerschaft Sensorik e.V. in Regensburg is the platform for sensorics as part of the cluster offensive of the state of Bavaria. More than 60 companies and institutes now belong to this association. These are among Fraunhofer EMFT’s customers and cooperation partners.

Fraunhofer EMFT is a founding member of the sensorics cluster and regularly provides information and presentations within the network. In June 2014 it co-exhibited at the joint cluster stand presented at the „Sensor + Test“ trade fair in Nuremberg. What is more, Fraunhofer EMFT’s Sensor Materials group permanently represents the institution on site in Regensburg as a contact partner for cluster members. Staff members also frequently make use of the sensorics cluster’s excellent professional development program.

The general meeting of the Sensorics Strategic Partnership was held at Fraunhofer EMFT along with a technology forum in Munich in 2014.

Microsystems Technology Cluster

Fraunhofer EMFT has been much involved in the wide-ranging activities of the Microsystems Technology Cluster (MST) ever since it was founded. Scientists and experts from the Fraunhofer institution regularly support cluster events by providing expert talks and exhibition stands, as at the MST symposium in Landshut, for example.

The Microsystems Technology Cluster has now undergone restructuring in terms of personnel and organization and Fraunhofer EMFT is pleased to be able to draw on the cross-sectoral communication and collaboration it offers, as well as supporting cluster partners in the future-oriented development of products and processes.
Chemicals Cluster

Fraunhofer EMFT has been a member of the Chemicals Cluster since 2008. As a contribution to the innovative development work in areas covered by cluster activities, Fraunhofer EMFT offers members its expertise in the selective synthesis of indicator dyes, the modification of polymer systems and the creation of functional polymers and surfaces by means of chemical modification. The expertise in this area produces a wide range of application-oriented demonstrators such as optical sensor foils and sensor pigments.

The Bavarian Chemicals Cluster brings together companies and research institutions operating in the chemical sector. The Bavarian government’s cluster offensive promotes product and process innovations in Bavaria in order to penetrate new markets. Collaboration takes the form of cross-sectoral associations consisting of large and small industrial companies, universities and Fraunhofer institutes, while the cluster can also take on responsibility for obtaining external funding for joint projects as well as looking after project coordination.

Cluster activities focus on highly innovative topics, always in close collaboration with the regional Bavarian networks. Particular support is provided for recently founded companies and start-ups in the chemical sector by involving them more closely in cluster activities. In this way the Chemicals Cluster has led to the Bavarian chemical industry establishing a leading role for itself as Germany’s industrial efficiency driver.

NeZuMed – network for innovative suppliers in medical technology

Fraunhofer EMFT has been a member of the NeZuMed network since the end of 2012. This membership enables scientists to take part in events, trade fairs, workshops, forums, symposiums and conferences. In engaging in this type of activity, Fraunhofer EMFT seeks to intensify dialog and scientific exchange with potential project partners so as to generate ideas for technological innovations and R&D projects.

The aim of NeZuMed is to establish an innovative organization for research and development among medtech suppliers. The focus is geared specifically towards promoting SMEs in Franconia, Bavaria and Thuringia by providing specialist expertise built up over many years. The aim of network cooperation is make it easier for such companies to become established in the interdisciplinary medtech market on a lasting basis.

The network provides a platform on which to define and implement measures to serve the advancement of medical technology and related fields. By involving all industrial partners and the user side very early on, the goal is to promote the development of market-oriented and innovative components and products in medical technology. The organization also serves as an efficient information network for tackling interdisciplinary challenges and generating low-cost, market-oriented solutions by tapping into synergies.
VISITS AND DELEGATIONS
A large number of visitors and delegations came to Fraunhofer EMFT in 2014 to meet scientists and take a closer look at the institution’s excellent technological infrastructure.

Visits and Delegations

- Delegation AIST, National Institute of Advanced Industrial Science and Technology, with Mr. Katase, Director-General Japan
  January 9, 2014

- Professor Suga, University of Tokyo
  February 21, 2014

- Business delegation from Denmark
  February 24, 2014

- Students from the Microtechnology Department of Ithzoe Training College
  March 18, 2014

- School students from St. Dominikus girls’ upper secondary school, Karlsruhe
  May 12, 2014

- Business delegation from Columbia
  May 15, 2014

- Delegation of the Mitsubishi Research Institute, Japan
  May 28, 2014

- Delegation AIST, National Institute of Advanced Industrial Science and Technology, Japan
  June 16, 2014

- Students from Weilheim upper secondary school
  July 24, 2014

- Egyptian State Secretary & Executive Director of STDF (Science and Technological Development Fund)
  September 19, 2014

- Delegation AIST – National Institute of Advanced Industrial Science and Technology, with Dr. Seto, Vice President, Japan
  September 22, 2014

Guest scientists

- Dr. Katsumi Miyama is a Professor at the Hokkaido University of Science in Sapporo, Japan and Visiting Professor at Fraunhofer EMFT from September 16, 2014 to April 30, 2015. His main interest is focused on the subject of low-temperature processes for heterogeneous 3D integration. Fraunhofer EMFT very much welcomes the opportunity to work with Dr. Miyama, who is a recognized packaging expert, and as a result hopes to expand its expertise in the increasingly important research field of assembly and interconnection technology as well as chip packaging.

- Dr. Charvaka Duvvury is an outstanding and internationally recognized expert in the area of reliability of semiconductor components vis-à-vis electrostatic discharge ESD and latchup. In the course of his period of research at Fraunhofer EMFT from March to April 2014, Dr. Duvvury made valuable contributions to strategy discussion, the establishment of the test method Capacitive Coupled Transmission Line Pulsing CC-TLP and the ESD properties of polymer transistors. Dr. Duvvury currently works as an international consultant and remains in close contact with Fraunhofer EMFT.
SPECIAL EVENTS
49 years of microelectronics at the Fraunhofer site in Munich

Fraunhofer EMFT celebrated its anniversary on November 18 at the Fraunhofer Haus in Munich. More than 160 guests spent an informative and entertaining evening with current and former staff of the institution.

Fraunhofer incorporated the group under the Munich Professor of Microelectronics Ingolf Ruge in 1974, creating the Fraunhofer Institute for Solid State Technology IFT. The aim was to boost microelectronics as a key technology capable of providing leverage for other industrial sectors. During the course of its existence, no less than four additional Fraunhofer institutes and as many directors were to emerge from the IFT and its successor institutions. Fraunhofer Senior Vice President Professor Alexander Verl praised Fraunhofer EMFT’s excellent integration in the microelectronics landscape of southern Bavaria with its powerful orientation towards small and medium-sized companies. Dr. Peter Wawer of Infineon Technologies explained the significance of microelectronics as an innovation driver behind solutions to the major challenges facing our society. Meanwhile Fraunhofer EMFT Advisory Board Member Dr. Hans-Jürgen Bigus of the lab technology manufacturer Hirschmann emphasized that the Fraunhofer institutes were crucial to SMEs as development partners and advisors.

Looking back to the founding years, Prof. Ingolf Ruge, Prof. Herbert Reichl and Dr. Alexander Imbusch gave accounts of the early days at Fraunhofer IFT. After many amusing anecdotes, Fraunhofer EMFT Director Prof. Christoph Kutter brought the audience back to the present by inviting the institution’s doctoral students to come up on stage, and present current themes under the motto „Research into sensors and actuators for people and the environment“.

// SPECIAL EVENTS

1  Podium discussion with Prof. I. Ruge, Prof. H. Reichl, Dr. A. Imbusch and Prof. C. Kutter

2  Doctoral students at Fraunhofer EMFT

TSensors Summit Munich™ for Trillion Sensor Roadmap

The 1st European Trillion Sensors Summit TM was held in Munich from September 15 - 17, 2014 under the auspices of Prof. Christoph Kutter (Director of Fraunhofer EMFT) in collaboration with Janusz Bryzek (TSensors Summit).

The idea for the TSensors Summit was born in Silicon Valley in 2013 with the aim of advancing the development of sensors and the sensor market. Interconnected sensors are regarded as one of the most promising future technologies, with potential demand for 45 trillion sensors in 20 years. Visions such as Smart Objects, Pervasive Computing, the „Internet of Things (IoT)“ and Industry 4.0 are all based on the concept of an internet-based network of physical objects which autonomously collect and analyze data while communicating with each other. An intelligent network of this kind requires countless sensors and actuators with new, extended functions.

The Munich Trillion Sensors Summit TM aims to bring together the stakeholders on the European sensor market and provide a platform for visionary sensor applications and ideas. More than 40 visionary speakers presented and discussed their ideas on the „Internet of Things“ including Prof. Dr. h.c. Ernst von Weizsäcker (Co-Chair International Resource Panel (UNEP), Co-President of the Club of Rome) and other fascinating speakers from global companies such as Intel, Infineon, Bosch, Samsung, Freescale, Iceberg, CEA Leti, VTT.

However, this international conference was not only about business ideas: after all, the vision of the Trillion Sensor World involves challenges as well as opportunities – in areas such as data protection, privacy and the ethical and commercial regulation of information exchange.

40 years of microelectronics at the Fraunhofer site in Munich

Fraunhofer EMFT celebrated its anniversary on November 18 at the Fraunhofer Haus in Munich. More than 160 guests spent an informative and entertaining evening with current and former staff of the institution.

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TRADE FAIRS AND CONGRESSES
Fraunhofer EMFT visits customers regularly on the latter’s own premises as well as drawing attention to the institution’s scientific and technological services at national and international events. For this purpose, the institution was again present at selected trade fairs and congresses in the course of 2014. Here is an overview:

**Trade fairs in 2014**

- **Landshut Symposium for Microsystems Engineering**  
  Landshut, March 12 - 13

- **DATE14**  
  Dresden, April 25 - 27

- **Interpack / PEPSO**  
  Düsseldorf, May 8 - 14

- **Sensor + Test**  
  Nuremberg, June 3 - 5

- **COMPAMED**  
  Düsseldorf, November 12 - 15

**Congress in 2014**

- **10th International Conference and Exhibition on Device Packaging**  
  Scottsdale/Fountain Hills, Arizona, USA  
  March 11 - 13

- **Trillion Sensors Summit**  
  Munich, Germany  
  September 15 - 17

- **EUROPT(R)ODE XII – XII Conference on optical chemical sensors and biosensors**  
  Athens, Greece  
  April 13 - 16

- **Actuator 14 – 14th International Symposium on new actuators**  
  Stuttgart, Germany  
  June 23 - 25

- **Eos/Esd Symposium**  
  Tucson, USA  
  September 7 - 12

- **EUROSENSORS 2014**  
  Brescia, Italy  
  September 7 - 10

- **ESTC 2014 – 5th Electronics System-Integration Technology Conference**  
  Helsinki, Finland  
  September 16 - 18

- **40th European Solid-State Circuit Conference**  
  Venice Lido, Italy  
  September 22 - 26

- **MFHS 2014 – 2nd International Conference on MicroFluidic Handling Systems**  
  University of Freiburg, Germany  
  October 8 - 10
Fraunhofer EMFT organizes science events every year on its own premises as well as presenting at numerous external events. The institution’s latest research and development work is regularly featured at national and international trade fairs and congresses.

Fraunhofer EMFT Annual Event

Once a year, Fraunhofer EMFT invites representatives of industry, ministries, project sponsors and the local press to an annual event held on its own premises. The motto of this event on Wednesday March 19, 2014 was: „Sensors – our seventh sense.” Sensors enhance and expand the capabilities of our senses. In many areas of our day-to-day lives they have become indispensable helpers we can no longer do without. Talks focused on the importance of sensors to all of us, especially in the future. At the subsequent get-together, Fraunhofer EMFT experts invited the approx. 90 participants to engage in further discussion.

MEMS Sensor Seminar – Sensor Roadmap: The Pathway to the next „BigThing”

On March 20 more than 80 participants from 10 countries came together at Fraunhofer EMFT to attend the international workshop „MEMS Sensor Seminar: The pathway to the „next big thing”“, organized in collaboration with Yole Développement. Talks by experts from the areas of end-user application, manufacture, research and development provided a broad perspective on the driving forces, opportunities and challenges at work in the sensor field. The seminar gave all those involved an excellent opportunity to share information and ideas and to network.

COSMIC Workshop 2014: Advances in Manufacturing of Organic Electronics

An event is held every year as part of the European project COSMIC to enable dialog between project partners and present the results to a broader public. From April 1 - 2 the latest results and fundamental insights from the projects were presented at Fraunhofer EMFT in some 15 talks. This year’s focus areas included system-in-foil, the reliability of foil systems and also design and simulation.

Innovations in Microsystems

Together with Bayern Innovativ, Fraunhofer EMFT organized the cooperation forum and exhibition „Innovations in Microsystems – Solutions for Modern Health Monitoring” in Munich on May 21. Innovation potential in health monitoring is particularly offered by mobile, interconnected Microsystems for real-time monitoring of vital signs during work, leisure and sport as well as age-appropriate assistance systems to enable a healthy, independent lifestyle. Experts from business and science reported on the trends and challenges in MEMS production – including microelectronics, assembly and connection technology, system integration of individual modules with energy management, communication, data processing and coupled sensor-actuator systems. The forum also featured an exhibition and facilitated contact between medtech companies and users.
A summer school was held at Fraunhofer EMFT from May 26 - 28 on the subject of system integration. The event was part of the EU project CONTEST, organized in collaboration with the projects OLIMPIA and EAGER. More than 50 participants from industry, universities and research institutions engaged in intense debate on trends and developments in the most diverse areas of system integration. The talks focused on topics such as haptic systems, optical systems, biosystems and neurosystems. Poster sessions gave young scientists the opportunity to present the results of their work and engage in discussion with the audience.

This training program was given by Fraunhofer EMFT experts from July 22 - 23 and provided an overview of the norms and factors to be taken into account when designing cleanrooms. Personnel behavior and test measurements in the cleanroom were illustrated with examples. The program was aimed at technologists and cleanroom technology specialists.

The Semiconductor Devices Characterization Seminar was held from October 7 - 9 as part of the ESD Tutorials seminar series organized by the ESD Association. Together with speakers from Texas Instruments and Intel, Fraunhofer EMFT experts addressed several issues in such as areas as ESD device design, ESD test methods and ESD protection concepts. The talks were supplemented with practical demonstrations and exercises in the Fraunhofer EMFT labs.

Fraunhofer EMFT has organized the international workshop „Forum Be-Flexible“ for over 10 years now, inviting researchers, scientists, industry partners and users to engage in a lively exchange. The event was held on November 19 and 20. In 2014, the event again focused on the latest R&D results in the areas of „Thin Semiconductor Devices“ and „Flexible Electronic Systems“ as well as product potential and future market perspectives. International participants attended the two-day event, taking the opportunity to engage in top-level scientific dialog.
Fraunhofer EMFT has promoted the development of up-and-coming talent in the area of science and technology for over 15 years. Since 2009 the institution has been a member of the „National MINT Pact – more women in MINT careers“, offering young people an insight into the prospects offered by technical professions in terms of training and university study (MINT = math, IT, science and technology).

Visits by school and university students to Fraunhofer EMFT

A large number of school and university students – from Europe to Asia – visit Fraunhofer EMFT every year to gain insights into the institution’s work. The young visitors are not only interested in the technologies and current research themes but also in the assignments and working conditions of scientists in the laboratories and cleanroom.

Particular emphasis is given to addressing girls and young women. For example, 25 high school students from St. Dominikus upper secondary school in Karlsruhe were invited to visit Fraunhofer EMFT on May 12, 2014. The young women were given insights into the areas of microsystems engineering and biosystem integration. They were also provided with an explanation of the application areas of Fraunhofer EMFT developments.

Career orientation weeks

Fraunhofer EMFT held career orientation weeks for school students in April 2014.

The institution offers a career orientation program for future scientists every year. Here the institution cooperates with various high schools, lower secondary schools and comprehensive schools in Munich and the surrounding area. The young participants are given a behind-the-scenes glimpse of the world of microsystems as well as the everyday working lives of scientists at Fraunhofer EMFT. The following issues were examined during the one-week career orientation program:

- What do we need microelectronics for?
- From idea to reality – it all starts with a design.
- How is a microchip produced and what is it made of?
- Working in a cleanroom – why cleanliness is so important.
- What does plastic have to do with electronics?
- Flexible systems need thin chips.
- Who checks to make sure everything works – and how?
- What is the lifetime of a microchip?
- Small, smaller, smallest – tiny pumps.

Girls’ Day

Girls’ Day was held at Fraunhofer EMFT on March 27, 2014 on the theme: „The intelligent milk carton – an introduction to the world of microsystems“. Five school girls aged 12 and 13 spent a day at Fraunhofer EMFT learning about the world of microdimensions in electronics. They discussed the manufacture and use of radio chips, as well as looking into the following question: „How can the information contained in chips be transmitted in a non-contact manner?“ They also used lasers to cut their names into foil and visited a cleanroom where they learned about various materials used in semiconductor technology.
Hands-on technology rather than dry theory: Fraunhofer EMFT now offers school girls from grade 5 a series of mobile „tech caching Parcours“ that allows them to engage in hands-on exploration of the world of optics, nanotechnologies and microsystems engineering. A total of 16 stations set fascinating tasks that allow the youngsters to test their own technical skills and learn interesting facts about various careers – from mechatronics technician to lab chemist.

Dye solar cell made of hibiscus tea

The „tech caching Parcours“ was premiered on July 15, 2014. Fifteen secondary school girls from Samuel-Heinicke-Realschule were able to give free rein to their scientific curiosity under the guidance of two teachers, a student, and three female Fraunhofer EMFT staff members and with the support of two 8th grade girls.

The ice was quickly broken: with all their powers of concentration, the 11- and 12-year-olds made a dye solar cell out of hibiscus tea which they then used to play music. They also observed the lotus effect on cabbage leaves. Within just a few minutes, the young inventors were able to program the intelligent robot lady „Roberta“ to follow a precisely defined triangular course. Meanwhile, manual skills were required when it came to grinding crystals and then filing and bolting metal pieces to make a holder for a salt lamp. The girls demonstrated a steady hand when they fixed components onto a small circuit board to solder an electronic tea candle. They were also able to detach a microchip from a foil with impressive dexterity, placing it under the microscope to conduct a material test.

After completing each station they were issued with a card providing further information on the skills acquired and the relevant careers. They were also called upon to give an evaluation: Did I enjoy the station? Did I finish the tasks or not? Subsequent discussion of these cards – at school, for example – can provide an indication of specific individual interests and aptitudes. For many of the girls it was the first time they had ever come into contact with technology in this way, and it was certainly an encounter they felt was well worthwhile: „I always thought all those things were really complicated, but the stations were a lot of fun and the tasks were interesting“, said Dodo, for example. And Anna can definitely imagine pursuing a career in technology in the future. As a memento, each of the girls were allowed to take a tea candle home with them which they had soldered themselves, along with a self-ground salt stone.

Arousing enthusiasm for MINT early on

The tech caching stations can be adapted and used for girls of different ages. „The main aim of the stations is to address girls at a young age so as to lay a lasting foundation for a leaning towards MINT topics early on. This is also in line with the idea of offering MINT motivation programs for girls before they opt for subjects at the end of 6th grade, as is the case at lower secondary schools, for example,“ explains Sabine Scherbaum, project manager of the Bavarian subproject as part of the mäta initiative to promote girls’ interest in technology.
Cooperation programs for educational institutions and companies

The mobile „tech caching Parcours“ is now available to companies for their own recruitment purposes:

- Event of short duration suitable to be held within a school or company context
- Hands-on activities at 16 stations, all relating to everyday life
- Discovery of unfamiliar phenomena
- Independent error monitoring
- Trained supervisors
- Group size: 12 - 16 school students
- Total duration approx. 2 - 2.5 hours
- The career profiles and technological orientation of the stations can be adapted to specific company needs if required

Special features

- Conceived and designed specifically to appeal to school girls
- Combines the fun of discovery with careers information
- High-tech topic areas covered: microsystems engineering, nanotechnologies, optical technologies

Selection of career profiles

- Process mechanic
- Microtechnologist
- Microsystems technician
- Electronics technician
- Precision optician
- Optician
- Precision mechanic
- Chemistry lab assistant
- Physics lab assistant
- Technical assistant
- Materials tester
- Cutting machine operator

The tech caching stations were created as part of the joint project mäta in collaboration with life e.V.
Many young people opt to begin professional life at Fraunhofer EMFT. The institution offers an excellent start to a career for trainees in research, science, technology and administration. Students in the field of physics, electrical engineering, process engineering, biochemistry and related areas have the opportunity to be involved in applied research at a practical level. They can take an internship, work as a research assistant, write their diploma/bachelor’s/master’s assignment and even undertake doctoral studies.

„My first contact with Fraunhofer EMFT was working with the Sensor Materials Group when I started on my master’s assignment for my degree at Regensburg University. I was really impressed by the friendly staff and their application-oriented research right from the outset. I felt involved from the beginning and was really well looked after by my dedicated colleagues. That’s why I decided to do my doctoral thesis at Fraunhofer EMFT in cooperation with Regensburg University so as to extend my knowledge further. Since January 2014 I have been working on the phototoxicity of fluorescent dyes in cell analytics and on the synthesis of indicator dyes and nanosensors.“
(Romy Freund, doctoral student)

„In September 2014 I started training as an IT assistant for system integration in the DV department. It’s a three-year course and covers various areas within the IT domain. At the moment I’m lucky enough to be the only trainee in the department, so my colleagues are able to take a lot of time for me. I’m already starting to learn some practical tricks for dealing with more complex problems. What I learned at college is also well integrated in my day-to-day work. I was really keen to come to Fraunhofer EMFT because I’ve always been interested in the research areas it’s involved in.“
(Michael Hirtreiter, trainee)

„I completed my master’s in Microelectronics and Microsystems at the Technische Universität Hamburg Harburg in June 2014. During the course of my master’s studies I developed a keen interest in the field of mixed-signal IC design. To learn and explore this field further, I decided to pursue my doctoral studies. I joined Fraunhofer EMFT in July 2014 as a research associate to work on the development of a mixed-signal IC in an advanced CMOS technology. At Fraunhofer EMFT I have found a congenial research environment with dedicated and experienced colleagues and supervisors. The applications of my area of research blend perfectly with the core competencies of the institute.“
(Pragoti Pran Bora, research associate)
"I studied Electrical Engineering at the University of Twente in Enschede, The Netherlands. Since July 2014 I have been working as a research engineer at Fraunhofer EMFT in the Circuits and Systems Division. In this position I am working in close collaboration with my colleagues and our project partners on the development of new mixed-signal circuit architectures that will allow for a high level of integration with future wireless sensors and communication systems. I find this task on the interface of analog and digital to be an exciting challenge and the prospect of moving our research accomplishments into application is highly motivating me. The interdisciplinary environment at Fraunhofer EMFT inspires me and I am looking forward to engage in new opportunities for advancing the integration of the sensors and actuators developed at our institute." (David Borggreve, research associate)

"I am currently studying electrical engineering at TU München. My focus was in the field of physical electronics but then I came to Fraunhofer EMFT last april for an internship and continued with my master thesis about foil-based DNA melting curve analysis. What I really appreciate at the EMFT is that my supervisors made me feel like an equal part of the team. I grew confident in my work and now also consider staying in research and doing my PhD." (Tawanchai Buchta, master student)

"I studied at the Polytechnic University of Turin, the Institut Polytechnique de Grenoble and the Swiss Federal Institute of Technology in Lausanne and I did my international MSc there in the field of „Nanotechnologies for integrated systems“. I gained initial professional experience at the IBM Almaden Research Center in the USA while doing my master’s degree assignment. I wanted to do my doctorate in the area of flexible electronics, preferably at a technology transfer institute specializing in applied research. Even at my interview I was very impressed by the infrastructure, the friendly colleagues and the research topics at Fraunhofer EMFT. For me it’s the perfect place to do my doctorate." (Nagarajan Palavesam, research associate)
SKF Telescopic pillar helps medical OEMs boost sales

SKF has launched a new telescopic pillar for the movement of medical procedure equipment that enables OEMs to offer greater load capacity and speed in surgical chairs and tables compared to previous models. The SKF Telescopic pillar – series CPMT helps OEM customers with growing patient weights and increases patient throughput in busy healthcare centers.

The SKF Telescopic pillar – series CPMT is a three-section telescopic pillar that provides a low retracted length (320mm) combined with higher stroke capabilities than previous models. For procedure chairs the low height provides improved accessibility for patients, without compromising total extended height for clinical procedures. The high positioning speeds (up to 34mm/s) offer faster service to support clinical efficiency.

The key benefits also include high load capacity (up to 600 kg with 4 times static safety), which is a particular benefit to manufacturers of surgical tables. In addition, the pillar offers OEM design flexibility features, such as a configuration option for high offset load capacity to provide high stiffness, and customizable threads on its outer surface for added attachment options.

The SKF telescopic pillar brings a competitive advantage to OEMs by offering greater load carrying capacity and lifting speed from a component that is virtually maintenance free over its lifecycle.

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Fraunhofer EMFT Micropump to Protect Against Blindness

At the COMPAMED trade fair, researchers of Fraunhofer EMFT will present a concept for an implantable micropump system for permanent regulation of the intraocular pressure. This approach shall enable the first effective long-term therapy for diseases of the eye, such as glaucoma or ophthalmophthisis.

The therapies of today for diseases of the eye, such as glaucoma or ophthalmophthisis, mostly only enable a temporary relief for the patients: To treat glaucoma, filtration operations are used to give the aqueous humor an artificial drainage path under the conjunctiva. In about a quarter of the patients, however, scar tissue develops in the drainage zone over time, resulting in poor drainage of the fluid, causing the intraocular pressure to increase again. In case of ophthalmophthisis (wasting or decay of the eyeballs), the production of aqueous humor is disturbed, so that the eye dries out. The researchers at Fraunhofer EMFT are working on a new and promising approach for a treatment: as part of the "MIKROAUG" project, funded by Germany's Federal Ministry of Education and Research, they are developing an active, microsystem-based implant system. The industry partners DUAL IS MedTech GmbH, Binder Elektronik GmbH, Jvi GmbH, MVZ Prof. Neuhann, and University Hospital of Cologne with Prof. Kirchhof are participating in the project, in a consortium headed by the Heidelberg-based company Geuder AG.

Continued on page 16
Fraunhofer EMFT engages in intensive press and media relations. It has been featured in connection with various topics in print and online media as well as on television and radio.

**PRESS**

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<td>95 % less lubricant</td>
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So genannte RFID-Chips (Radio-Frequency Identification) dienen als verlässliche und funktionsfähige Lesezeichen. Sie werden immer öfter in Lebensmittelkette und Verpackungen eingesetzt, um die Lebensmittelverfolgung und die Lebensmittelsicherheit zu verbessern. Sensortechnik in der Zukunft, so die Gefühle. 

»Der offene Formfaktor ermöglicht ganz neue Anwendungen«
Fraunhofer VufE Nachrichten, Ausgabe 54 – March 2014

Biegsame Temperaturanzeige komplett in Folie laminiert
Elektronik Praxis – 03.04.2014

Flexible technologies: New perspectives for sensors
EE Times Europe – 05.04.2014

Flexible Elektronik für Verpackungen
Interpack Magazin – 10.04.2014

Die Welt der Mikrosensoren: Internet der Dinge als Hoffnungsträger der Chiphersteller
VDI Nachrichten – 25.04.2014

VDE mahnt gezielte Förderung der Mikroelektronik an
VDI Nachrichten – 25.04.2014

Verpackungen werden clever.
Messe Düsseldorf Gruppe, Basis for business – May 2014
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<td>[MittelstandsWiki – 06.05.2014]</td>
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<tr>
<td>Forscher arbeiten an smarten Verpackungen</td>
<td>[stern.de – 06.05.2014]</td>
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<tr>
<td>Flexible Systeme in Verpackungen</td>
<td>[interpack – May 2015]</td>
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<tr>
<td>Intelligenz in der Verpackung</td>
<td>[interpack news – 10./11.05.2014]</td>
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<td>Interactive packaging to display contextual messages</td>
<td>[EE Times Europe – 23.05.2014]</td>
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<td>Fraunhofer-Institut entwickelt Verpackung, die mitdenkt</td>
<td>[neue verpackung online – May 2014]</td>
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<td>Die Verpackung, die mitdenkt</td>
<td>[Aargauer Zeitung – May 2014]</td>
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<tr>
<td>Die Verpackung, die mitdenkt</td>
<td>[Pforzheimer Zeitung – May 2014]</td>
</tr>
<tr>
<td>Intelligente Pharmaverpackungen verhindern Produktpiraterie</td>
<td>[MM Logistik - 20.06.2014]</td>
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</tbody>
</table>
Mikropumpe schützt vor Erblindung  
[Fraunhofer µE Nachrichten, 
Ausgabe 55 – June 2014]

Smarte Hülle  
[Fraunhofer µE Nachrichten, 
Ausgabe 55 – June 2014]

VDE mahnt gezielte Förderung der Mikroelektronik an  
[Mechatronik – 08.07.2014]

Die Vision von der „Trillion Sensor World“  
[Sensor Magazin, Ausgabe 3 – July 2014]

Mit intelligenten Verpackungen gegen Produktpiraterie  
[Labor Praxis – 21.07.2014]

Trillion Sensor Summit program set for Munich  
[EE Times Europe – 29.07.2014]

The Trillion Sensors Summit Munich  
[CMM Magazine – 01.09.2014]

Die faszinierende Welt von Nano und Mikro  
[forum Magazin, 
Ausgabe 3 – September 2014]

Mikrostrukturen für autarke Systeme der Zellkultivierung  
[MIKROPRODUKTION, 
Ausgabe 4 – September 2014]

»Sensorik hilft uns, Ressourcen nachhaltiger zu nutzen«  
[Fraunhofer µE Nachrichten, 
Ausgabe 56 – September 2014]
<table>
<thead>
<tr>
<th>Artikeltitel</th>
<th>Quelle</th>
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<tbody>
<tr>
<td>Mit Kreativität und Fingerspitzengefühl – Mobiler tech caching Parcours lädt zum Experimentieren ein</td>
<td>Fraunhofer VfUE Nachrichten, Ausgabe 56 – September 2014</td>
</tr>
<tr>
<td>Happy Birthday, Mikroelektronik</td>
<td>Fraunhofer VfUE Nachrichten, Ausgabe 56 – September 2014</td>
</tr>
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<td>Augenheilkunde: Pumpe gegen Augendruck</td>
<td>Medizin-und-Elektronik.de – 01.10.2014</td>
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<td>MiNT-Begeisterung frühzeitig wecken</td>
<td>Mechatronik – 13.10.2014</td>
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<tr>
<td>Das Eigenleben der Dinge</td>
<td>PM Magazin – 17.10.2014</td>
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<tr>
<td>Neue Projekte bei Sensormaterialien der Fraunhofer EMFT</td>
<td>Pressemitteilung BioPark Nr. 151 – November 2014</td>
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<td>Mikropumpe schützt vor Erblindung</td>
<td>Mechatronik – November 2014</td>
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<td>Micropump to Protect Against Blindness</td>
<td>messekompakt.de – November 2014</td>
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<tr>
<td>A Telemetric Module for Wireless Control</td>
<td>messekompakt.de – November 2014</td>
</tr>
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<td>Mikropumpe schützt vor Erblindung</td>
<td>Devicemed – 11.11.2014</td>
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<tr>
<td>40 Jahre Mikroelektronik: Ohne Sensoren läuft nichts</td>
<td>CHIP – 23.11.2014</td>
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<tr>
<td>3D heterogeneous system integration</td>
<td>Chip Scale Review – November/December 2014</td>
</tr>
<tr>
<td>INT und EMFT feiern 40-jähriges Jubiläum</td>
<td>Quersumme, Ausgabe 4 – December 2014</td>
</tr>
<tr>
<td>Smarte Verpackung</td>
<td>weiter.vorn 1.15 – December 2014</td>
</tr>
<tr>
<td>22. FED-Konferenz zeigte Zukunftschancen auf</td>
<td>PLUS – December 2014</td>
</tr>
</tbody>
</table>
Communicative exchange is vital in science and research. This is why Fraunhofer EMFT scientists published their insights in various forms in the course of 2014. The following list provides a small selection of their academic publications and talks.

Publications

Rozalia Beica, Jean-Christophe Eloy, Peter Ramm
**Key Applications and Market Trends for 3D Integration and Interposer Technology**
(ISBN: 978-3-527-33466-7)

**Determination of residual stress with high spatial resolution at TSVs for 3D integration: Comparison between HR-XRD, Raman spectroscopy and fibDAC**
IEEE Xplore, eurosime, Belgium, May 2014

**Multifunctional System Integration in Flexible Substrates**
IEEE Catalog Number: CFP14ECT-USB
(ISBN: 978-1-4799-2406-6)

Kornelius Tetzner, Indranil Ronnie Bose, Karlheinz Bock
**Organic field-effect transistors based on a liquid-crystalline polymeric semiconductor using SU-8 gate dielectrics on flexible substrates**
Crossover of knowledge between bonding of MEMs and 3DIC
IEEE Xplore, LTB-3D, Tokyo, July 2014

I. Bose, K. Tetzner, K. Borner, K. Bock
Air-stable, high current density, solution-processable, amorphous organic rectifying diodes (ORDs) for low-cost fabrication of flexible passive low frequency RFID tags
Journal of Microelectronics Reliability, Berlin, September 2014

Residual Stress Investigations at TSVs in 3D Micro Structures by HR-XRD, Raman Spectroscopy and fibDAC
IEEE Xplore, ECTC, Orlando, USA, September 2014

Vincenzo Fiore, Placido Battiato, Sahel Abdinia, Stephanie Jacobs, Isabelle Chartier, Romain Coppard, Gerhard Klink, Eugenio Cantatore, Egidio Ragonese, Giuseppe Palmisano
A Comprehensive Solution for a 13.56-MHz RFID Tag in an Organic Complementary TFT Technology on Flexible Substrate
IEEE-CMDT, November 2014

P. Ramm, P. Schneider, R. Dal Molin
3D Heterogeneous System Integration
Chip Scale Review Magazin, November 2014

G.A.M. Nastasi, A. Scuderi, H.-E. Endres, W. Hell, K. Bock
Simple Cost Effective and Network Compatible Readout for Capacitive and Resistive (Chemical) Sensors
Procedia Engineering 87, S. 1234 - 1238

Peter Schneider, Andy Heinig, Christian Bayer, Renzo Dal Molin, Maximilian Fleischer, Peter Ramm
Technology, Simulation and Design for 3D Integrated Heterogeneous Sensor Systems
Proc. 3D ASIP 2014, Burlingame, December 2014

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Talks
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Europe in 3D: The Brains behind e-BRAINS (Interview with Reinhard Pufall, Maximilian Fleischer, and Peter Ramm)
3D InCites
Stirring up interest in 3D IC technology and 3D integration
January 2014

Ramm, P.
Heterogeneous Sensor Integration for Smart Ambient Intelligence Systems
e-BRAINS Workshop on Heterogeneous 3D integration of sensors and circuits for Smart Microsystems
Lausanne, Switzerland, February 17, 2014

Erwin Yacoub-George, Andreas Drost, Dieter Hemmetzberger, Dieter Bollmann, Robert Faul, Karlheinz Bock
Interflex: challenges and solutions to fabricate a double-sided wiring layer for a “system in foil”
Smart Systems Integration Conference, Vienna, Austria
March 26 - 27, 2014

Multifunctional System Integration in Flexible Substrates

---------------------
S. Kibler, M. Richter, B. Möller, C. Kutter
Geregelte Mikroschmierung von Präzisionslagern in Hochleistungsspindeln mittels kapazitiver Dosierüberwachung
ITG-GMA Fachtagung Sensoren und Messsysteme 2014
Nuremberg, June 3 - 5, 2014

A. Ohlander, S. Bauer, H. Ramachandraiah, A. Russom, K. Bock
Microfluidic Detection Module For DNA Analysis Using Integrated Microheaters And DNA Microarrays On Plastic Foil
ITG-GMA Fachtagung Sensoren und Messsysteme 2014
Nuremberg, June 3 - 5, 2014

Optimization of a Piezoelectric Micropump Actuator for Medical Application in Glaucoma and Phthisis Therapy
ACTUATOR 2014, 14th International Conference on New Actuators, Bremen, Germany, June 23 - 25, 2014

G.A.M. Nastasi, A. Scuderi, H.-E. Endres, W. Hell, K. Bock
Simple, cost effective and network compatible readout for capacitive and resistive (chemical) sensors
Euroensors 2014, Brescia, Italia, September 8 - 10, 2014

Julia Sporer
Sensormaterialien und Sensorsysteme an der Fraunhofer EMFT
Fraunhofer Institut für Arbeitsschutz IFA, St. Augustin
October 1, 2014

C. W. Jenke, M. Köhn, M. Wackerle, C. Kutter, M. Richter
Dynamic behavior of a piezoelectric micropump actuator
2nd International Conference on MicroFluidic Handling Systems, University of Freiburg, Germany, October 8 - 10, 2014

S. Kibler, L. Hassan, M. Richter, C. Kutter
Feedback controlled microdosing system for nanoliter per second dosing rates using a capacitive phase boundary time-of-flight flow sensor
2nd International Conference on MicroFluidic Handling Systems, University of Freiburg, Germany, October 8 - 10, 2014

N. Palavesam, C. Landesberger, K. Bock
Investigations of the Fracture Strength of Thin Silicon Dies Embedded in Flexible Foil Substrates
SIITME Conference, Bucharest, Romania
October 23 - 26, 2014

A. Ohlander, Th. Ganka, T. Binder, F. Wiest, A. Russom, K. Bock
Real-time Monitoring of Melting Curves on DNA Microarrays in Plastic Lab-on-Foil System Using Silicon Photomultiplier Detectors
MicroTAS Conference, San Antonio, Texas, USA
October 23 - 26, 2014

C. Kutter
Status Quo: Science Community
Electronica 2014, MEMS-Forum: Internet of Things, Munich
November 11, 2014

PD. Borggreve
Design of Analog-to-Digital Converters in 28 nm FD-SOI CMOS Technology
YHTA (Young HTA) Session, St-Martin d’Uriage, France
November 12 - 14, 2014

P. Schneider, A. Heinig, C. Bayer, R. Dal Molin, M. Fleischer, P. Ramm
Technology, Simulation and Design for 3D Integrated Heterogeneous Sensor Systems
Invited Talk @3D ASIP Conference, Burlingame, USA
December 8 - 10, 2014
The following Fraunhofer EMFT patents were disclosed in 2014:

**Carrier substrate with recessed edge, method for reversible fixing of a substrate semiconductor substrate and method for processing a substrate**
Christof Landesberger
WO 2014117853

**Method for exposing a layer**
Erwin Hacker
DE 10 2013 202 458 A1

**Device and method for determining a strength of an adhesion of a biological material**
Jenifer Schmidt, Joachim Wegener, Martin Alberti, Hanns-Erik Endres
DE 10 2013 200 613

**Semitransparent heater for biological and chemical assays**
Anna Ohlander, Gerhard Klink, Karlheinz Bock, Aman Russom
WO 2014064040

**Module, system and method for analyzing three-dimensional structures**
Jenifer Schmidt, Joachim Wegener
DE 10 2012 219 866

**Pump arrangement comprising a safety valve arrangement**
Martin Richter, Martin Wackerle
WO 2014/094879 A1

**Electrical device for connection to an infrastructure power grid and method**
Robert Faul
DE 10 2012 216 369

**Solar panel and its method of production**
Dieter Hemmetzberger, Karin Potje-Kamloth, Sabine Brunklaus, Jens Wüsten
DE 102012 209 322 A1

**Sensor element with a phonotonic crystal arrangement**
Gerhard Mohr, Anna Hezinger, Sabine Trupp, Jennifer Schmidt, Matthias Stich
DE 10 2012 219 643 B4

**Safety label for a container seal and container seal with safety label**
Gerhard Mohr, Anna Hezinger, Sabine Trupp, Jennifer Schmidt, Matthias Stich
DE 10 2012 211 067 A1

**Sensor arrangement for a vacuum therapy system, vacuum therapy system with sensor functions and analysis method**
Gerhard Mohr, Anna Hezinger, Sabine Trupp, Jennifer Schmidt, Matthias Stich
DE 10 2012 201 390

**Transistor structure, method for the production of a transistor structure, force measuring system**
Ignaz Eisele, Martin Heigl, Karl Haberger
DE 10 2011 089 261
Fraunhofer EMFT staff promote the transfer of knowledge through various memberships of networks and collaborative ventures. This enables them to tackle interdisciplinary tasks that go beyond the confines of the institution itself.

### Memberships and Activities

<table>
<thead>
<tr>
<th>Organization</th>
<th>Scientist</th>
<th>Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMA, AMA Science Board and AMA Sensor Innovation Award</td>
<td>Karlheinz Bock</td>
<td>Member</td>
</tr>
<tr>
<td>AMC, Advanced Metallization Conference</td>
<td>Peter Ramm</td>
<td>Membership of the Executive Committee</td>
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<tr>
<td>Association Multi Material Micromanufacturing (4M)</td>
<td>Martin Richter</td>
<td>Head of Microfluidics</td>
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<tr>
<td>Cluster-Offensive Bayern:</td>
<td></td>
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<tr>
<td>• Chemistry</td>
<td>Sabine Trupp</td>
<td>Members and technical consultants</td>
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<tr>
<td>• Power electronics</td>
<td>Christof Landesberger</td>
<td></td>
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<tr>
<td>• Sensors</td>
<td>Hanns-Erik Endres</td>
<td></td>
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<tr>
<td>• Mechatronics and automation</td>
<td>Robert Faul</td>
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<td>Cosima student competition</td>
<td>Martin Richter</td>
<td>Jury member</td>
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<tr>
<td>Critical Manufacturing, Portugal</td>
<td>Peter Kücher</td>
<td>Member of the Advisory Board</td>
</tr>
<tr>
<td>CS MANTECH, Compound Semiconductor Manufacturing Technology, USA</td>
<td>Karlheinz Bock</td>
<td>Member of the Technical Program Committee</td>
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<tr>
<td>dib, deutscher ingenieurinnenbund e.v.</td>
<td>Sabine Scherbaum</td>
<td>Member</td>
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<tr>
<td>German Physical Society</td>
<td>Christoph Kutter</td>
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<td></td>
<td>Hanns-Erik Endres</td>
<td>Members</td>
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<td></td>
<td>Axel Wille</td>
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<tr>
<td>ECS, Electrochemical Society</td>
<td>Peter Ramm</td>
<td>Symposium organizer</td>
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<tr>
<td>Organization</td>
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<td>Position</td>
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<tr>
<td>ECTC, Electronic Components and Technologies Conference, USA</td>
<td>Peter Ramm</td>
<td>Member of the Advanced Packaging Subcommittee</td>
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<td></td>
<td>Karlheinz Bock</td>
<td>Member of the Emerging Technologies Subcommittee</td>
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<tr>
<td>Eduard Rhein Foundation</td>
<td>Christoph Kutter</td>
<td>Member of the Board of Curators</td>
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<tr>
<td>EITI, European Interconnect Technology Initiative</td>
<td>Karlheinz Bock</td>
<td>Member</td>
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<tr>
<td>EOS/ESD Association, USA</td>
<td>Horst A. Gieser</td>
<td>Members</td>
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<td></td>
<td>Heinrich Wolf</td>
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<tr>
<td>EOS/ESD Symposium, USA</td>
<td>Heinrich Wolf</td>
<td>Member of the Technical Program Committee</td>
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<tr>
<td>ESD Association</td>
<td>Horst Gieser</td>
<td>Members, standardization, experts</td>
</tr>
<tr>
<td></td>
<td>Heinrich Wolf</td>
<td>Members</td>
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<tr>
<td>ESD-FORUM e.V.</td>
<td>Horst A. Gieser</td>
<td>Board Chairman and Founding Member, Conference Chair of the 13th ESD-FORUM ESD-FORUM e.V.</td>
</tr>
<tr>
<td>ESTC, Electronics Systems Integration Technology Conference</td>
<td>Karlheinz Bock</td>
<td>Member of the Technical Program Committee</td>
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<tr>
<td>EuMV, European Microwave Week</td>
<td>Christoph Kutter</td>
<td>Advisory council of the cross-sectoral consultation body</td>
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<td>FlexTech Alliance, USA</td>
<td>Karlheinz Bock</td>
<td>Member of the international advisory body</td>
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<tr>
<td>Forum MedTech Pharma, Bayern Innovativ</td>
<td>Karlheinz Bock</td>
<td>Member</td>
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<td>Fraunhofer-Allianz Nanotechnologien</td>
<td>Sabine Trupp</td>
<td>Member and technical consultant</td>
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<tr>
<td>Fraunhofer-Gesellschaft</td>
<td>Dieter Bollmann</td>
<td>Elected representative of the Scientific and Technical Council</td>
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<td>Fraunhofer-Netzwerk Elektrochemie</td>
<td>Hanns-Erik Endres</td>
<td>Member</td>
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<td>G.I.F., German Israeli Foundation for Scientific Research and Development</td>
<td>Karlheinz Bock</td>
<td>Expert consultant</td>
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<tr>
<td>Landshut University, Microsystems Technology Cluster</td>
<td>Robert Faul</td>
<td>Technical consultant</td>
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<tr>
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<tbody>
<tr>
<td>IEEE, Institute of Electrical and Electronics Engineers, USA</td>
<td>Karlheinz Bock, Peter Kücher, Christoph Kutter, Linus Maurer, Peter Ramm</td>
<td>Members</td>
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<td></td>
<td>Detlef Bonfert</td>
<td>Senior Member</td>
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<tr>
<td>IEEE (CPMT), Components, Packaging and Manufacturing Technology, USA</td>
<td>Karlheinz Bock, Detlef Bonfert, Christoph Kutter, Peter Ramm</td>
<td>Members</td>
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<tr>
<td>IEEE (EDS), Electron Devices Society, USA</td>
<td>Detlef Bonfert, Peter Ramm</td>
<td>Members</td>
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<tr>
<td>IEEE (ComSoc), Communication Society, USA</td>
<td>Detlef Bonfert</td>
<td>Member</td>
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<tr>
<td>IEEE (IITC), International Interconnect Technology Conference, USA</td>
<td>Peter Ramm</td>
<td>Member of the Technical Program Committee</td>
</tr>
<tr>
<td>IEEE (ISCDG), International Semiconductor Conference Dresden – Grenoble</td>
<td>Christoph Kutter</td>
<td>Head of the Technical Program Committee</td>
</tr>
<tr>
<td>IEEE (MTT), Microwave Theory and Techniques Society, USA</td>
<td>Detlef Bonfert, Linus Maurer</td>
<td>Members</td>
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<tr>
<td>IEEE (3DIC), International 3D System Integration Conference</td>
<td>Peter Ramm</td>
<td>Head of the Organizing Committee Europe and Founding Member</td>
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<tr>
<td>IEEE Sensor Council</td>
<td>Peter Kücher</td>
<td>Member</td>
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<tr>
<td>IEW, International Electrostatic Workshop, USA</td>
<td>Heinrich Wolf</td>
<td>Member of the Technical Program Committee</td>
</tr>
<tr>
<td>iMAPS, International Microelectronics Assembly and Packaging Society, USA</td>
<td>Detlef Bonfert, Peter Ramm</td>
<td>Member</td>
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<tr>
<td>iMAPS DPC, iMAPS Device Packaging Conference, USA</td>
<td>Peter Ramm</td>
<td>Chairman of the subcommittee on 3D packaging</td>
</tr>
<tr>
<td>Industry Council on ESD-Target Levels</td>
<td>Horst A. Gieser</td>
<td>Member</td>
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<tr>
<td>Innovationspreis der deutschen Wirtschaft</td>
<td>Christoph Kutter</td>
<td>Member of the Board of Trustees</td>
</tr>
<tr>
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<tr>
<td>ISSE; International Spring Seminar in Electronics</td>
<td>Detlef Bonfert</td>
<td>Member of the Steering Committee</td>
</tr>
<tr>
<td>IWLP, International Wafer-Level Packaging Conference</td>
<td>Peter Ramm</td>
<td>Chairman of the subcommittee on 3D integration</td>
</tr>
<tr>
<td>Journal IEEE TCPMT, Transactions on Components, Packaging, and Manufacturing Technology</td>
<td>Karlheinz Bock</td>
<td>Expert consultant</td>
</tr>
<tr>
<td>Micro- and Nanotechnology Journal der Bentham Science Publisher Ltd.</td>
<td>Karlheinz Bock</td>
<td>Member of the Advisory Council of Editors and Expert Consultant</td>
</tr>
<tr>
<td>MITE, Journal Microsystem Technology</td>
<td>Karlheinz Bock</td>
<td>Expert consultant</td>
</tr>
<tr>
<td>MRS, Materials Research Society</td>
<td>Karlheinz Bock</td>
<td>Member</td>
</tr>
<tr>
<td>mstfemNet meets Nano and Optics in the National Pact for Women in MINT Careers</td>
<td>Sabine Scherbaum</td>
<td>Fraunhofer EMFT consultant</td>
</tr>
<tr>
<td>MST Kongress</td>
<td>Martin Richter</td>
<td>Member of the Program Committee</td>
</tr>
<tr>
<td>Plastic Electronics Conference</td>
<td>Karlheinz Bock</td>
<td>Conference co-chair of the „Integrated Smart Systems“ section</td>
</tr>
<tr>
<td>Robert Bosch Zentrum Reutlingen</td>
<td>Ignaz Eisele</td>
<td>Member of the Advisory Board</td>
</tr>
<tr>
<td>SEMI North America</td>
<td>Peter Ramm</td>
<td>Member of the „Standards 3DS-IC“ Committee and the Technical Program Committee</td>
</tr>
<tr>
<td>SIIITME, International Symposium for Design and Technology in Electronic Packaging</td>
<td>Karlheinz Bock, Detlef Bonfert</td>
<td>Member of the Steering Committee</td>
</tr>
<tr>
<td>SIIITME, International Symposium for Design and Technology in Electronic Packaging</td>
<td>Detlef Bonfert</td>
<td>Member of the Scientific Committee and Chairman of the Technical Program Committee</td>
</tr>
<tr>
<td>SMTA, Surface Mount Technology Association</td>
<td>Peter Ramm</td>
<td>Member of the Technical Program Committee IWLP</td>
</tr>
<tr>
<td>SSI, Smart Systems Integration Conference</td>
<td>Karlheinz Bock</td>
<td>Member of the Technical Program Committee</td>
</tr>
<tr>
<td>Swedish Foundation for Strategic Research</td>
<td>Karlheinz Bock</td>
<td>Expert consultant</td>
</tr>
<tr>
<td>TIE, Interconnection techniques in Electronics</td>
<td>Karlheinz Bock, Detlef Bonfert</td>
<td>Members of the Steering Committee</td>
</tr>
<tr>
<td>TH Darmstadt</td>
<td>Karlheinz Bock</td>
<td>Expert consultant</td>
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<td>Trillion Sensor Summit Munich</td>
<td>Christoph Kutter</td>
<td>Co-Chair</td>
</tr>
<tr>
<td>TUT Tampere University, Finland</td>
<td>Karlheinz Bock</td>
<td>Expert consultant</td>
</tr>
<tr>
<td>University College Cork</td>
<td>Peter Ramm</td>
<td>Expert Consultant Research Quality</td>
</tr>
<tr>
<td>VDE ITG, Informationstechnische Gesellschaft</td>
<td>Linus Maurer Werner Muth</td>
<td>Members</td>
</tr>
<tr>
<td>VDE/VDI-Gesellschaft Mikroelektronik, Mikro- und Feinwerktechnik, GMM</td>
<td>Christoph Kutter Karlheinz Bock</td>
<td>Deputy Chair</td>
</tr>
<tr>
<td>VDE/VDI-Gesellschaft Mikroelektronik, Mikro- und Feinwerktechnik, GMM</td>
<td>Horst A. Gieser Christoph Jenke</td>
<td>Members</td>
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<tr>
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Chips featuring six NanoFET structures.
Chip size 2 mm x 0.6 mm