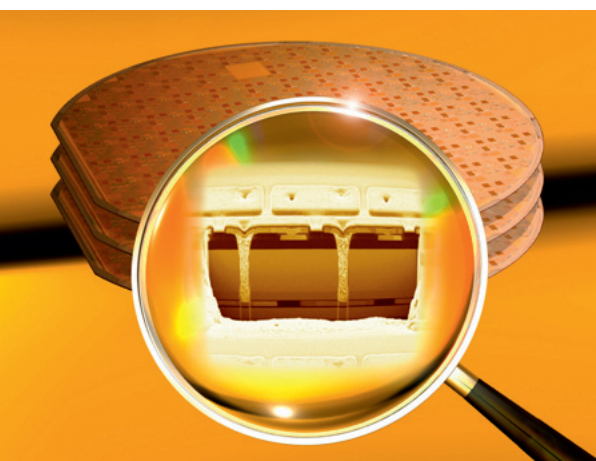




## Super-brains for the IoT age



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Without microelectronics, the “Internet of Things” (IoT) would be blind, deaf, and mute. But in order to be able to keep up with rapid development in this digital age, chips must become smaller, more multifunctional, and more powerful. 3D integration is considered a key technology in order to keep moving the boundaries of the possible out more and more.

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### ■ From the institutes

#### New automotive lighting revolutionizes road safety

A German research alliance has developed the basis for smart, high-resolution LED headlights, taking adaptive forward lighting to a new dimension. Fraunhofer IZM developed a connection technology that allows the resolution of LEDs to be increased by a factor of more than a thousand. Fraunhofer IAF demonstrated a method of eliminating  $\mu$  defects; this method can increase component yield.

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SUPERTHERME project completed successfully

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#### Magic RFID formula for the packaging industry

Intelligent packaging is on the rise. The implementation of RFID technology in the packaging industry is becoming increasingly important especially in terms of information, identification, and security. With its ROAD server, Fraunhofer IPMS provides an easy solution to combine the wireless and optical identification of packaging. This makes it easy to use integrated RFID tags to identify packaging and their content and to read and evaluate product information.

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... comes from Natasha Walker

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Interview with Silke Cuno.

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The degasser includes an integrated silicon micropump for producing the necessary vacuum.

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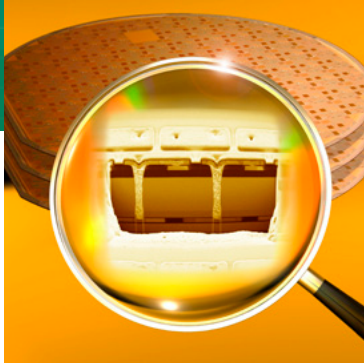
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Date	Event / WWW	Location	Group institutes involved
03/08 – 03/09	Smart Systems Integration 2017 <a href="http://www.mesago.de/en/SSI/home.htm">www.mesago.de/en/SSI/home.htm</a>	Cork, Ireland	Group institutes
03/14 – 03/15	43 <sup>rd</sup> Freiburg Infrared Colloquium <a href="http://www.infrared-workshop.de">www.infrared-workshop.de</a>	Freiburg, Germany	IAF
03/14 – 03/16	Embedded World 2017 <a href="http://www.embedded-world.de/en">www.embedded-world.de/en</a>	Nuremberg, Germany	Group institutes
03/14 – 03/16	LogiMAT 2017 <a href="http://www.logimat-messe.de/en">www.logimat-messe.de/en</a>	Stuttgart, Germany	IIS / SCS, IPMS
03/14 – 03/16	JEC World 2017 <a href="http://www.jeccomposites.com/events/jec-world-2017">www.jeccomposites.com/events/jec-world-2017</a>	Paris, France	IZFP
03/19 – 03/23	OFC: The Optical Networking and Communication Conference & Exhibition <a href="http://www.ofcconference.org">www.ofcconference.org</a>	Los Angeles, USA	HHI, IPMS
03/20 – 03/24	CeBIT 2017 <a href="http://www.cebit.de/en">www.cebit.de/en</a>	Hanover, Germany	Group institutes
04/02 – 04/05	EuroSimE <a href="http://www.eurosime.org">www.eurosime.org</a>	Dresden, Germany	IKTS
04/05 – 04/07	Photonix 2017 <a href="http://www.photonix-expo.jp/en">www.photonix-expo.jp/en</a>	Tokyo, Japan	IPMS
04/24 – 04/28	Hannover Messe 2017 <a href="http://www.hannovermesse.de/home">www.hannovermesse.de/home</a>	Hanover, Germany	Group institutes
04/26 – 04/27	Workshop: Innovation in Failure Analysis and Material Diagnostics of Electronics Components <a href="http://www.cam.fraunhofer.de/events/fraunhofer-cam-workshop-2017">www.cam.fraunhofer.de/events/fraunhofer-cam-workshop-2017</a>	Halle (Saale), Germany	IMWS
05/09 – 05/12	Control 2017 <a href="http://www.control-messe.de/en/control/">www.control-messe.de/en/control/</a>	Stuttgart, Germany	IDMT, IZFP
05/15 – 05/18	6 <sup>th</sup> FOKUS Media Web Symposium <a href="http://www.fokus.fraunhofer.de/go/mws">www.fokus.fraunhofer.de/go/mws</a>	Berlin, Germany	FOKUS
05/16 – 05/18	SMT Hybrid Packaging <a href="http://www.mesago.de/en/SMT/home.htm">www.mesago.de/en/SMT/home.htm</a>	Nuremberg, Germany	IZM
05/16 – 05/18	PCIM Europe 2017 <a href="http://www.mesago.de/en/PCIM/home.htm">www.mesago.de/en/PCIM/home.htm</a>	Nuremberg, Germany	IZM
05/30 – 06/01	Sensor + Test 2017 <a href="http://www.sensor-test.de">www.sensor-test.de</a>	Nuremberg, Germany	EMFT, IPMS
05/30 – 06/02	ECTC 2017 <a href="http://www.ectc.net">www.ectc.net</a>	Florida, USA	IZM

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3D TSV technology.  
© Fraunhofer EMFT / Bernd Müller

## Highly integrated chips: super-brains for the IoT age

Without microelectronics, the “Internet of Things” (IoT) would be blind, deaf, and mute. But in order to be able to keep up with rapid development in this digital age, chips must become smaller, more multifunctional, and more powerful. 3D integration is considered a key technology in order to keep moving the boundaries of the possible further out.

Microelectronic systems are at the core of many products shaping our everyday lives – from smartphones to driver assistance systems and smart homes. Many of today’s chips have such complex functionalities that they could also be considered mini-computers. This is made possible by such technologies as 3D integration, where in general heterogeneous components of a microelectronic system are stacked on top of one another and vertically connected by electrical through via wiring to a single 3D circuit (3D-IC).

### Low-temperature processes protect devices

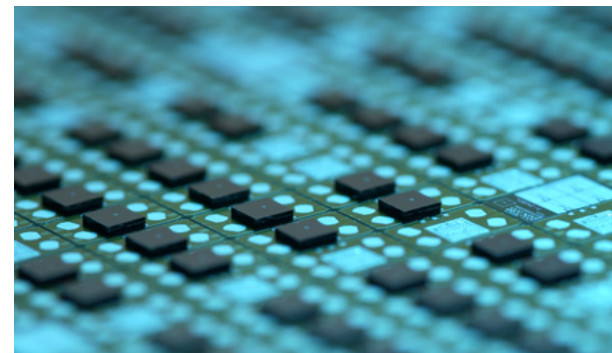
“The trend towards the Internet of Things makes heterogeneous 3D integration a key technology, but also presents challenges,” according to Dr. Peter Ramm, head of Heterogeneous System Integration at Fraunhofer Research Institution for Microsystems and Solid State Technologies EMFT. The scientist is considered a pioneer of 3D integration – his team has e.g. developed the technology of SLID bonding (solid / liquid interdiffusion). In this technology a low-melting solder layer between two high-melting metals is heated up in order to connect the devices both mechanically and electrically. The Munich-based scientists are making use of an intermetallic compound which is solid up to 600 °C. This allows for high mechanical stability of the systems. The immense competitive pressure in IoT applications, however, demands that systems become not only smaller and smaller but also more powerful and robust. In order to meet these challenges, Fraunhofer EMFT signed a license agreement with Invensas Corp. in September, allowing the integration of two of the most modern 3D integration technologies, ZiBond® and DBI® (Direct Bond Interconnect), into its service portfolio. The two processes can be carried out at relatively low temperatures of approximately 200 °C, which has a positive effect on the reliability and life time of the components.

### Intelligence in the hardware for trouble-free communication

Within DBI® technology, the components are electrically joined both mechanically and electrically after special surface pretreatment of the deposited copper and oxide layers. Thus the complex through-plating procedure is no longer required, which makes it possible to manufacture the systems in a cost-effective manner – a basic requirement for access to mass markets such as consumer electronics. This technology also enables producing “pitches” (structural width and clearance between the joints) of only 2 µm, thus allowing for highly integrated chip-stacks with enormous performance.

Josef Weber from the Heterogeneous System Integration department of Fraunhofer EMFT explains why this is so important: “In the Internet of Things, an abundance of information must be processed in fractions of a second. 3D integration technologies such as DBI® offer excellent approaches to processing masses of data at the system level before it is even fed to the cloud.” One research aim for the next few years is thus already clear to the Munich-based scientists: high-performance miniaturized sensor IC systems to allow the smart objects of the future to talk to each other a lot.

Chip stack on a basic wafer.  
© Fraunhofer EMFT / Bernd Müller



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## More mobility thanks to intelligent assistance systems

Urbanization has led to an increase in both the need for and the variety of forms of mobility. The Fraunhofer microelectronics institutes have been working for more than 20 years on developing powerful and energy-efficient systems to allow people to travel safely by car, on foot, or by air. In this special, we will present you with some examples of applications from the "Mobility & Urbanization" business unit.

### Environmentally friendly air travel with "CleanSky"

The EU's "CleanSky" program is intended to make growing air travel more environmentally friendly. The aim of the project is to reduce CO<sub>2</sub> emissions and noise pollution by 50 % and nitrogen oxide by 80 %. The scientists are also planning to introduce a sustainable life cycle for all components of an airplane. The Fraunhofer Institute for Electronic Nanosystems ENAS is involved in the development of a new "smart" wing that will result in lower fuel consumption and noise levels.

### On safer roads with "Ko-TAG"

As part of the "Ko-TAG" project, the Fraunhofer Institute for Integrated Circuits IIS developed an active driver assistance system for pedestrian protection, in conjunction with industrial partners. In order to reduce the number of traffic accidents and to alleviate their consequences, the scientists looked into cooperative sensor technology based on transponder systems. Fraunhofer IIS developed one part of the tracking system: the angular measurement and inertial sensors. In order to detect hazards in good time and reliably, the Fraunhofer scientists are also working on the movement classification of vulnerable road users.

### Saving energy with the 200 kW SiC DC/DC converter

Local direct current (DC) grids are the solution behind many energy-saving options. The newest highlight in this area is the bidirectional DC converter from the Fraunhofer Institute for Integrated Systems and Device Technology IISB, which is constructed of silicon-carbide switches and is designed for battery voltages of up to 750 V and battery charge and discharge currents of up to 300 A. The Fraunhofer development was realized in an installation space of only 1.4 l (143 kW/l) – a previously unattainable power density in the manufacture of these types of converters.

### The electric sports car "IISB-ONE" – an innovative test vehicle with road approval

With the electric sports car "IISB-ONE" from Fraunhofer IISB, an expanded R&D platform for power-electronic vehicle components has been created. The realization of the electric drive train used only systems developed at Fraunhofer IISB. An additional highlight is an inductive charging system at the front of the vehicle. The modular vehicle concept allows the flexible integration of future developments. With its double drive unit and 160 kW that accelerate the vehicle without interruption to tractive force due to shifting, you experience a very sporty driving feeling. At the same time, vehicle electric drive is a very efficient way of using regeneratively produced energy for mobility.

### LIDAR system for gesture recognition

The Fraunhofer Institute for Silicon Technology ISIT has developed a 3D camera based on a 2D MEMS scanner that applies the principle of phase difference between a transmitted laser beam and the detected "echo" as a distance measurement. The phase detection algorithm allows 60 million 3D measurements per second. The camera has a resolution of 450 × 450 pixels and provides six images per second. The depth resolution is intended to be a few millimeters and the maximum detectable distance from the object is 2 m.



*The test version of the "IISB-ONE" electric sports car, which has road approval, during a test drive in Nuremberg's city traffic.  
© Fraunhofer IISB / Kurt Fuchs*

### About the business area:

The „Mobility & Urbanization“ business unit focuses its efforts on car-related developments. For electromobility applications, for example, the institutes in the Group develop systems to add electric vehicles to a network, including such information as consumption figures and the necessary communication systems. Drive systems, energy storage, and the smart power electronics behind them are closely linked to the „Energy Efficient Systems“ business unit. An additional focus is the use of microelectronics for communication and distribution infrastructures.

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*Live demonstration of the "Ko-TAG" project, an active driver assistance system for pedestrian protection, in Aschaffenburg. © Fraunhofer IIS*



Silke Cuno. © Fraunhofer FOKUS

#### About Silke Cuno:

Silke Cuno, who has an M.A. from the Technical University of Berlin, works in the DPS (Digital Public Services) Research Center at Fraunhofer FOKUS in Berlin. Over the last few years, she was involved in the development and coordination of international cooperations and European ICT research projects in the context of smart cities, particularly in projects that support administration and industry in strategically implementing interoperable information and communication solutions. Most recently, she coordinated the STREETLIFE project being funded by the European Commission on the topic of "Integrated Personalised Mobility for Smart Cities" with 12 partners and three pilot projects in Berlin, Tampere, and Rovereto. Her interest is focused on the area of "sustainable cities," smart city platforms, and social innovation.

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## "The mobility change requires networking"

Sustainable mobility concepts are considered a central factor in order to improve quality of life in cities. Fraunhofer Microelectronics News spoke to Silke Cuno, director of the EU project "STREETLIFE" about new approaches to solutions.

#### Ms. Cuno, what challenges will be faced by tomorrow's cities?

In the future, more and more people will live in cities – by 2050, it is forecast that the urban population will be twice what it is today. The aim is to treat the quality of life of all humans equally, while also protecting the environment and the climate. This requires a realignment of energy and mobility systems. A change in mobility requires that road users, means of transport, and operators act in a mutually networked manner. You need access to as much real-time data as possible, as well as urban 3D models such as we have made use of in the STREETLIFE project. Future service systems are intended to allow individual, sustainable mobility offerings in the form of intermodal mobility service chains: "Mobility as a Service." The task of government is to regulate and to guarantee inclusion.

#### One main aim of the project was to reduce CO<sub>2</sub> emissions by motivating road users to use sustainable means of transport. What incentives do you have in mind?

To begin with, information: for many users, the availability of mobility-related, intermodal information in real-time is important. Road users are offered several options of largely seamless route combinations when they query a route; the combinations are made up of many means of transport (intermodal). For users, for example, it is interesting to know how much time they save; how much CO<sub>2</sub> or how many calories they are using when cycling; how the weather is; where the accident black spots are; which events and shops they will pass, etc. The use of gamification approaches in the STREETLIFE apps has also significantly increased user engagement. The option of giving user feedback has also been very well received. The cycling community, in particular, has shown great interest in being able to give specific tips on improving infrastructure. Overall, it became clear that people really do change their mobility behavior based on these prerequisites: bicycles and public transport were used more frequently than cars.

#### From March to May, pilot phases took place in Berlin, Tampere, and Rovereto. What are the most important lessons learned from this field test?

In the pilot phase, the specific requirements of the cities needed to be taken into account. To this end, STREETLIFE worked with local stakeholders. This enabled us to get to know better the demands on a mobility platform and, at the same time, develop a general and transferable reference architecture for open urban mobility platforms. The most important lesson was that one should collect user requirements as quickly as possible at local level and have as many users testing as possible. We were also surprised by the positive effects of the gamification method.

#### How can relevant decision-makers benefit from the project results in the future?

We largely placed our trust in open data, open source components, and open APIs. This allows the solutions to be individually adapted for other cities. With our experiences, we can advise urban planners or other decision-makers on the use of innovative technologies in the area of mobility and support them in making use of the applications we created. All documents on the project should be available for download on our website from January.

#### Last but not least, can you tell us which means of transport you prefer?

I like cycling most of all, but in bad weather I am happy to use public transport as an alternative. In Berlin, I would like to see an improvement to the cycling infrastructure to make cycling safer for everyone.

#### Ms. Cuno, thank you very much for talking to us.

Ms. Cuno was talking to Tina Möbius.

## New automotive lighting revolutionizes road safety

A German research alliance has developed the basis for smart, high-resolution LED headlights, taking adaptive forward lighting to a new dimension. Fraunhofer IZM developed a connection technology that allows the resolution of LEDs to be increased by a factor of more than a thousand. Fraunhofer IAF demonstrated a method of eliminating  $\mu$  defects; this method can increase component yield.

Light is one of the most important helpers in a car; without it, safe driving is impossible. Particularly in bad weather or the darker times of year, suitable illumination protects against accidents. A new, smart car light will help to ensure perfect illumination of the road in every situation.

### Adaptive headlights – continuous analysis for the best lighting conditions

When this smart, high-resolution headlamp is used, the driving and weather situations are continuously analyzed. Variable and adaptive light distribution results in custom-fit illumination in every situation. At higher speeds, for example, the range of the cone of light is automatically increased. In city traffic, on the other hand, a wider distribution of light increases safety as the sidewalk and fringes are illuminated in addition to the road. This function is realized fully electronically without mechanical actuators. The anti-dazzle main beam always gives the driver the best possible view at night – without affecting other road users. This improves perception and is an important contribution to reducing the risk of accidents during night driving.

For the implementation, Osram Opto Semiconductors, Infineon, and the Fraunhofer Institute for Reliability and Microintegration IZM developed an innovative LED chip. To this end, LED arrays with 1024 pixels are mounted on an active driver circuit that actuates each pixel individually. With proper cooling, the chips were structured to allow compensation for a few micrometers of height difference. Thermo-compressing bonding with porous gold nano-sponge and reflow soldering with highly reliable gold-tin were investigated in parallel. Both assembly techniques were applied successfully and were shown to have a robust interface for subsequent LED processes.

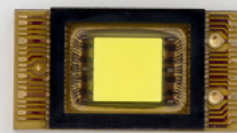
Previously, adaptive headlamps used several LED components arranged beside and

above / below one another. For this new car light, Osram designed, around the high-resolution LED chip, an LED module whose electrical and thermal interface would allow a direct link to the vehicle electronics. Based on the functional requirements of Daimler, HELLA specified the main technical requirements placed on the light source. The light and electronics specialist developed the entire optical system of the light modules as well as the cooling concept, and built the prototype headlight.

### Extremely low-defect LED chip

One of the particular technological challenges of the high-resolution LED headlamp is the relatively large chip with 1024 pixels. This is because as the LED chip size increases it raises the risk of failure or decreased luminosity of the individual light points in the pixel matrix during the production process. To solve this problem, the Fraunhofer Institute for Applied Solid State Physics IAF in Freiburg developed a new technology to treat  $\mu$  defects during the manufacturing process, thus allowing the elimination or isolation of  $\mu$  defects in LED chips. The ultraviolet laser micromachining suppresses  $\mu$  defects, thus lowering the reject rate and the manufacturing costs. What is more, the service life of the LEDs is extended – a competitive edge that also improves customer satisfaction.

*The new class of smart adaptive headlights can, thanks to thousands of individually controllable pixels, be targeted to protect other road users from being dazzled. They do this while still illuminating the remaining environment optimally.*  
© OSRAM Licht AG



*The new type of LED component with 1024 individually actuated pixels is about the size of a fingernail. Combining three of these LED components allows for a resolution of 3072 pixels per headlamp.*  
© OSRAM Licht AG

### About the project:

The  $\mu$ AFS project was funded by the Federal Ministry of Education and Research (BMBF) and ran from February 2013 to September 2016. The project participants included • Osram Licht AG and its semiconductor division Osram Opto Semiconductors as well as the Speciality Lighting automobile electronics group • Infineon Technologies AG • HELLA KGaA Hueck & Co. • Daimler AG and the two Fraunhofer institutes IZM and IAF.

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*Intelligent packaging is becoming more and more important.*  
© Fraunhofer IPMS

## Cleverly packaged, intelligently protected: magic RFID formula for the packaging industry

Intelligent packaging is on the rise. The implementation of RFID technology in the packaging industry is becoming increasingly important especially in terms of information, identification, and security. With its ROAD server, Fraunhofer IPMS provides an easy solution to combine the wireless and optical identification of packaging. This makes it easy to use integrated RFID tags to identify packaging and their content and to read and evaluate product information.

Things become difficult when various RFID components from different manufacturers are left to communicate with each other. In cases in which these components require further integration with optical identification methods such as barcode reader systems, they require extensive implementation times and considerable cost.

The Fraunhofer Institute for Photonic Microsystems IPMS has therefore developed the universal RFID-OPC-US-AutoID server ("ROAD server") software solution. This software provides for easy and cost-efficient integration of various readers, tags, and sensor technology in complex process environments regardless of manufacturer, frequency band, protocol, or interface. As the first middleware of its kind, the ROAD server implements the OPC UA (unified Architecture Open Platform Communication) AutoID companion specification to provide manufacturer-independent communication in automation technology.

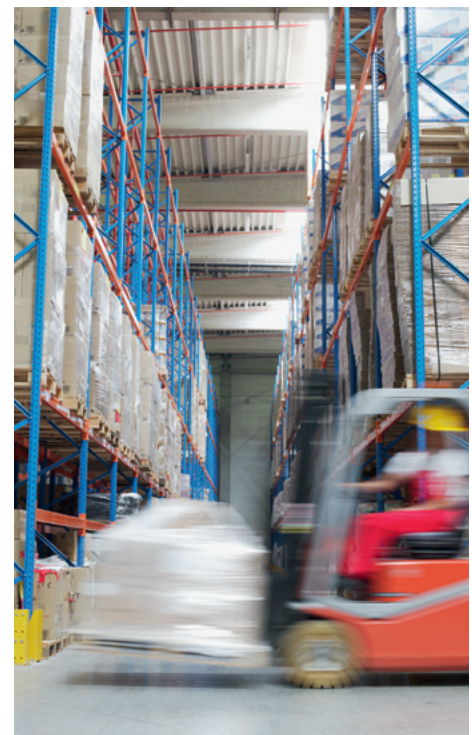
### Ideal conditions for safe transport of food and medicine

Initially used only for RFID components, the Dresden-based research team led by Prof. Dirk Reichelt has now extended the ROAD server to include the integration of 1D and 2D barcode technologies. When implemented on the OPCUA interface basis, applications can be further used regardless of changes to the reader or transponder population. "This is of particularly great interest to the packaging industry. Our software solution enables the easy combination of wireless and optical identification methods. Regardless of whether a packet or shipping crate carries a barcode or an RFID tag, standard reader devices and tags for various frequency ranges can connect and communicate with each other in process constructions over a single standardized in-

terface through the ROAD server. Integration of further sensor transponders for reporting physical parameters such as temperature, moisture, light, or pressure is also possible. In the future, the integration of additional sensors such as limit value sensors is conceivable," explains Prof. Reichelt.

Transporting food, medicines, or hazardous materials must be rigorously controlled. Moisture and high temperatures inside shipping crates can result in quality deterioration and product decay as well as dangerous situations. Sensor values can be wirelessly read and product characteristics can be examined quickly and safely over integrated RFID tags without opening the packaging.

*RFID technologies are on the rise in the packaging industry.* © MEV Verlag



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## Increased sensory perception of self-driving cars

Automated driving is considered the issue of the future in the automobile industry. As "independent" road users, these vehicles must grasp their environment in fractions of a second and react correctly to complex situations. The "Flash-LiDAR" technology being enhanced by Fraunhofer researchers could, in the future, complement existing assistance systems and contribute to better safety.

During the driving test, every future driver must show that he or she can maintain an overview of the course of the road, the lanes, the traffic lights, the traffic signs, and any obstacles even in complex situations. At the same time, it is vital to keep an eye on other road users and to react correctly within seconds to unexpected or incorrect behavior. As part of the trend towards the "Internet of Things," vehicles should be able to do all of this in a few years without control by the occupants. Their most important helpers will be highly specialized sensors, which will also be the "sensory organs" of things. The safety and reliability requirements cannot be high enough – then the fatal consequences of technological failure in this sector became all too clear last summer when the first fatal accident with an autonomous electrical car happened in the US.

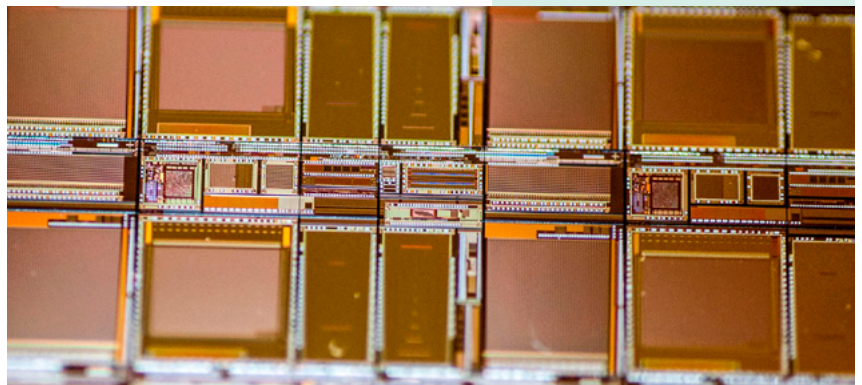
### A view of the entire vehicle environment

In order to increase the safety of autonomous driving, sensor systems based on LiDAR technology (Light Detection and Ranging) could complement the existing camera and radar technology. LiDAR systems transmit pulsed laser beams that are reflected off the surface of objects. The LiDAR device can receive the backscattered signals with time-of-flight cameras. Based on the time that the light needs to reach the objects and return, the distance, position, and speed of vehicles, cyclists, pedestrians, or road work can be calculated. In this manner, LiDAR is able to give a complete picture of the vehicle environment and helps to reliably detect obstacles in traffic. Common LiDAR solutions are, however, very bulky and prone to mechanical failure, which is why the technology has so far barely been used in the automobile industry.

### A single flash to capture the entire scene

Researchers at the Fraunhofer Institute for Microelectronic Circuits and Systems IMS have now enhanced LiDAR. They use highly sensitive sensors that do not require rotating mirrors and can capture the entire scene or environment around the vehicle with a single laser flash. "Flash-LiDAR" is what the researchers call their new generation of sensors, which are made up of several special photodiodes developed at Fraunhofer IMS and known as single-photon avalanche diodes (SPADs). These SPADs are a hundred times more sensitive than the photodiodes integrated into smartphones, for example. Both the sensor and the evaluation electronics are fitted into a single chip, which makes the development particularly small and flat. Automakers can therefore install them easily behind the windshield or in the headlamp, for example. The aim of the Duisburg-based researchers is to be able to cover a distance of up to 100 m using Flash-LiDAR. The first systems with the new sensor generation will enter series production in 2018.

*SPAD sensor chips are realized within CMOS technology. © Fraunhofer IMS*



*It is not always easy to keep a clear eye on everything in city traffic.*  
© MEV Verlag

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Photocatalytically effective ceramic foams. © Fraunhofer IKTS

## Is our water a cocktail of medicines? How ceramics can help to remove drug residues from the water supply.

Ceramic foams and membranes remove drug residues from our waste water efficiently and in an environmentally friendly manner. They can also filter gray water and disinfect process water. In contrast to conventional biological methods, special processes developed by Fraunhofer IKTS are able to eliminate trace substances difficult to remove from drinking water and waste water processing.

For many years, media have been reporting about drug residues in our water. This refers to both the pollution of lakes and watercourses with trace substances and at-risk ground and drinking water. The concentration of active substances, such as diclofenac, bisphenol A, triclosan, and ibuprofen are, as yet, not hazardous to humans, but they are already beginning to cause significant disturbances in the ecosystems of plants and animals.

### Efficient water treatment without the use of chemicals

The Fraunhofer Institute for Ceramic Technologies and Systems IKTS is therefore developing special methods to remove these critical trace substances from the water. The technologies work without the use of chemicals and do not generate any undesired byproducts. This is a significant advantage when compared to familiar methods, such as active carbon filtering or ozonization.

### A wide range of uses: ceramic devices for water filtration and disinfection

Particularly efficient are ceramic components, such as open-pored ceramic foams coated with special catalysts that render the trace substances harmless in conjunction with UV light. By means of ceramic membrane adsorbents, trace substances can be effectively contained. These water treatment systems, currently being developed at Fraunhofer IKTS, can be used directly at the source in order to treat domestic waste water efficiently in sewage plants. They can also be used as a final treatment stage in a drinking water plant or small system directly at the end user's premises.

The benefit of the IKTS technologies is that they are "based on the combination of purely physicochemical processes, such as filtration, electrolysis, and photocatalysis," explains Dr. Burkhardt Faßauer from Fraunhofer IKTS. Thanks to functionalized and highly stable ceramic materials and parts, these processes – some of which are aggressive – are now combined with one another in a small space, allowing the trace substances to be removed safely.

Furthermore, these technologies can be used to disinfect water and to eliminate organic pollution. Ceramic components can thus be used in many parts of a water and waste water treatment system: as a disinfectant for process water, as a membrane filter for gray water, and as a coated ceramic foam for the treatment of gray water.

### autartec® – decentralized water technologies for floating houses

One current plan is the floating "FreiLicht" house in the eastern German region of Lusatia for which Fraunhofer IKTS is developing and testing systems without chemical or biological agents for drinking water and waste water treatment. This is intended to prove that the removal of trace substances can work in the long term, even in decentralized practical operation.

Thanks to the new technology, drug residues in drinking water can now be removed, which was not previously possible. The ceramic parts thus solve the performance, flexibility, and availability problems of biological methods for decentralized waste water treatment plants.



Membrane module for submerged use. © Fraunhofer IKTS

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## 5G: from 2020, a new technology will be launched

5G allows new top speeds, integrated heterogeneous networks, connects billions of devices and sensors, and can react in a mobile and agile manner to various requests. The rollout of the first 5G pilot networks is planned for the end of 2018. Commercial 5G services should be available by the end of 2020 and, by 2025, there should be uninterrupted 5G coverage.

With its operative launch in 2020, 5G is intended to offer the following options: data rates 100 times higher than today's LTE networks (up to 10,000 MBit/s). Subscriber and device capacity that is around 1,000 times higher, 100 billion mobile devices connected at the same time worldwide, extremely low application-specific latency times of under 1 millisecond, and higher availability in terms of coverage and reliability. This will bring improvements to video and music streaming, for example. Even in a normal intercity train, the connection is

often lost. 5G should make streaming possible even in high-speed trains (up to 500 km/h). Ultra-reliable networks are another area. These are used for disaster control, for example, or for controlling critical infrastructures such as the electricity grid. Networks such as these require high security standards, a high quality of service (QoS), and low latency times.

There are different requirements again for the high bandwidths of massive multimedia. Through network intelligence and virtualization, 5G can meet the requirements of every application.

To support customers now in the development of 5G products, Fraunhofer FOKUS is offering a 5G Playground – a test environment in which network operators, manufacturers, and IT companies can already try out new, convergent 5G network architectures and 5G services.



*The worldwide 5G standard will be a highly dynamic network of networks. © Fraunhofer FOKUS / Matthias Heyde*

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## Experience events up close, right from your sofa

Were you not able to get tickets to the final? Or you don't feel like facing the crowds at your favorite singer's concert? In the near future, thanks to virtual reality, everyone will be able to follow events from the comfort of their sofa. Nobody will miss out on the feeling of being in the front row.

"There's no stadium in the world with enough space for every excited fan. So imagine a live event somewhere in the world – filmed with professional cameras such as our OmniCam-360 and then broadcast by satellite to a huge worldwide audience. Every individual viewer has the best seat in the house, right in their own home," says Dr. Ralf Schäfer, head of the video department at Fraunhofer HHI.

In September 2016, Fraunhofer HHI, together with SES S.A., presented a research and development project at the IBC in Amsterdam. The project demonstrated the transmission of a 10K x 2K panoramic video signal via satellite to several devices.

The panoramic signal was received at the SES stand and forwarded to an Ultra HD screen as well as several head-mounted de-



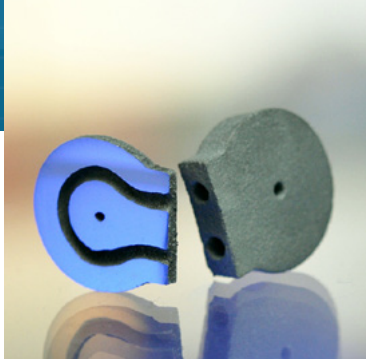
*SES and Fraunhofer HHI demonstrate virtual reality via satellite. © Fraunhofer HHI*

vices for virtual reality (VR). The viewers could choose between a VR headset or the TV screen, determining their own viewing angle and zooming in and out. The filming was done using Fraunhofer HHI's OmniCam-360.

The presentation gave the audience its first impressions of how a VR 360° video might look in the future. The viewer will be part of a virtual event, whether it is a sporting fixture, a concert, or a live show.

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*Wire die with integrated cooling channel in the raw state: at Fraunhofer IKTS in Dresden, hard-metal components are developed according to customer requirements via 3D binder jetting. © Fraunhofer IKTS*

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## ■ Complex hardmetal tools out of the 3D printer

High mechanical and chemical as well as a high temperature resistance and extreme hardness are required for tools that are used in mechanical and automotive engineering. Their manufacturing is complex and cost-intensive. Researchers at Fraunhofer IKTS now managed to develop complex hardmetal tools via 3D printing in a quality that is in no way inferior to conventionally produced high-performance tools.

"Meanwhile, it is known that through resource-saving and tool-free 3D printing, even complex, individualized geometries can be realized quickly," says Dr. Tassilo Moritz, group leader of "Shaping" at Fraunhofer IKTS. The binder jetting method is used in this case.

The starting powders and granules are locally wetted with an organic binder by a print head and bound. The challenge was to get one hundred percent dense components, which have a perfect microstructure

and thus good mechanical properties. By varying the binder matrix, bending strength, fracture toughness, and hardness can be adjusted individually. "Through the use of 3D-printed complex green bodies, which were subsequently sintered under conventional sintering conditions, we achieved components with a typical hardmetal structure and one hundred percent density. Moreover, it is possible to get a homogeneous cobalt distribution, thus achieving a comparable quality to conventionally produced high-performance cemented carbide-based tools," explains Johannes Pötschke, group leader "Hardmetals and Cermets" at Fraunhofer IKTS.

Fraunhofer IKTS supports manufacturers and end users of hardmetal tools in the selection of appropriate materials and in product-specific development of 3D printing processes. For the first time, complex prototypes made of hardmetal were presented at WorldPM 2016 in Hamburg last October.

## ■ 3D sound for impressive VR experiences

During the dark and cold time of year, who doesn't dream of being beamed to a Caribbean island to get some sun, however briefly? Thanks to VR glasses, little getaways like this are possible, at least virtually: in fractions of a second, these glasses can transport us straight into another world. To allow users to enjoy VR applications with all their senses, scientists at Fraunhofer IIS have developed "Cingo," a sophisticated audio technology that creates an amazingly realistic sound impression. Cingo processes both surround and 3D sound content for playback via headphones and adapts the sound field to the user's head movements in real time. Users perceive the sound from various directions and can locate sounds exactly within a (virtual) space – a thrilling virtual reality experience for videos and games is guaranteed.

Cingo is available as a mature software implementation for end device and chip manufacturers as well as for providers of multimedia services. With TCL Communication, Samsung, and LG, the Erlangen-based audio experts have been able to persuade strong industrial partners of the benefits of their solution. Cingo is integrated into the LG 360 VR, the new Alcatel VISION and the



*VISION VR glasses from Alcatel with impressive 3D sound. © Alcatel Mobile Devices*

HULU VR App. In Germany, Fraunhofer IIS recently presented the new sound dimension for VR applications at the IFA. The visitors to the Fraunhofer trade show booth were able to experience convincing VR sound with the Alcatel VISION and the Samsung Gear VR.

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## Moving images in a new dimension

The viewer can freely change his individual perspective of view and gets deeper into the events of the film – it is a high-definition, 360° panoramic video experience: the 360° video solution from Fraunhofer FOKUS allows the display of panoramic videos on HbbTV sets by generating the video image for a desired viewing angle based on the cloud. Only the selected 360° video clip is streamed to the end device, which considerably reduces the required data rate when compared to the transmission of the entire 360° video. The solution from Fraunhofer FOKUS uses this method to create brilliant 360° video experiences on either an HbbTV set or on mobile end devices. Another advantage for mobile end devices is the reduction in battery consumption, as the device does not have to carry out complex calculations. In September, Fraunhofer FOKUS presented its 360° video streaming solution at the International Broadcasting Convention in Amsterdam and at the Internationale Funkausstellung (IFA) in Berlin.

## SUPERTHEME project completed successfully

What do spices in the kitchen and dopant atoms – as they are known – in nanoelectronics have in common? The correct dose is crucial – both for tasty food and for a functional circuit with more than a billion transistors.

Just as too many chili peppers can spoil the food, one dopant atom too many can impair the functionality of a computer chip. Researchers within the Fraunhofer IISB-coordinated EU project SUPERTHEME investigated how to prevent the latter from happening. The project was completed successfully in 2016 with the final review by the European Commission.

The fact that electronic devices such as smartphones work owes no small thanks to a sophisticated optimization of the chip manufacturing processes. Tiny variations within these processes can have a critical effect on the function of the chips. For this reason, highly developed simulation programs are needed to study these effects on the computer before manufacturing processes are implemented in practice.

Within the SUPERTHEME ("Circuit Stability Under Process Variability and Electro-Thermal-Mechanical Coupling") project, scientists

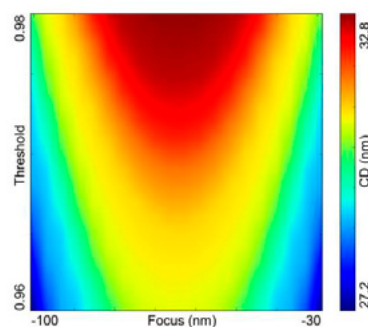
The "HbbTV (Hybrid Broadcasting Broad-band TV) Application Toolkit" is an easy and fast way for application developers and content creators of broadcasters to produce HbbTV applications for their programs. The toolkit offers content creators such tools as templates that contain various features to create HbbTV apps. For example, interactive video galleries can be included. Additional plug-ins support a companion screen function, meaning that TV content can be used on several devices simultaneously.

The Broadcast Probing System from Fraunhofer FOKUS offers a cloud-based system for monitoring digital broadcast networks to detect potential misconfigurations and service degradation in broadcasts. This feedback helps operators to optimize their broadcast operations. The main purpose of the Broadcast Probing System is the cost-effective and near real-time service monitoring at lots of locations to support the detection of faulty conditions.

tists developed a comprehensive system of simulation programs to cope with this challenge.

Using this system, it was possible for the first time to predict the combined effect of process variations in various steps along the manufacturing chain by means of simulations. This gives industry a tool with which processes and circuits can be optimized and the functionality of a wide variety of chips can be ensured. A part of the simulation system is already being offered commercially by the Scottish software house Gold Standard Simulations, which was one of the project partners.

You can find more information at: [www.supertHEME.eu](http://www.supertHEME.eu)



Fraunhofer FOKUS at IBC.  
© Fraunhofer FOKUS

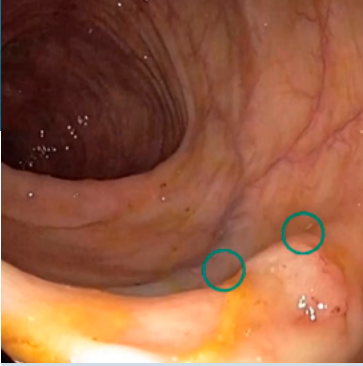
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*Example of simulation-based examination of the effect of process variations: The dependence of the critical dimension CD (e.g. that of a transistor) on the parameters of the lithography process (focus and dose; the second is related to the quantity "Threshold" in the image) used for structuring.*  
© Fraunhofer IISB



*KoloPol recognizes polyps (indicated by the green circle) in real time. © Fraunhofer IIS*

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## Automatic polyp detection for more efficient cancer screening

Colorectal cancer is the second leading cause of death from cancer in Germany. In 90 % of all cases it arises from polyps in the lining of the colon or rectum. These are usually asymptomatic. Regular image-based screening (colonoscopy) can offer a certain level of prevention, and every public health insurance holder over the age of 55 may take advantage of this. During such a colonoscopy, a physician examines the colon and rectum via an endoscope. The effectiveness of this procedure depends greatly on the experience and diligence of the physician performing it. Various studies suggest that between 12 and 24 % of polyps are overlooked.

As part of the "KoloPol" project, which is being funded by the Federal Ministry of Education and Research (BMBF), researchers at Fraunhofer IIS have developed software that may aid doctors by automatically de-

tecting polyp-like regions during colonoscopies. Prominent sections of tissue with abnormal shape, coloration, texture, etc. are detected automatically and highlighted in order to guide the physician's view to interesting regions of the image. The software could thus raise the detection rate of polyps, and, in addition to improved detection, could reduce the amount of time doctors spend on each exam.

From July to October 2016, the system underwent a technical validation at the university hospital Klinikum Rechts der Isar at the Technical University of Munich (TUM). Specifically, its operation and effectiveness were tested in a clinical setting on 58 patients, and the detection of polyps during routine colonoscopies was evaluated. Over 70 % of the polyps detected by the physician were seen by the KoloPol-software.

## Energy-efficient cooling – Fraunhofer IISB integrates vacuum cold water storage into cooling infrastructure

At Fraunhofer IISB in Erlangen, a cold water storage tank with vacuum insulation – unique at this size – has been installed. The custom design from the Sirch company in Kaufbeuren has a storage capacity of 80 m<sup>3</sup>.

The storage system is operated under real conditions and is examined precisely to ensure reliability and efficiency. The direct connection with the existing infrastructure is the reason why this project stands out

and yields more information than classic laboratory demonstrators.

The water, which is cooled down overnight, is held in the buffer storage and made available during the day. Thus, the stored cold energy can be used for peak demand management and support to reduce chiller usage at high outside temperatures. Forecasts promise energy savings of about 15 % due to the increased efficiency of the cooling supply at low outside temperatures. The energy saving potentials can even be increased, when cold energy from free cooling is used to charge the storage unit during the cold winter months.

Thanks to the vacuum insulation, above-ground tank storage units – which are relatively easy to install – can be operated outdoors at low loss rates. In addition to the best possible thermal insulation for the storage unit, sophisticated operating strategies are required in order to be able to implement the desired efficiency gains practically. This is where a Fraunhofer IISB-developed smart control unit for the storage system comes in. Fraunhofer IISB has also developed its own powerful stationary electrical lithium-ion energy storage units. The smart combination of both thermal and electrical energy storages allows a convenient and efficient compensation of peak demands for electricity. The resulting savings make the concept particularly attractive to commercial enterprises.



*At Fraunhofer IISB, the entire chain of energy use is considered within an industrially comparable application. The vacuum cold water storage unit is located near the construction site of the new expansion building B at Fraunhofer IISB. This building will be used from summer 2018 for research and development of power-electronic systems and electrical energy technology. © Kurt Fuchs / Fraunhofer IISB*

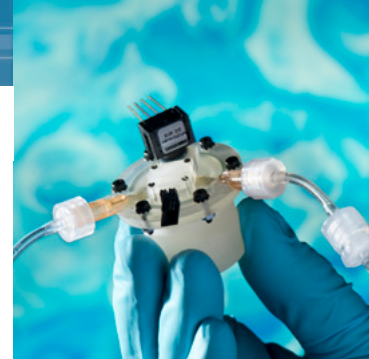
## Self-sufficient degasser for micro-dosing processes

Gases dissolved in liquids can cause serious problems in chemical or biotechnological processes: for example, changes in pressure or temperature can cause the gas in the liquid to outgas, resulting in tiny gas bubbles in the liquid. These in turn may lead to falsified measurement values of the sensors, diminished compressing ability of the liquid, or lower performance of the equipment. To be on the safe side, it is necessary to degas the liquid beforehand. The degassers available for tackling this challenge today are bulky and expensive, and can in most cases only be used in well-equipped laboratories with a vacuum connection.

The scientists at Fraunhofer EMFT have developed a self-sufficient micro degasser, capable of removing gas bubbles and dissolved gas from liquids. The functionality is based on guiding the liquid through a porous tube running through a vacuum chamber, where the gas is diffused. The clever part is that the degasser contains an integrated silicon micro-membrane pump de-

veloped at Fraunhofer EMFT. This pump is capable of producing negative pressures of up to -55 kPa, which is enough to create the necessary vacuum in the chamber and to maintain it during the degassing process. The fact that only a power outlet is needed for the operation opens up wide application opportunities. Another advantage is that a pressure sensor has been integrated into the chamber, enabling the activation of the pump at need, when the vacuum pressure drops below a defined pressure limit. This saves energy and prolongs the lifetime of the micropump.

A functional demonstrator of the micro degasser already exists, exhibiting a degassing efficiency of 50 % at a flow rate of 50-200 µl/min in the tests so far. It is equipped with two standard Luer connectors for the intake and drain, as well as an electronic interface for the voltage control of the micropump, thus allowing for uncomplicated integration of the degasser with most systems.



*The degasser includes an integrated silicon micropump for producing the necessary vacuum.*  
© Fraunhofer EMFT / Bernd Müller

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## Speech recognition for improved safety at sea

Communication problems in navigation are particularly dangerous: in more than 40 % of cases, they are the main cause of accidents; in more than 90 % of cases they are at least an aggravating factor. As a matter of fact, speech comprehension on board vessels, between ships, and between ships and control centers on land present a significant challenge: on the one hand due to the noise levels on board and the often low quality of voice transmission, and on the other due to the fact that crew members of ships, tugs, and marine traffic control are often of many different nationalities.

Researchers at Fraunhofer IDMT now want to use acoustic signal processing and computer-based speech recognition to contribute to improved safety at sea: at last year's SMM trade fair (Shipbuilding, Machinery & Marine Technology) in September, the scientists presented an online training platform for what is known as "Maritime English." With speech input and output, the system makes it possible to practice the standardized maritime phraseology (SMCP – Standard Marine Communication Phrases) in a realistic and dialogue-based manner. The voice input for the chatbot that was

developed for this purpose was implemented in cooperation with the navigation and logistics department of Jade University of Applied Sciences Wilhelmshaven, Oldenburg, Elsfleth.

One technological challenge is to attain reliable computer-based recognition of nautical commands despite differing pronunciations. In order to improve detection technologies for use in international ship-ping, the scientists would like to adapt their signal recording and processing methods to the acoustic conditions in traffic control centers and on the bridge.



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*Prospective nautical officers practice maritime communication in the ship-piloting simulator at Jade University of Applied Sciences Wilhelmshaven, Oldenburg, Elsfleth.*  
© Fraunhofer IDMT / Daniel Schmidt





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*The business office of Fraunhofer Microelectronics is located directly at the River Spree in the heart of Berlin.*

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## Editorial notes

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

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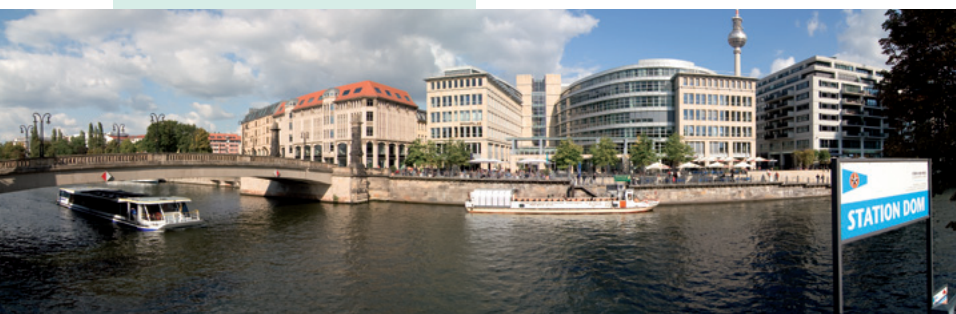
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## The last word ...

### ... comes from Natasha Walker

**Ms. Walker, what are you working on at the moment?**

I am moderating a global group of practitioners and politicians from Africa, the Middle East, and Europe. The aim is to develop digital and conventional strategies to tackle youth unemployment. At the same time, I am preparing for a large organizational development process for a global company and, in another project, I am working on designing bi-national dialogues and moderating all over Europe. Here, experts are developing a "New Pact for Europe."

Some time ago I was moderating a large event organized by the mayor of Mannheim with foreign students who were considering spending their future in that intercultural city on the Rhine. Two days later, I was in Brussels moderating the multilateral steering group of the EU's "Better Migration Management," while my pro bono work took me by the end of the week to Paris, where I moderated the international leadership team of the social impact enterprise "Dialog im Dunkeln." My work is very varied!

**Which Fraunhofer project do you find particularly exciting?**

I am always enthusiastic about how micro-electronics is improving our quality of life. On the one hand, in the area of diagnostics (e.g. The Fraunhofer Institute for Photonic Microsystems IPMS), but also with new ideas for geriatric care (e.g. the Fraunhofer Institute for Integrated Circuits IIS). A few weeks ago, I got to know Prof. Jan Stallkamp, the Director of Fraunhofer PAMB in Mannheim – an enthusiastic researcher who very much enjoys motivating international students to choose a career in research.

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

MP3, of course, but also the hidden Fraunhofer innovations in cars are leading to important efficiency improvements and promoting reductions in emissions. That's very important to me too.

**What do you wish you had more time for?**

Both for adventures and for some quiet time with my family. And for the piano, the

violin, and for writing. Together with my former professor from Oxford, we discuss literature in a forum that she founded – we also write our own texts.

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

Happy and content children, relationship, and clients. I would also like to make a useful contribution to promoting social entrepreneurs that tackle the greatest social injustices in an intrepid and innovative manner. I would like to continue to be inspired by my work and to have pumped a lot of positive energy into the various processes that I support. I would also like to spend part of the year beside the sea.

**What song belongs to the "soundtrack" of your life?**

"Laschia ch'io pianga," or else "Girlfriend in a Coma" by The Smiths.

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

Gratefulness creates its own energy.



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#### About Natasha Walker:

Natasha Walker is a communications consultant focusing on moderation in change processes. After studying language and literature at the University of Oxford, she started building up 20 years of international experience – since 2010, she has had her own company, NWA. She advises companies and SMEs, foundations, the European Commission, the UN, German federal ministries, and scientific facilities on complex processes of dialogue. She has also been associated with the Fraunhofer Group for Microelectronics for many years. She recently moderated the Group's anniversary event. She is in demand for her large-group methods and for moderating expert committees within companies and on social and political themes in Germany and abroad.

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