

**30** Years  
**IIS**  
**IISB**

**HIGHLIGHTS**

**30 YEARS**

**FRAUNHOFER IN THE METRO-  
POLITAN REGION NÜRNBERG**

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# EDITORIAL



Dear reader,

30 years after their foundation, the Fraunhofer Institute for Integrated Circuits IIS and the Fraunhofer Institute for Integrated Systems and Device Technology IISB have together made the Metropolitan Region Nürnberg one of the most successful locations in which the Fraunhofer-Gesellschaft is represented. The institutes have offices in Erlangen, Nürnberg, Fürth, Bamberg, Waischenfeld, and Coburg.

From their shared origins, the two institutes have independently pursued their interests in developing strong and close ties as partners to Bavarian industry, exploiting synergies that provide a real boost to their home region. The two institutes and Friedrich-Alexander-Universität Erlangen-Nürnberg cooperate closely and pool their expertise to create a research location of unique status throughout Germany.

The institutes not only supply industry with excellent know-how and highly qualified personnel; their research activities also create hundreds of valuable high-tech jobs in the region. All this came from modest beginnings: On July 1, 1985, the Fraunhofer-Gesellschaft acquired ZMI GmbH and incorporated it into its newly established Fraunhofer Working Group for Integrated Circuits AIS in Erlangen as an Applied Electronics department with 20 employees. Prof. Dieter Seitzer was the director, supported by his deputy Dr. Heinz Gerhäuser. A second department, Device Technology, was founded at the same time. It had 15 employees and was headed by Prof. Heiner Ryssel. These two departments grew into today's IIS and IISB institutes. The foundations were laid in those early days for what still characterizes the two Fraunhofer institutes today: a focus on electronics, cooperation with industry, a close connection to the university, and the enthusiastic commitment of their employees.

For 30 years, IIS and IISB have been innovators in the fields of microelectronics, power electronics, information and communications technology, and semiconductor technology. Their latest joint initiative is the Leistungszentrum Elektronikssteme LZE, which was founded in 2015 together with the University of Erlangen-Nürnberg and industrial partners.

Today, over 1,100 IIS and IISB employees are engaged in contract research for industry, service companies, and public institutions. Their combined budget of well over 145 million euros a year comes from contract research, with base funding accounting for only around 20% of the total. With 880 employees, IIS is the largest institute in the Fraunhofer-Gesellschaft.

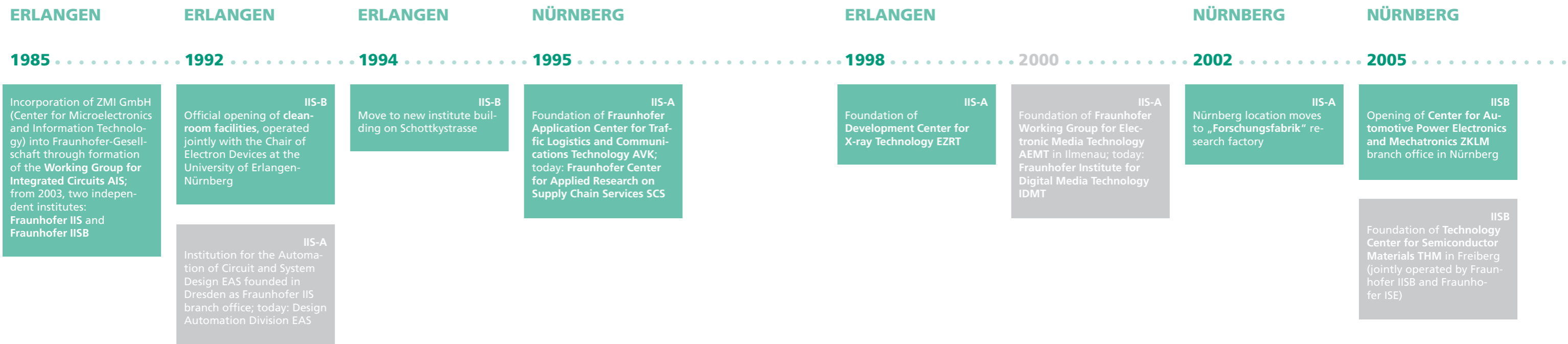
This brochure contains highlights from 30 years of research and provides an overview of the accomplishments and broad expertise of Fraunhofer IIS and Fraunhofer IISB.

*Prof. Dr. Albert Heuberger*  
*Director Fraunhofer IIS*

*Prof. Dr. Lothar Frey*  
*Director Fraunhofer IISB*

# DEVELOPMENT OF FRAUNHOFER IIS AND IISB

1985 – 2006

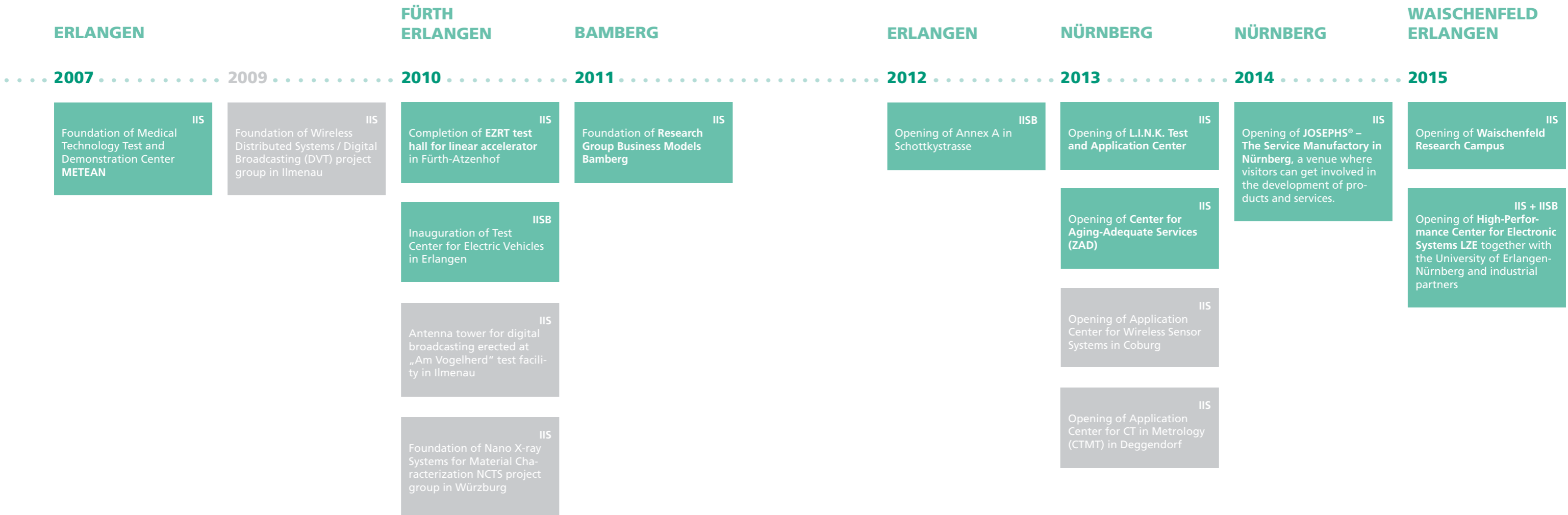


Development of Fraunhofer IIS and Fraunhofer IISB inside the Metropolitan Region Nürnberg

Development of Fraunhofer IIS and Fraunhofer IISB outside the Metropolitan Region Nürnberg

# DEVELOPMENT OF FRAUNHOFER IIS AND IISB

2007 – 2015



# HIGH LIGHTS

## Fraunhofer IISB

The Fraunhofer Institute for Integrated Systems and Device Technology IISB carries out research and development in the fields of semiconductors and power electronics. The institute's work comprehensively covers the entire value chain for electronic systems all the way from basic materials to power electronics applications, with particular emphasis on electromobility and power supply.

The institute works in close collaboration with industrial partners on the development of solutions in the fields of materials design, semiconductor technology and manufacturing, electron devices and moduls, simulation, and reliability testing. Its activities also include the development of systems for vehicle electronics, power electronics, and energy infrastructures.

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

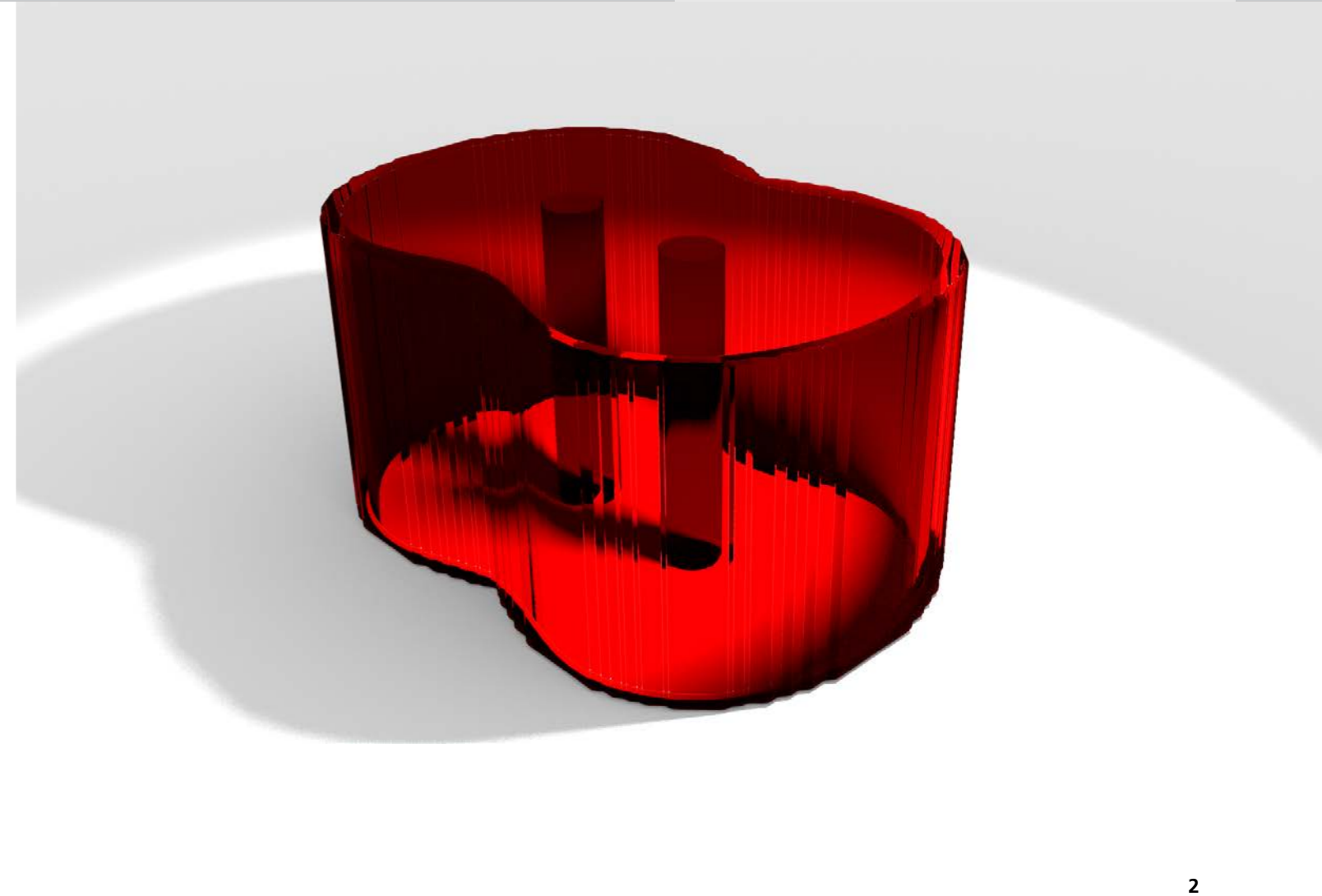
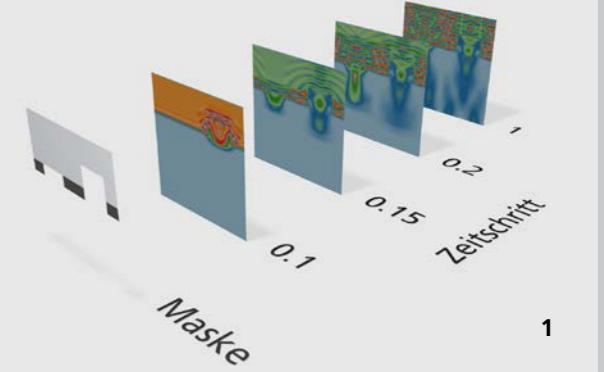
## FOR MORE POWERFUL COMPUTER CHIPS, SEE DR.LITHO

Developed by Fraunhofer IISB, Dr.LiTHO is cutting-edge simulation software for photolithography. One of the most important process steps when manufacturing computer chips, photolithography involves using an optical system to transfer the chip design to a photosensitive resist film on a semiconductor wafer. This film functions as a mask for the conducting, semiconducting, or insulating structural components used to build electron devices and circuits. Even tiny structures of just a few nanometers in size must be reproduced without errors. This is where Dr.LiTHO offers decisive help by describing the interplay of optical and chemical effects, such as the interaction of light with nanostructures, or the spontaneous formation of structures in smart materials.

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1 Simulation of light diffraction on small structures in a phase mask.

2 Simulation of spontaneous structure formation in a co-block polymer.



1

02

**SolarWorld Junior Einstein Award 2010** for research into the formation of silicon crystals and the avoidance of impurities in silicon crucibles. This helps to increase the efficiency of solar cells and reduce the costs for solar electricity.

## AWARD-WINNING SILICON CRYSTALS FOR PHOTOVOLTAICS

Solar cells are made largely from silicon crystals. The manufacture of high-quality silicon crystals weighing up to 1,000 kg is carried out primarily using directional solidification. Non-crystalline silicon is melted in a crucible at 1,420°C and then solidified through crystallization from bottom to top. Quality and yield are dependent on the crystallization conditions. Over the past 10 years, Fraunhofer IISB has worked together with the photovoltaic industry to improve material quality while reducing costs. This highly successful work received the Innovationspreis Mikroelektronik in 2009, the SolarWorld Junior Einstein Award in 2010, the Georg Kurlbaum Award in 2011, and the Ulrich Gösele Young Scientist Award in 2012.

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1 Fraunhofer IISB employee at R&D unit for manufacturing silicon crystals.

2 Silicon wafers for photovoltaics and solar cells.

2

## VGF KNOW-HOW FROM ERLANGEN INSIDE EVERY SMARTPHONE

Most smartphones contain electron devices that are made from the semiconductor material gallium arsenide (GaAs). High-quality GaAs crystals are needed to manufacture these devices. Today GaAs crystals are made using the vertical gradient freeze (VGF) method, whereby the raw material is melted in a crucible at 1,250°C and – starting from a crystal nucleus – directionally solidified. Obtaining high yields and crystal quality requires exact knowledge and control of the temperature field. In the 1990s, Fraunhofer IISB already helped to develop the VGF technique and drove advances in computer simulation for precise temperature prediction. These advances essentially enabled the continuous growth of efficient production in Germany. Today, VGF GaAs – and therefore IISB know-how – can be found inside almost every smartphone sold in Germany.

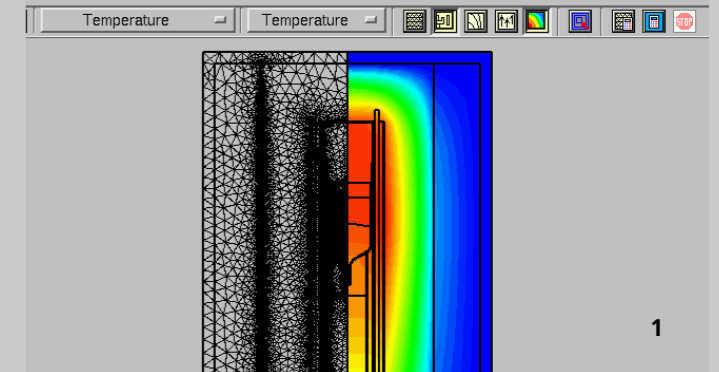
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1 Graphical user interface of the CrysVUn computer program developed at Fraunhofer IISB for calculating temperature distributions.

2 GaAs crystals and the wafers made from them in various diameters. The GaAs crystals were manufactured using the VGF method.



1



2

## LESS IS MORE!

Nanostructures are becoming increasingly important in the world of technology. However, precise quality control of the manufactured structures is needed to ensure that they function properly. An effective and cost-efficient means of doing this is atomic force microscopy (AFM). With this method, a very thin tip – the scanning probe – scans the relevant structures. Long, thin probes with extremely fine tips are required for structures with very steep sides. Regular scanning probes are much too wide for this purpose. Working together with NanoWorld Services GmbH, which has been located at Fraunhofer IISB since 2002, this problem has now been resolved by using ion beams to sharpen standard scanning probes with extreme precision. The refined probes permit measurement of even the most complex nanostructures with unparalleled accuracy.

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*Nano scanning probe with extremely fine tip modified at Fraunhofer IISB using ion beams (scanning electron microscope image).*

## INTEGRATED SILICON CAPACITORS ARE MORE RELIABLE

Modern power electronics allows significant progress to be made in the efficient use of electrical energy. However, increasing miniaturization and progressively lower-loss circuit technology mean that power electronics have to be operated at ever higher clock rates. This also increases the electrical and thermal loads on the electron devices used, leading to a rise in failure rates. Film capacitors are critical components, but they are increasingly struggling with heat problems. A remedy for this is the partial replacement of film capacitors with new kinds of silicon capacitors developed at Fraunhofer IISB. These silicon capacitors reduce the current load, can be cooled more efficiently, and can be fitted right next to the power devices – increasing the reliability and compactness of power electronics.

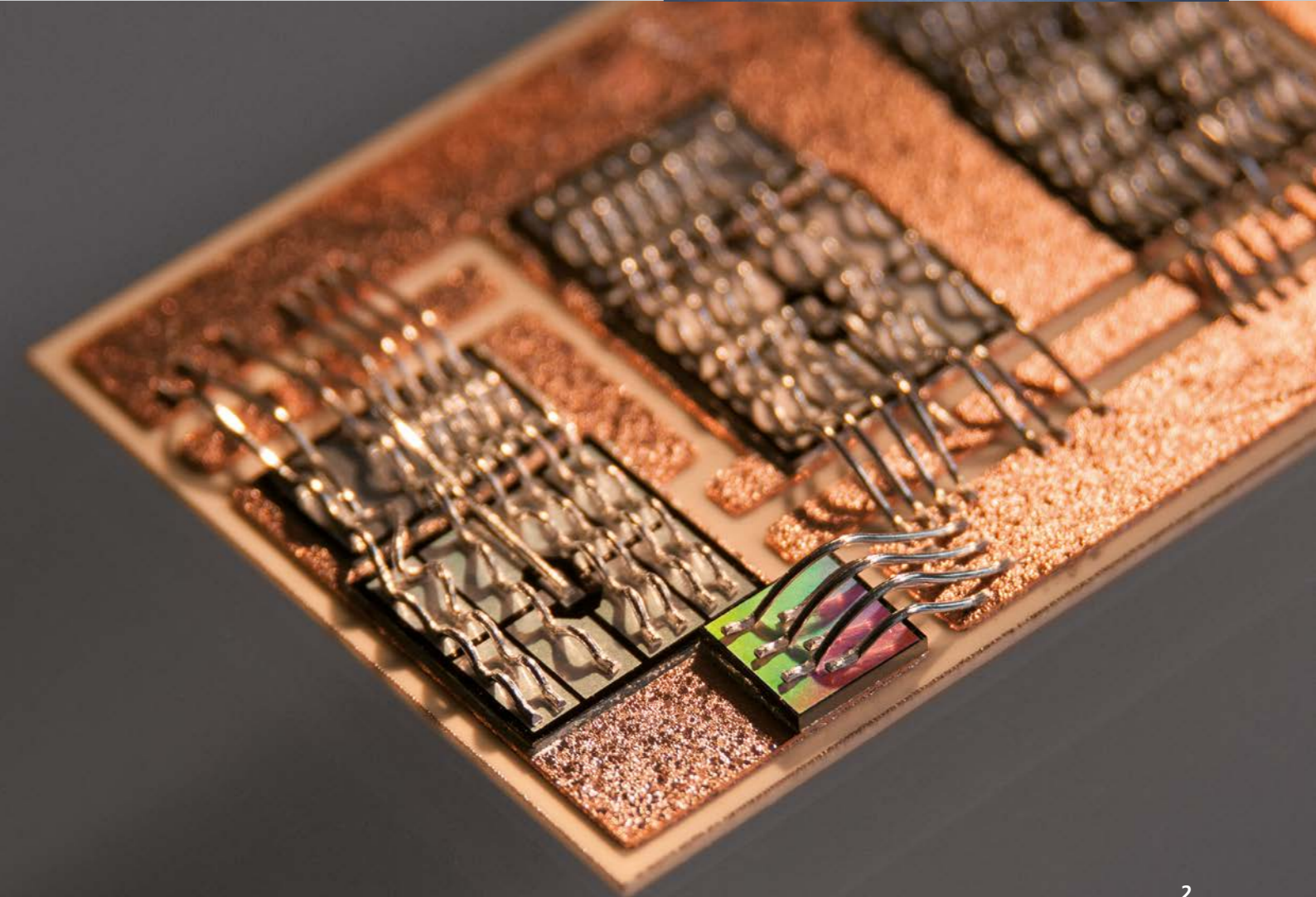
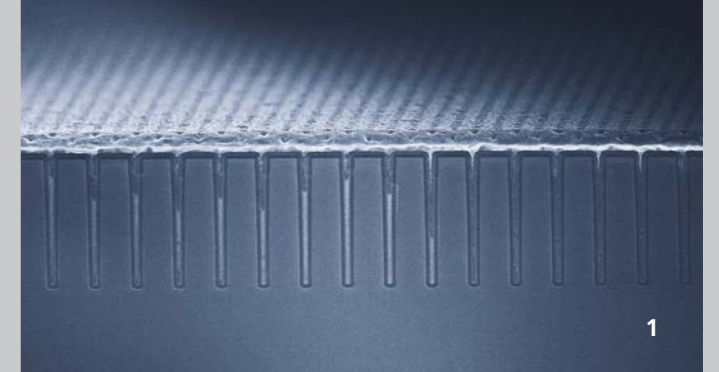
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1 Electron microscope image of an integrated silicon capacitor developed at Fraunhofer IISB (cross-section).

2 Innovative silicon capacitor in an electronic power module.



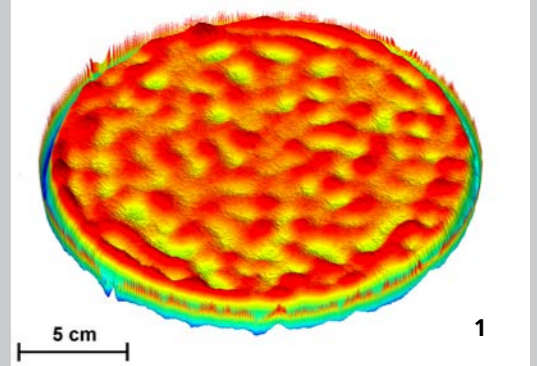
## HIGH-PRECISION MEASUREMENTS FOR MICROCHIPS

Microchips are getting smaller and more powerful all the time. The structures of the integrated circuits are now so tiny that the surface of silicon wafers on which the chips are produced have to be level to perfection. Unevenness in the order of even a few hundred atomic layers significantly reduces the yield of functioning chips. Researchers at Fraunhofer IISB have developed a new measurement technique that measures and graphs the evenness of a silicon wafer across its entire surface to an accuracy of 0.00000001 meters – and does so within just a few seconds. Translated to a macro scale, the power of the technique is equivalent to that of a measurement device capable of instantly recording any imperfection to flatness down to the thickness of a human hair over a surface the size of the city of Erlangen.

### Contact

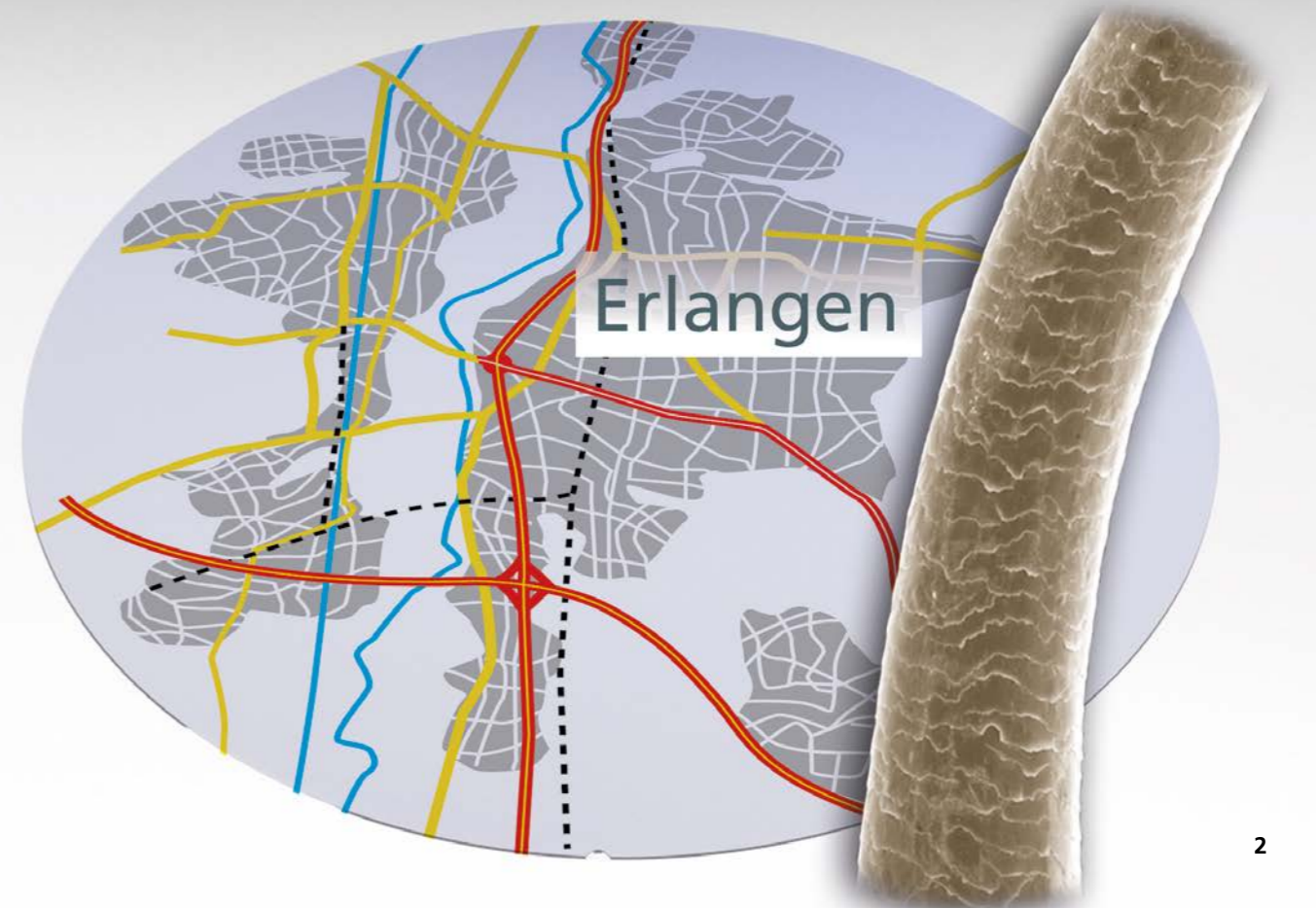
Dr. Anton Bauer

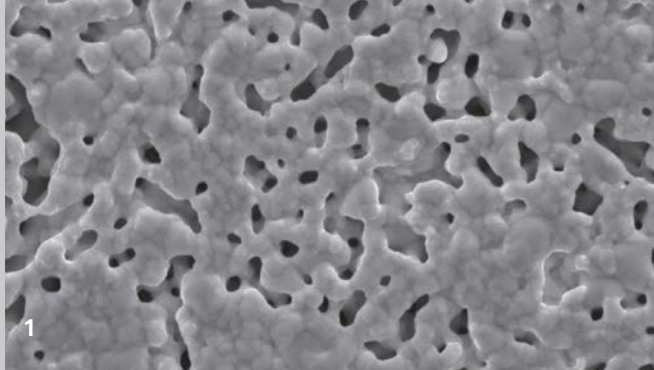
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1 Measurement of a silicon wafer reveals imperfections to surface flatness in the nanometer range.

2 Illustration of the technique's capabilities: if a silicon wafer was the size of the city of Erlangen, the new measurement technique could record flatness imperfections down to the thickness of a human hair.





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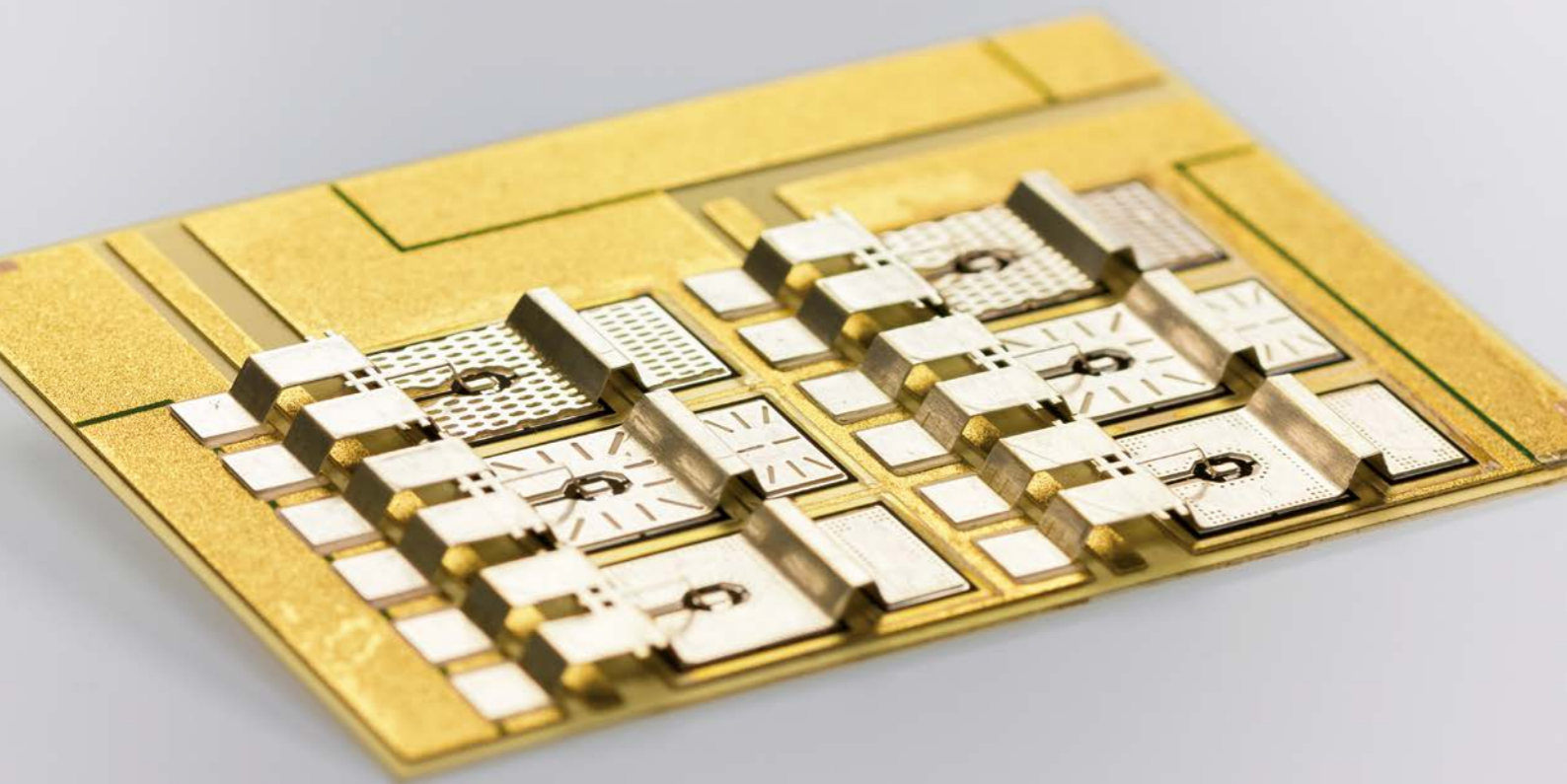
## BAKING WITH TINY SILVER BEADS

Modern semiconductor devices are the workhorses of power electronics. Although these shiny metallic wafers are scarcely thicker than a human hair, they have to work extremely hard. Despite efficient cooling mechanisms, they are subject to intense heat during operation. In order to hold hot devices in place, very resilient bonding techniques are required. One such technique involves sintering with tiny silver particles. Through clever process control, silver nanoparticles are caked together at low temperatures without fusing, an idea inspired by porcelain manufacturing. Using the sintering technique in power electronics means the expensive semiconductors can cope with higher heat loads, getting better performance out of them and reducing costs by up to 30%.

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1 Cross-section of „baked“ sintering layer made up of tiny silver beads.

2 Switch module for the automotive industry, with power components sintered on both sides.

## FRAUNHOFER IISB POWERS ELECTROMOBILITY

Fraunhofer IISB has been developing integrated drive inverters for electric and hybrid vehicles since 2000. In the course of various research projects, including a project with the European Center for Power Electronics (ECPE) industrial network, initial solutions were developed for the full integration of power electronics into the electrical drive systems of hybrid vehicles. Feasibility was demonstrated in principle through new mechatronic solutions. Continuous further development led to the integration of power electronics into wheel hub inverters for electric vehicles, an advancement demonstrated impressively in the „Schaeffler E-Wheel Drive“ created together with the industrial partner Schaeffler Technologies. This new development, which has already clocked up several thousands of kilometers in an experimental vehicle, won the Innovationspreis Mikroelektronik in 2014.

### Contact

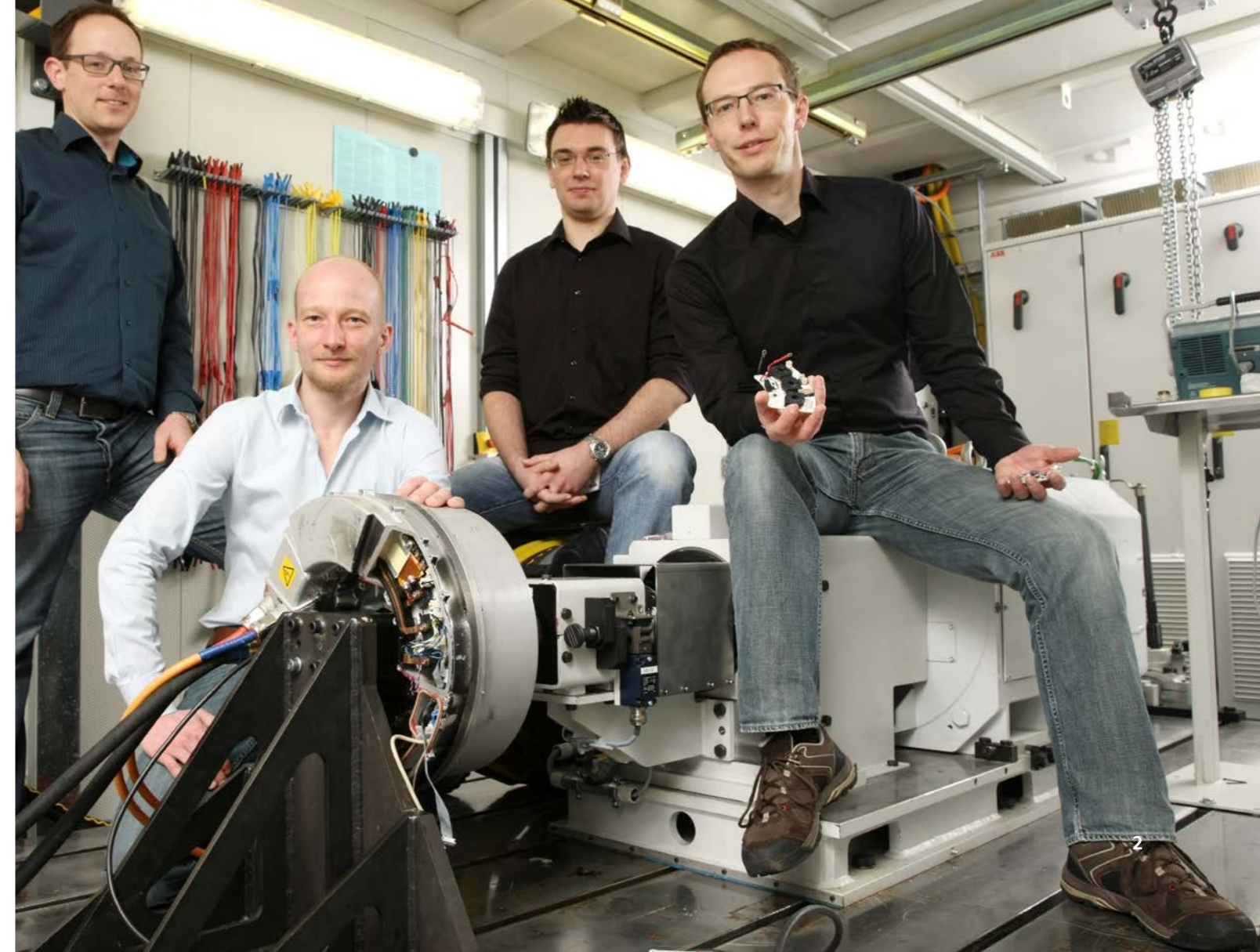
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**Innovationspreis Mikroelektronik 2014** for the new „Schaeffler E-Wheel Drive“ wheel hub system for electric vehicles, which was developed by Schaeffler Technologies in cooperation with Fraunhofer IISB.

**1** Fully integrated electric drive system for a hybrid car.

**2** The innovation award winners at the engine test bench in Fraunhofer IISB's test center for electric vehicles.



**SEMIKRON Innovation Award 2015** for the full SiC DC/DC converter with a power density of 143 kW/dm<sup>3</sup>

## COMPACT VOLTAGE CONVERTERS FOR ELECTRIC VEHICLES

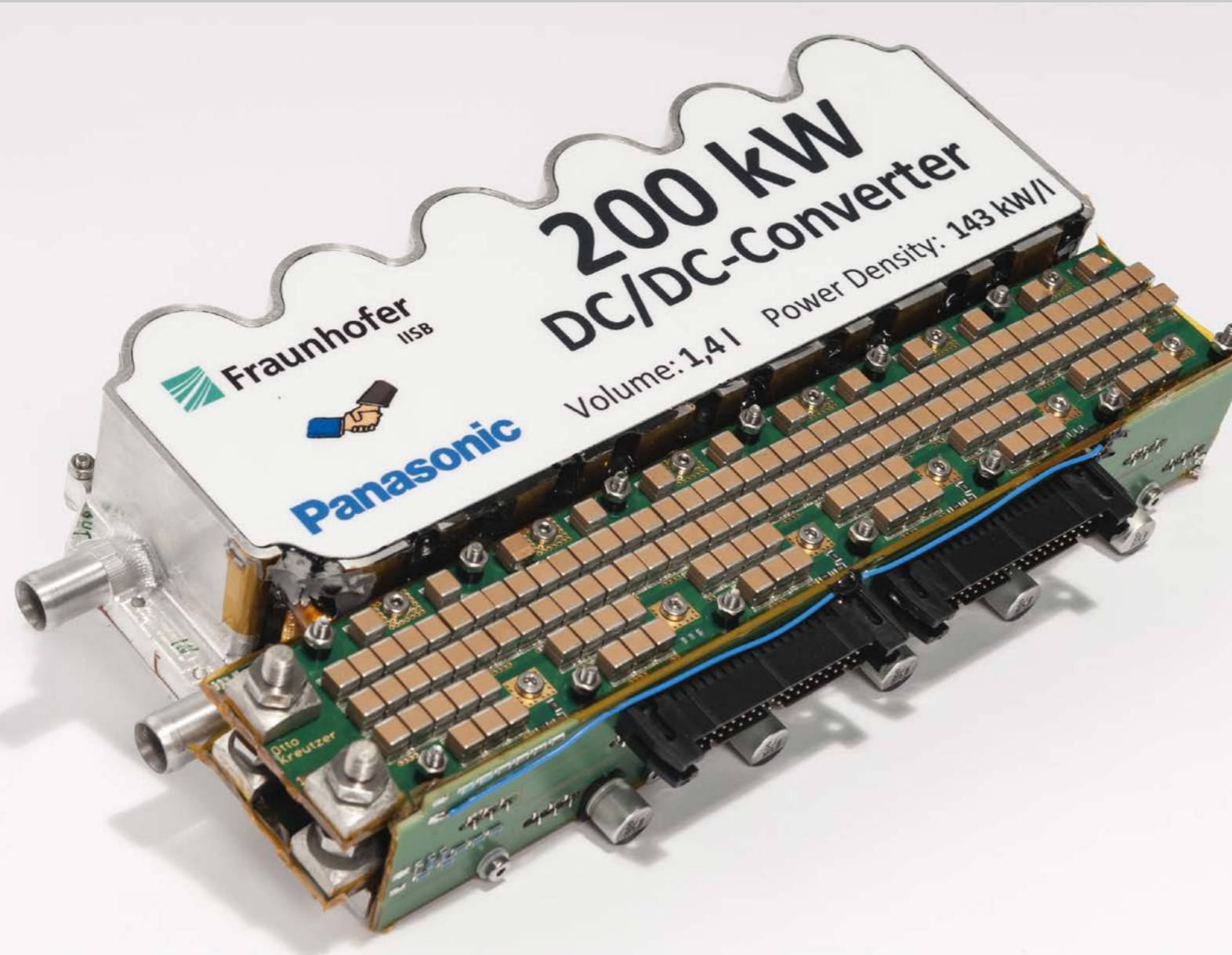
Since 2003, Fraunhofer IISB has been developing bidirectional, highly compact voltage converters for electric and fuel cell vehicles. They were used for the first time in a German Aerospace Center (DLR) experimental fuel cell vehicle. Further developments ensued, such as the voltage converter for Daimler's F-600 fuel cell vehicle. Through the use of innovative semiconductor devices based on silicon carbide, it was possible to increase the converters' power density from 5 kW/liter to up to 143 kW/liter over the course of a decade. Development of a 200 kW voltage converter with this exceptionally high power density won the SEMIKRON Innovation Award in 2015.

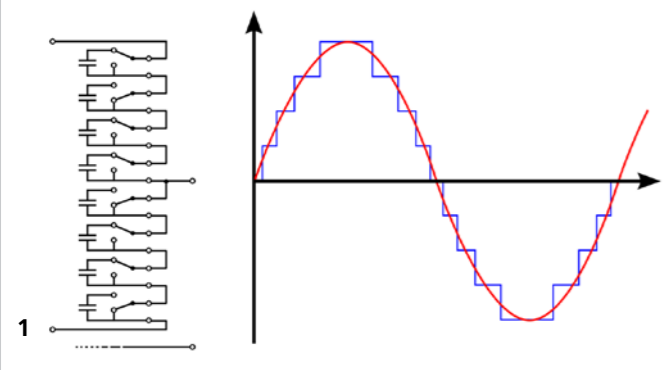
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*200-kilowatt DC/DC converter  
with silicon carbide components  
and a record power density of  
143 kilowatts per liter.*





10

## POWER ELECTRONICS FOR ENERGY TRANSPORT

Restructuring and modernizing power grids is a major challenge of the transition to a new energy economy. A key part of the solution is power electronics components and systems for the distribution and transport of electrical energy. Fraunhofer IISB supports industry with innovative developments in the field of multi-level converters for converting between direct and alternating current. These innovations offer considerable advantages over conventional technology, such as higher flexibility, easier connection of offshore wind parks to power grids on land, and efficient interconnection between various grids. A typical field of application is high voltage direct current (HVDC) transmission, where plants with up to 2 gigawatts transmission capacity are currently built. These plants are hugely expensive and have to work for over 30 years. The focus of Fraunhofer IISB's research is on extremely reliable circuits and special housings for power devices, which prevent one fault from affecting neighboring parts of the system.

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1 Switching topology of a classic multi-level converter.

2 Award-winning cell design for multi-level systems.

## DIRECT CURRENT GRIDS – SMART AND HANDS-ON

Photovoltaic power plants for producing renewable energy deliver direct current. Battery storage systems also work with direct current, and almost all electronic consumers require direct current internally. However, the public power grid works with alternating current. To connect direct current plants and devices to the conventional power grid, therefore, suitable converters and power adapters are always required to convert AC into DC and vice-versa. Yet all that converting is actually unnecessary, wasteful, and technically out of date. Local direct current grids in buildings or industrial complexes – such as those developed by Fraunhofer IISB – are much more effective: renewable energy sources, battery storage devices, computers, lighting, electric vehicles, and many other DC components can be connected with each other in optimal, energy-saving ways. Meanwhile, there is no longer any need for cumbersome power adapters, which opens up whole new design possibilities.

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**1** *Clean and tidy workstation thanks to 24-V DC supply with uniform plug.*

**2** *The DC Grid Manager is the core component in local direct current grids and allows optimal interconnection between a wide variety of electrical sources, storage systems, and power consumers.*



## LOCAL ENERGY INFRASTRUCTURE FOR INDUSTRY

As well as being connected to the public power grid, industrial enterprises and larger buildings also possess local energy systems with power classes ranging from a few tens of kilowatts to several megawatts. Numerous forms of energy are used, such as electricity, heat, cold, or various kinds of gases. The SEEDs project investigates practical ways of realizing sustainable energy use for industrial environments by combining and connecting the various energy sources and storing self-produced energy. To this end, Fraunhofer IISB is expanding its own office and laboratory buildings into a research and demonstration platform for the general optimization of local energy systems while also serving as an example for industrial businesses. SEEDs is sponsored by the Bavarian Ministry of Economic Affairs and Media, Energy and Technology.

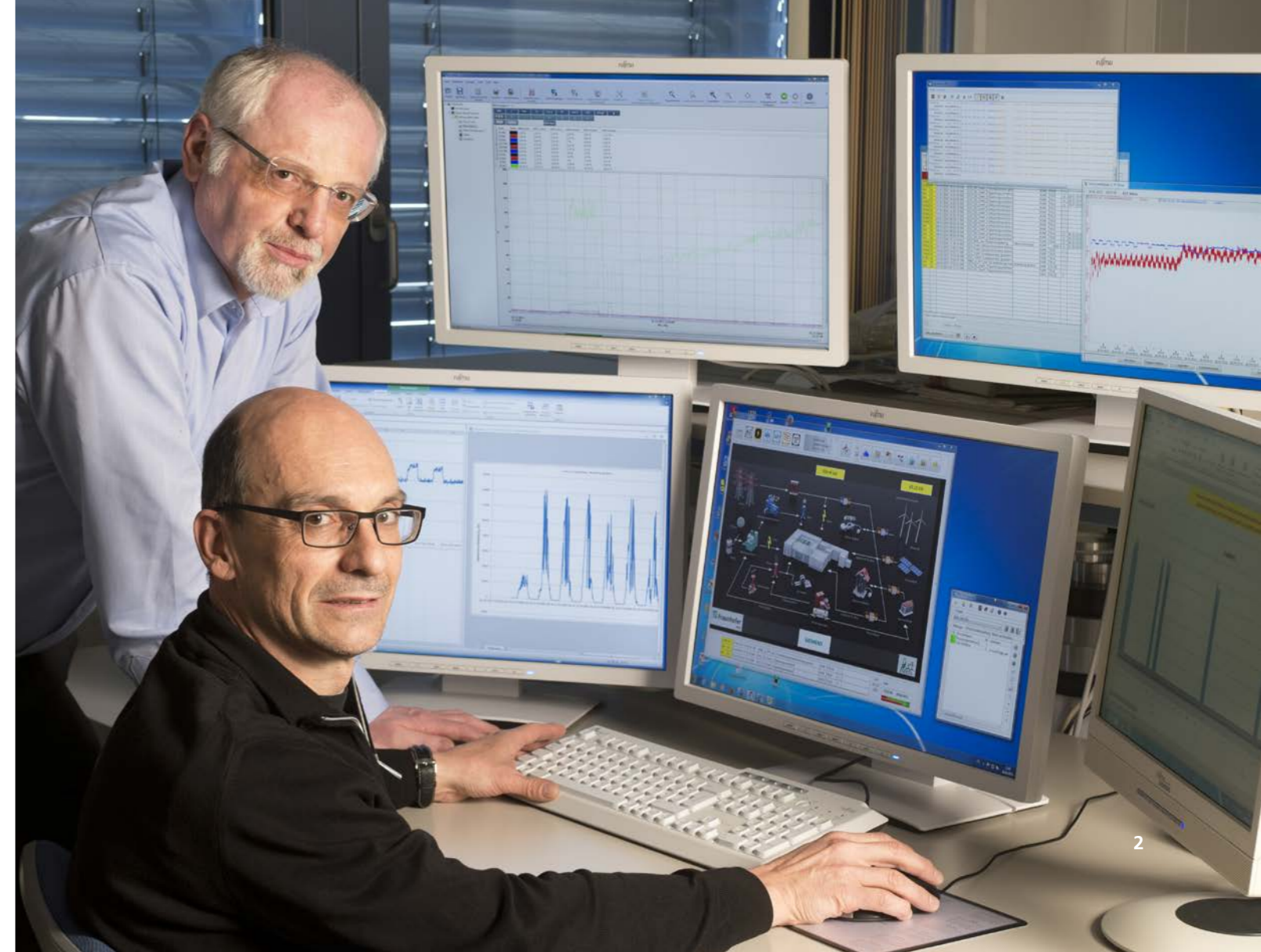
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*1 In Fraunhofer IISB's hydrogen test facility, researchers investigate the incorporation of hydrogen as an energy source in the local energy infrastructure.*

*2 At Fraunhofer IISB, all local energy flows (electricity, heat, cold) are monitored and analyzed. The results form the basis for optimizing the local energy system.*



# HIGH LIGHTS

## Fraunhofer IIS

The Fraunhofer Institute for Integrated Circuits IIS is one of the world's leading application-oriented research institutions for microelectronic and IT system solutions and services. It ranks first among all Fraunhofer Institutes. With the creation of mp3 and the co-development of AAC, Fraunhofer IIS has reached worldwide recognition.

In close cooperation with partners and clients the Institute provides research and development services in the following areas: Audio & Multimedia, Imaging Systems, Energy Management, IC Design and Design Automation, Communication Systems, Positioning, Medical Technology, Sensor Systems, Safety and Security Technology, Supply Chain Management and Non-destructive Testing.

About 880 employees conduct contract research for industry, the service sector and public authorities. Founded in 1985 in Erlangen, Fraunhofer IIS has now 13 locations in 10 cities: Erlangen (headquarters), Nuremberg, Fürth, Dresden, further in Bamberg, Waischenfeld, Coburg, Würzburg, Ilmenau and Deggendorf. The budget of 120 million euros is mainly financed by projects. 23 percent of the budget is subsidized by federal and state funds.

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

Audio & Multimedia: mp3 und AAC audio codecs

## THE SOUND FOR BROADCASTING AND THE WEB

Transmitting music via telephone was an idea institute founder Prof. Dieter Seitzer had way back in the 1970s. However, he could hardly have envisioned that it would transform the world of communication. Prior to 1995, digital music consisted of huge volumes of data stored on CDs. Transmitting an uncompressed file at 1,411 kbit/s would have taken up approx. 22 ISDN telephone lines. Fraunhofer IIS carried out research on this topic from 1987, and the institute presented the new mp3 audio standard in the 1990s. Suddenly high-quality audio was available in handy file sizes. The first mp3 players were sold in 1998, and today many billions of devices use this format.

Through the popular practice of streaming, today's music lovers want to access their favorite songs or videos online from wherever they are. The ISO MPEG HE-AAC standard is one of the most widely used audio coding technologies for this purpose: there is scarcely a cellphone or PC, TV set or set-top box that works without HE-AAC. And content is coded using HE-AAC wherever you look, from DAB+ to YouTube. Accordingly, HE-AAC is to radio broadcasting and streaming what mp3 is to private users: a worldwide standard without which modern consumer electronics and media use would not be possible.

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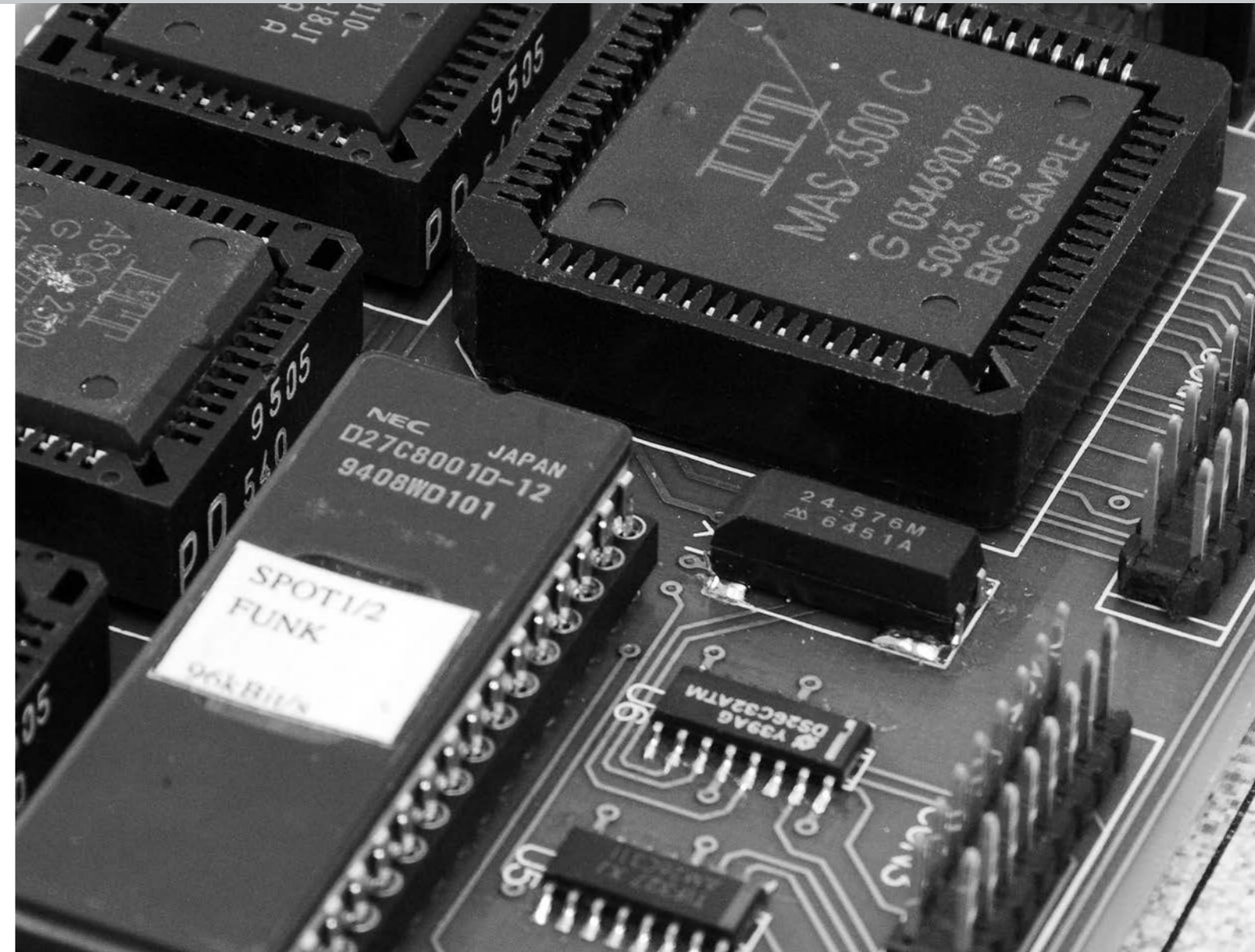
**Fraunhofer Prize 2004** for „AudiolD – Sturdy content-based identification of audio signals“

**German Future Prize 2000** for „mp3 – Compression of audio signals in hi-fi quality for the internet and radio“

**Microelectronics Innovation Award 1999** for „mp3 single-chip decoder“

**Fraunhofer Prize 1992** for „Data rate reduction of digitally coded audio signals for transmission and storage“

*Initial prototype of an mp3 player from 1994. The prototype was the size of a cigarette packet and had a storage capacity of one megabyte.*



**Fraunhofer Prize 2013**  
for the magnetic field sensor  
3D Hall sensor

IC Design and Sensor Systems: HallinOne® magnetic field sensor

## DETERMINING POSITIONS

Nowadays, what's behind clever technology is seldom widely known. Why does a washing machine not wobble during a spin cycle even when the washing is distributed unevenly? The answer is simple: A magnet fitted in the drum generates a magnetic field, and a 3D HallinOne® magnetic field sensor developed by Fraunhofer IIS detects the direction of the field in all three dimensions. In this way, the imbalance in the laundry drum can be identified and compensated. It was over 15 years ago that IIS scientists first had the idea to design a 3D Hall sensor based on CMOS technology. This enables manufacture at the lowest possible cost and optimizes the solutions that can be made available for position measurements.

Developing customized chips is one of Fraunhofer IIS's core competencies. In fact, the institute has become one of the leading IC design organizations in Europe. In the meantime, HallinOne® offers 6D position measurement, providing even greater accuracy, precision, and reliability. This allows positional shifts and rotational movements in a magnet to be recorded simultaneously. Applications include control elements in human-machine applications.

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*The magnetic 3D measuring cell  
ensures that the washing  
machine runs smoothly and  
does not wobble.*

Medical Technology: FitnessSHIRT

## T-SHIRT MEASURES VITAL FUNCTIONS

Nobody would willingly lug bricks around with them. However, this was exactly the size of the chunky circuit board developed at Fraunhofer IIS in 1995 for a „multi-channel transducer for medical engineering applications“. 20 years later and the sensors for the mobile recording of vital parameters look a lot more user-friendly. A stylish FitnessSHIRT contains textile electrodes that allow it to measure the wearer's pulse along with their breathing rate, the number of steps they have taken, and the activity they are engaged in, such as walking, running, or cycling. It assists in the care of high-risk patients, helps sportspeople to optimize their training, and provides the foundation for a healthy lifestyle. In the future, the FitnessSHIRT will also assist relief forces in dangerous situations. To this end, researchers at Fraunhofer IIS are developing systems to help locate people and to continuously monitor vital functions.

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**Fraunhofer Prize 1995**  
for the „development of a multi-channel transducer for medical engineering applications“

**1** *How things change! This wearable sleep home monitoring device from 2006 does not look all that comfortable.*

**2** *In the FitnessSHIRT, the wearer scarcely feels the integrated electronics.*



Supply Chain: „TOP 100 in European Transport and Logistics Services“

## THE BIBLE FOR LOGISTICS PROFESSIONALS

Every year for 20 years now, professionals have found everything they needed to know about the logistics market in Germany and Europe in the „TOP 100 in European Transport and Logistics Services“ study – from current developments to detailed company profiles. The first edition appeared in 1995 under the stewardship of Prof. Peter Klaus, who at the time was director of the Fraunhofer Application Center for Traffic Logistics and Communications Technology AVK. Today the „TOP 100 in European Transport and Logistics Services“ is published in German and English in alternate years by the now renamed Fraunhofer Center for Applied Research on Supply Chain Services SCS and provides valuable knowledge that cannot be found elsewhere. Logistics is a discipline that spans a wide variety of industries, which means that it is not singled out in statistics. Anyone who needs information about this market either has to laboriously collect and compare it themselves from different sources or else procure it from the companies themselves. For obvious reasons, the latter is only possible for a neutral organization such as Fraunhofer.

*The TOP 100 has grown and adapted year on year in response to the changing needs and developments in the market – in terms of scope, contents, and target groups. Readers come from the worlds of logistics, industry, politics, research, consultancy, and academia.*

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Medical Technology: Endorama software

## PANORAMIC VIEW INSIDE THE BODY

Working with partners, Fraunhofer IIS already developed a digital high-speed camera for the motion analysis of vocal cords back in the 1990s which is still used to investigate voice disorders. Today, numerous advances in medical image analysis support medical diagnosis in laboratories and hospitals. When doctors use an endoscope while examining or carrying out surgery on a bladder wall, for example, they examine just a tiny section of the organ at a time – their view resembles that captured through a keyhole. The „Endorama“ software expands this view to a panorama, which it pieces together from all the images recorded. Orientation and navigation inside the body are improved through sensor-based systems for image rectification and image panoramas capable of expanding the field of view in real time. In the future, the researchers also want to use the new techniques for industrial applications, such as for peering into twisted cavities in technical environments.

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**Fraunhofer Prize 1996**  
for „digital high-speed video  
system“

**1** *In 1998, the high-speed camera inside endoscopes was already capable of taking 10,000 images a second.*

**2** *Today the Endorama software pieces together a panoramic view of the inside of the body from a large number of individual images.*



Non-destructive Testing: TireChecker optical inspection system

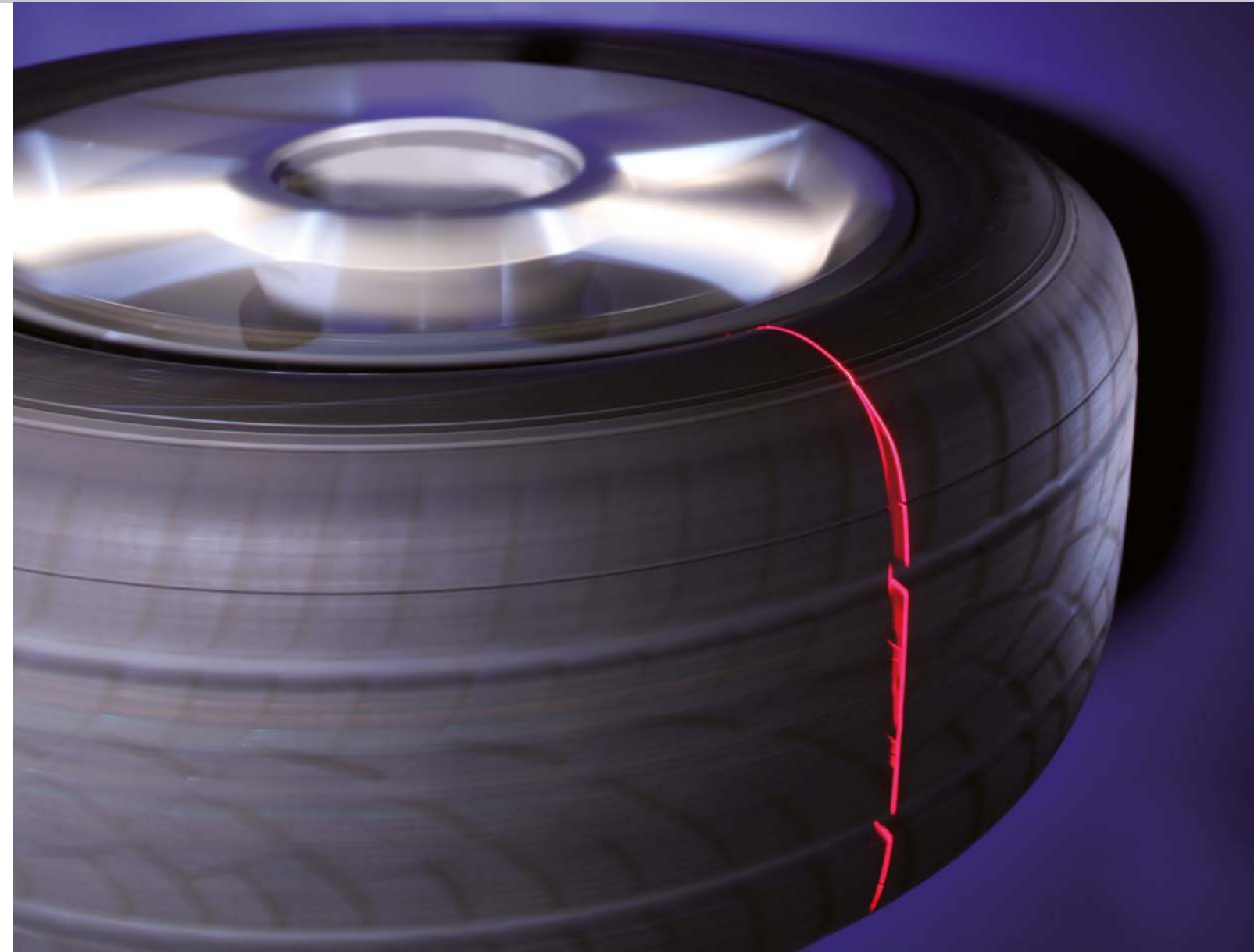
## MEASURING WITH LIGHT

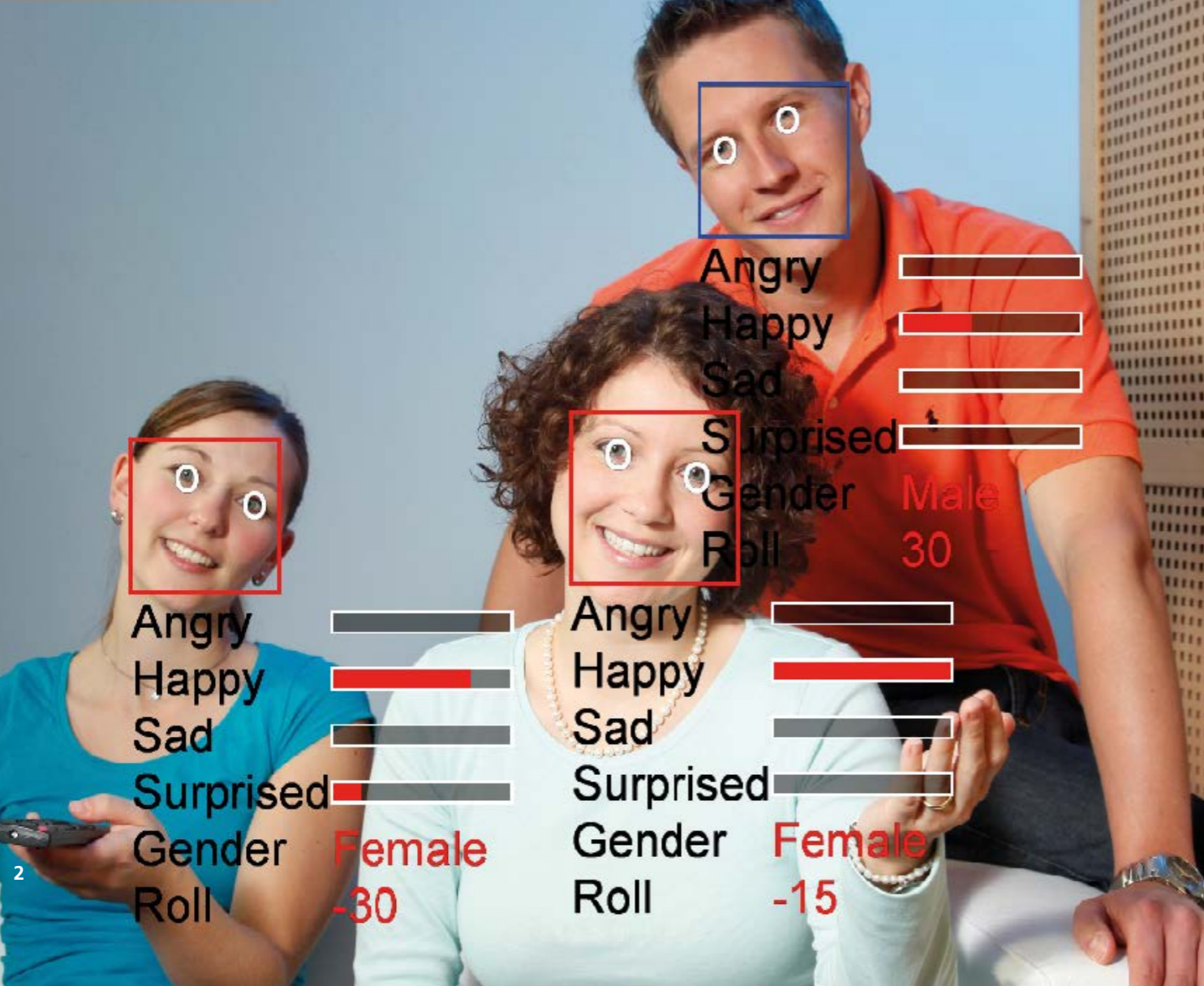
The internationally patented TireChecker inspection system measures the three-dimensional height contour of the entire surface of a car tire during a single revolution. Using a sheet-of-light measurement technique, a line of light is projected onto a tire and recorded by a special camera at a determined angle to the direction of projection. A height profile is then calculated from the intersection of the light line with the surface. Through the rotation of the tire, a few thousand height profiles of the surface are recorded within a second. The sheet-of-light technique is superbly well suited to the rapid three-dimensional measurement of the surface of a test object. Development work on TireChecker began in 1998 and the system has been constantly improved and refined since then.

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*The sheet-of-light measurement technique enables three-dimensional surfaces to be quickly measured while in motion.*





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German Innovation in Market Research Award 2012 to EMO Scan (GfK Verein), in which SHORE™ is integrated as a major component.

Imaging Systems: SHORE™ facial recognition and analysis software

# ANGRY? HAPPY? SURPRISED?

In 1998, only those who stood in exactly the right position in front of the access terminal and were recognized as employees were admitted to the institute. The so-called SESAM facial recognition system could recognize certain facial characteristics but not faces themselves. Because the positioning was so awkward and time-consuming, the institute's scientists decided to develop a system that was able to recognize faces. The result is SHORE™, a software for facial detection and analysis that works in real time. Today SHORE™ not only recognizes faces, but also age, gender, and facial expressions. The system is also capable of processing images and videos created under difficult light conditions and with low-performance cameras. SHORE™ is available on all commonly used platforms and operating systems. It delivers exceptionally fast and reliable results on mobile devices. For market researchers, medical doctors, and developers of systems that involve human-machine interaction the software is very useful. SHORE™ is currently used by over 400 licensees worldwide. In the future, the developers want to further improve the recognition of facial expressions, so that subtler emotions are also picked up.

1 With the precursor technology to facial recognition, you had to position yourself right in front of the camera.

2 Today the software recognizes faces and also age, gender, and mood.

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## Non-destructive Testing: Intelligent System for Automated Radioscopy (ISAR)

# THE FAULT DETECTIVE

Since 1994, the Intelligent System for Automated Radioscopy (ISAR) has been detecting foreign materials and casting defects in safety-relevant lightweight components such as alloy wheels and cast aluminum chassis frames, as well as in welds and plastics. ISAR is used by leading international light metal foundries as a key component in serial testing.

As we advance toward Industry 4.0, the system will become even more important as test results obtained by ISAR are used increasingly for process optimization (process feedback) in addition to quality testing. This means that the system learns from every component tested and, with the aid of process models, infers from the faults detected how, for example, a casting machine has to be set or readjusted to prevent casting errors. The future will also see the linking together of several testing approaches in a defined hierarchy. If we take radioscopy and inline computed tomography as an example, a 2D radioscopy unit might first check whether a fault is present; when necessary, the same system would initiate a local CT measurement in order to precisely locate and evaluate the fault.

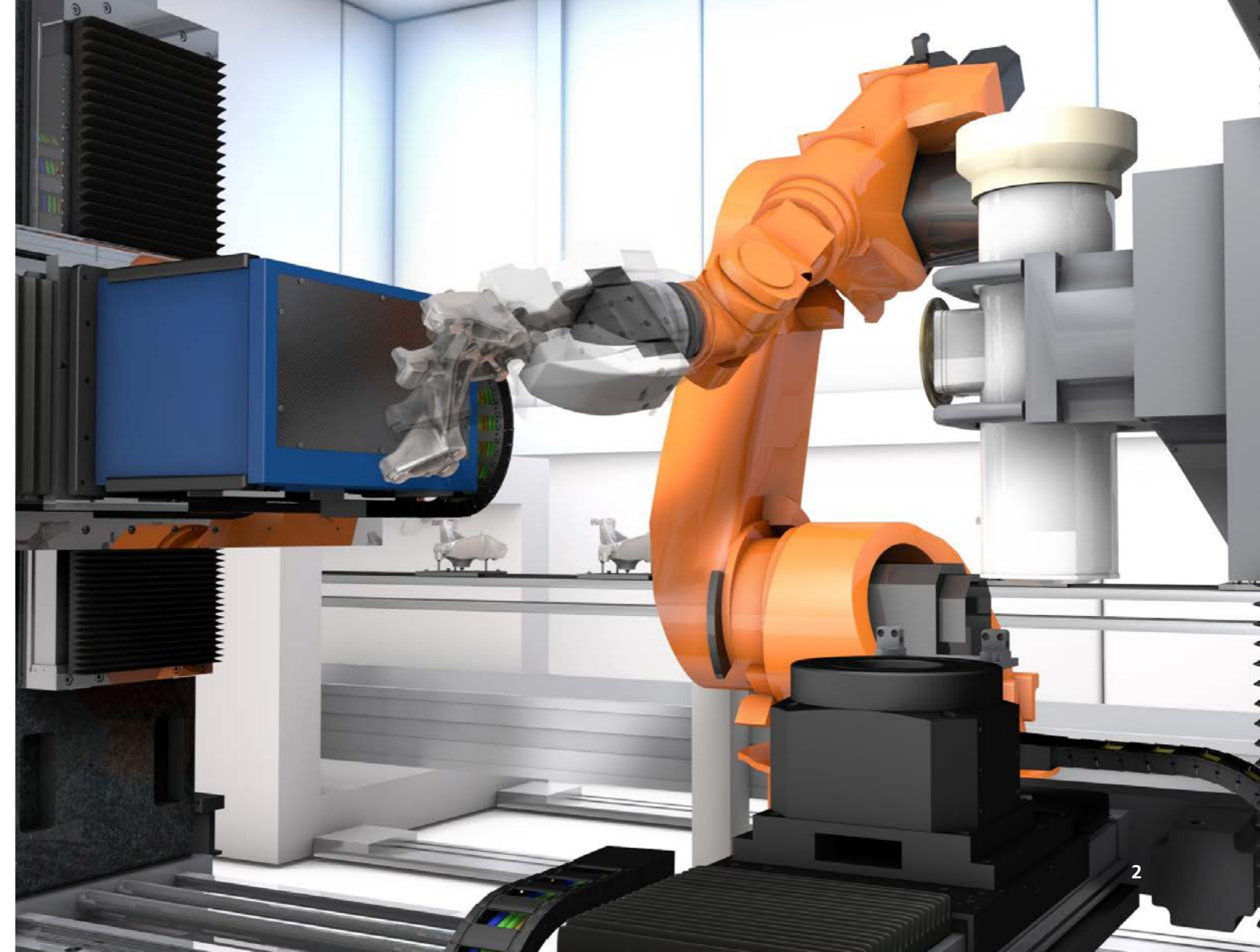
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**Fraunhofer Prize 2001**  
for „ISAR – Intelligent System  
for Automated Radioscopy“

**1** Since 1994, the ISAR x-ray inspection system has been used as a key tool in the serial testing of components.

**2** Already in its seventh generation, ISAR still defines the state of the art for the fully automated evaluation of x-ray images.





Positioning: Galileo

## SECURITY AND RELIABILITY FOR EUROPE

Nobody today would want to be without navigation systems. Whether you are driving or jogging or working in logistics, it is useful to know where you are. To be more independent from the American GPS and the Russian GLONASS standards, the purely commercial Galileo satellite navigation system is being built in Europe. The advantage of Galileo is that it is more reliable, available, accurate, and secure.

Fraunhofer IIS has been involved in the collaborative European project as a research partner since 2001 and provides one of the main development sites for Galileo receiver technologies with the GALILEOLAB at its Nürnberg location. Through the combination of various systems such as GPS, Galileo, EGNOS, and WLAN, it is possible to continuously acquire exact positional information even in places where conventional localization technologies still have gaps.

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*Reliable and particularly powerful localization technologies are created in the GALILEOLAB in Nürnberg by combining different systems.*



Positioning: RedFIR® real-time localization

## WHO HAS THE BALL?

Angle of arrival, time of arrival, event detection – these are key terms in radio-based location positioning. This technology can easily identify the position of optically concealed objects, a major advantage over video-based tracking systems. RedFIR® performance analysis is capable of identifying where people and objects are in real time to a high degree of precision.

For over a decade, Fraunhofer IIS has been successfully implementing positioning technologies for the sport industry and has played a major role in chip-in-ball technology. Data about players and the ball are becoming increasingly important in soccer training. The focus is on the position of the ball in relation to the player and the behavior of the different units of the team in relation to the ball. RedFIR® makes a detailed analysis possible, which can be adapted individually to training styles and players. The system is already being used successfully for youth development in the national German Bundesliga.

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*RedFIR® real-time localization  
collects data about ball move-  
ment and player behavior.*

Energy Management: OGEMA 2.0 open source framework

## SMART MANAGEMENT OF ELECTRICAL ENERGY

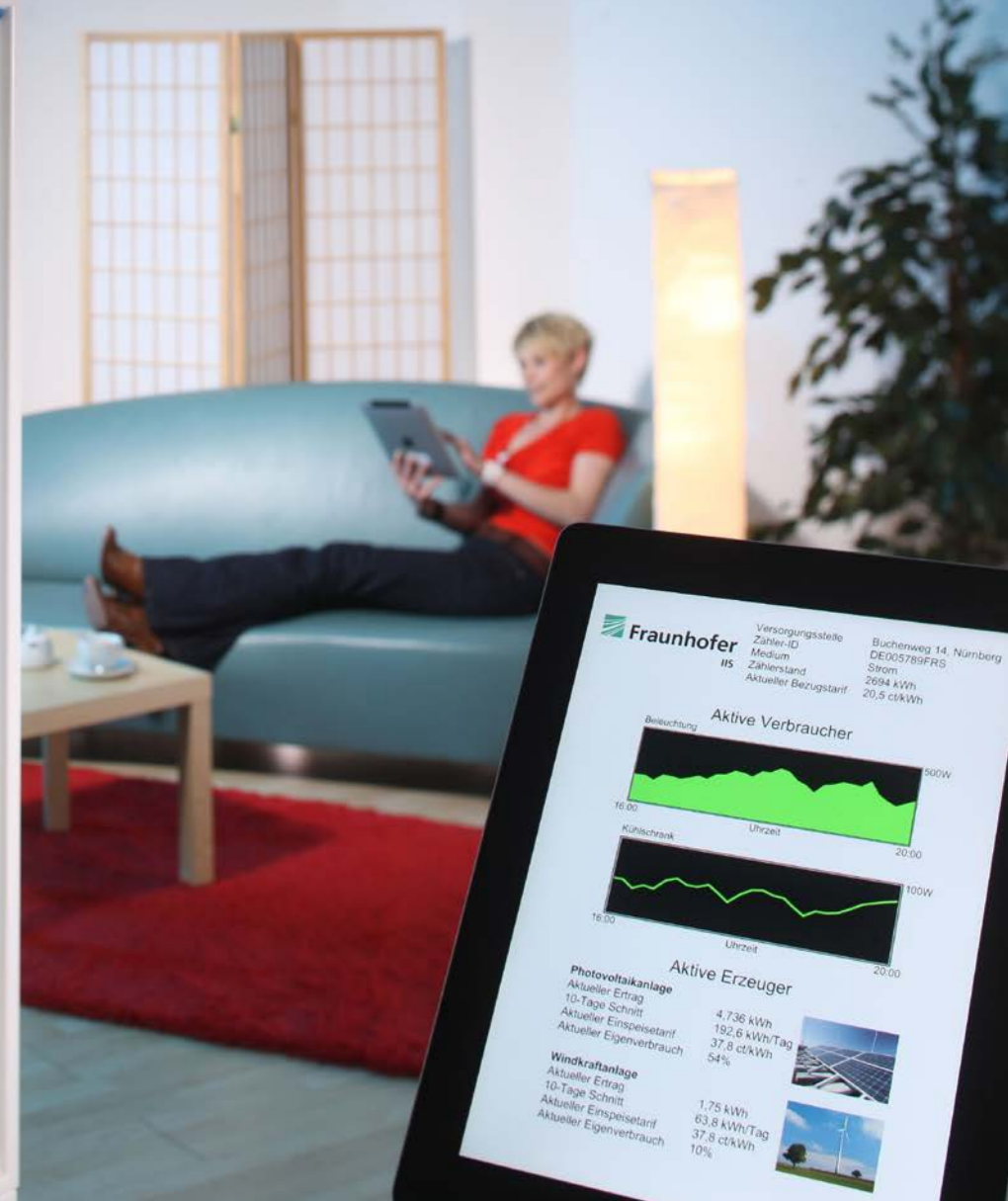
Optimal use of energy starts with power generation and energy harvesting followed by efficient use in transport, production processes and buildings up to storage in battery systems as well as the development of new concepts for power grids. Fraunhofer IIS has been working intensively on these issues for the past ten years. Starting point was the use of microsystem technology and microelectronics in decentralized energy production.

Not only hardware but also software is an important factor for energy-efficient embedded systems used for energy management. The OGEMA 2.0 open source framework facilitates the secure, user-friendly control of buildings and industrial processes as well as the optimization of energy consumption. A variety of different systems can be connected, which can be monitored and controlled by apps. Target applications include energy generation from private photovoltaic installations, use of cogeneration plants or control of production processes. The integrated security concept comprises a permission and role management which is an important attribute for reliable operation in the Internet of Things.

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*OGEMA 2.0 allows the flow of energy to be controlled securely and easily from a tablet computer.*



1



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**Microelectronics Innovation  
Award 2012**  
for POLKA polarization camera

Imaging Systems: POLKA polarization camera

## SEEING WHAT OTHERS CAN'T

Glass is clear and transparent: there's nothing else to see. At least, not for the human eye. A polarization sensor „sees“ things very differently. If polarized light encounters glass or plastic that contains mechanical tensions, its polarization changes. This is displayed as a false-color image. In factories, this helps to detect residual stresses in glass or clear plastic containers, for example, and to separate out defective ones during production.

In 2007, developers at Fraunhofer IIS started to work on a camera chip that would generate graphical, space-resolved polarization information. Today the image sensor is fitted in the POLKA polarization camera and can capture the polarization characteristics of light in a single shot. Its read-out rate of up to 50 frames per second makes it suitable for use in inline inspection applications working at high throughput. In the manufacture of lightweight materials such as carbon fiber reinforced plastics, for example, POLKA reveals the orientation of fibers. Their alignment is an important determinant of the material's strength.

1 *POLKA opens up completely new testing and analysis methods.*

2 *The polarization information obtained is displayed as a false-color image. This allows to visualize the material tensions in a PET bottle.*

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2

### Non-destructive Testing: XXL computed tomography

## LOOK AT THE SIZE OF THAT!

Whole cars, shipping containers, aircraft components – the high-energy CT scanner in Fürth can test objects even as large and thick-walled as these non-destructively. And that is only the start of the application spectrum of this unique CT machine. Since the results of such tests have become known, increasing numbers of customers from a wide variety of sectors have been prompted to approach Fraunhofer IIS scientists with their unresolved issues, and to discuss not only possible solutions but also to share their ideas about how the technology can be developed further. An artist had x-ray images taken of classic Ferraris, paleontologists have examined the bone structure of a Tyrannosaurus Rex skull, and historians have made use of tomography to visualize for the first time mechanisms in antique music instruments. The Development Center for X-ray Technology in Fürth is currently the only place where fully assembled large objects can be subjected to a spatial analysis in sub-millimeter detail. They can then be studied layer for layer and evaluated in 3D as a whole or in parts. The insights and experience gained continuously contribute to the further development of the system. As the laboratory system is very flexible and permits many variations as regards scanning method, object geometry, and detail resolution, it's exciting to imagine what will be brought in for inspection next.

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**1** Large objects such as crashed cars can be scanned using the XXL CT technology.

**2** The 14 meter high test hall is equipped with a turntable three meters in diameter as well as a three ton X-ray source and a four meter long detector installed on two „manipulation towers“.



Imaging Systems: easyDCP software for digital cinema

## IMMERSING YOURSELF IN THE CINEMA EXPERIENCE

What has software got to do with the movies? A mere decade ago, hardly anyone was interested in this question. The images flickered on the screen from big analog film reels. And then suddenly it seemed as if the internet-based and digital formats crowding onto the market at an ever faster rate were going to leave cinema behind altogether. Although computer animations and special effects were used by a few pioneers such as George Lucas in their films, they were still expensive, time-consuming exceptions. That has all changed: today there are digital cinemas everywhere showing digital 2D and 3D films and it's probably not long before movie-goers are plunged into immersive movie experiences as well. In addition to hardware, delivering such cinematic experiences requires software that facilitates seamless digital work processes all the way through to the end product. The easyDCP software developed at Fraunhofer IIS makes it possible to create, play back, and encrypt digital cinema packages (DCPs). Over 1,500 post-production companies and studios already use the software worldwide. The easyDCP was also used at the Berlin International Film Festival to check DCPs and make sure that every film in the festival program can be enjoyed in all its glory on the big screen.

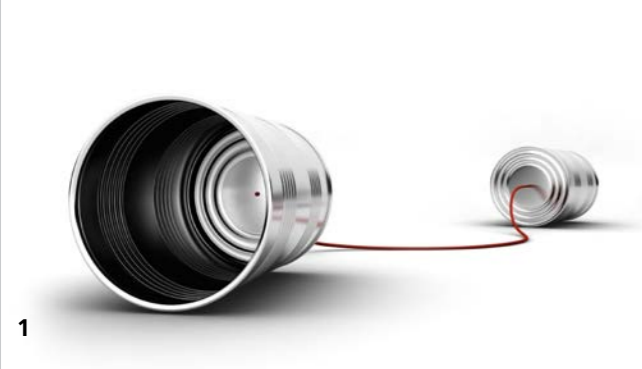
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**Fraunhofer Prize 2014**  
for easyDCP (digital cinema  
package) software

*The DCP (digital cinema package)  
contains the encrypted digital  
film and audio data as well as  
the subtitles for the various  
language versions.*





1

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Fraunhofer Prize 2010 for „Audio coding conquers huge market for voice communication.“

Audio & Multimedia: Enhanced Voice Services (EVS) communication codec

## BETTER QUALITY PHONE CALLS

For most phone calls, the voice on the other end sounds muffled and indistinct. Since the advent of telephony over 100 years ago, sound quality has scarcely improved. This is about to change: twelve leading companies from the cellphone sector have developed the Enhanced Voice Services (EVS) 3GPP communication codec, which will dramatically improve the quality of speech and audio communication over cellphones and smartphones while also significantly increasing efficiency. And so cellphone users will be able to experience live concerts, their grandchild's birthday song, or the chiming of Big Ben in crystal-clear at-the-scene quality. This is because EVS will permit not only language but also music and background atmosphere to be rendered in unrivaled true-to-life quality.

Fraunhofer IIS made a major contribution to the development of EVS, drawing on its many years of experience in the development of audio coding technologies for voice communication. For example, Apple's internet telephony service FaceTime and many professional video conferencing systems use special variants of the AAC codec optimized for low coding delay, which were also largely developed by Fraunhofer IIS.

1 *The speech quality on cell-phones often recalls that of old transmission technologies.*

2 *With EVS, you hear others as if they were standing next to you.*

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2



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28



2

Energy Management: Voltage converters for energy harvesting

## DRAWING ENERGY FROM YOUR SURROUNDINGS

In view of our constantly rising energy consumption, wouldn't it be nice if you could simply wave your hands and conjure up some energy? Actually, you can. Fraunhofer IIS uses vibrations and temperature differences to power small electronic devices. As key components of this energy harvesting, the researchers are developing optimized voltage converters known as Maximum Power Point Trackers. Among other applications, this technology will allow sensors to be operated wirelessly and without batteries. The plan is to make the voltage converters even smaller and more efficient in the future, so that energy harvesting systems can be implemented in ever more applications.

1 The electrodynamic generator enables energy to be produced through shaking.

2 The BlueTEG sensor wristband uses the temperature difference between the skin and the surrounding environment to generate energy; it transmits data via Bluetooth.

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Audio & Multimedia: Cingo® and Symphoria®

## I'LL TAKE A CONCERT HALL TO GO PLEASE!

Nowadays it is no longer enough merely to transmit audio content. People want to relive the music they heard at a concert hall or stadium in the same high quality on their tablet computers or while driving. But smartphones and tablet computers usually have low priced loudspeakers and headphones. And although cars often have high-end sound systems, the acoustics inside vehicles are generally very complex. To address these shortcomings, Fraunhofer IIS develops intelligent algorithms that process the music for playback in order to optimize the audio experience for the respective device being used.

One example of this is Cingo, which permits the playback of stereo, surround, and 3D sound on mobile devices over headphones and even stereo speakers. Cingo transforms our versatile digital companions into pocket-sized cinemas or concert halls, which is why the technology has already been adopted by market leaders such as Google and Samsung. By contrast, Symphoria creates a 3D surround-sound experience in vehicles. It virtually opens up the sound image of the sound system, and the occupants feel as if they were in a concert hall. Audi introduced the first vehicles featuring Symphoria at the end of 2014.

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**Fraunhofer Prize 2015**  
for Cingo® and Symphoria®.

*Samsung's Gear VR uses  
Fraunhofer's Cingo to place its  
users right in the thick of the  
acoustic action.*





Communication Systems: Fraunhofer On-Board Processor (FOBP)

## FRAUNHOFER IIS IN SPACE

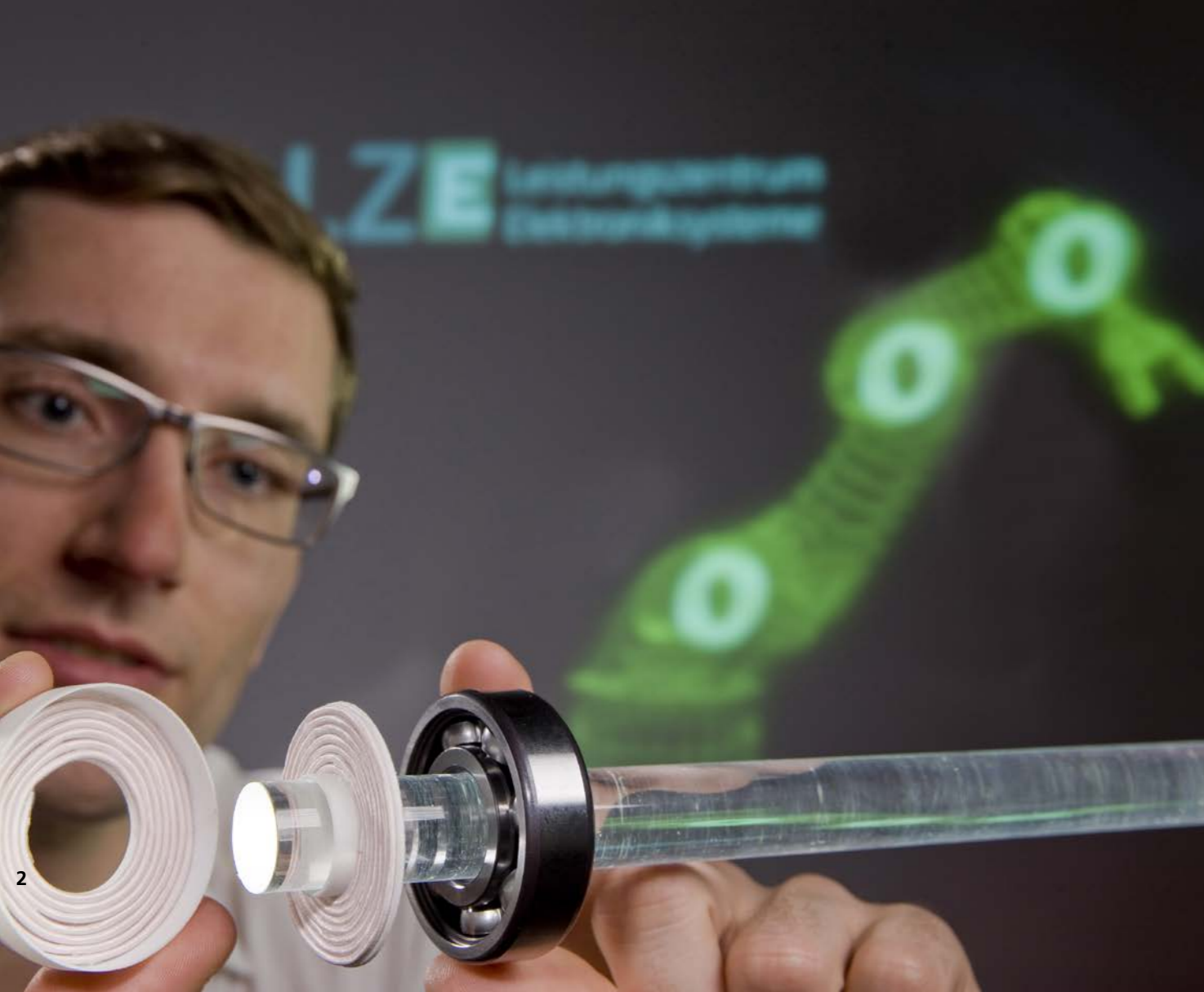
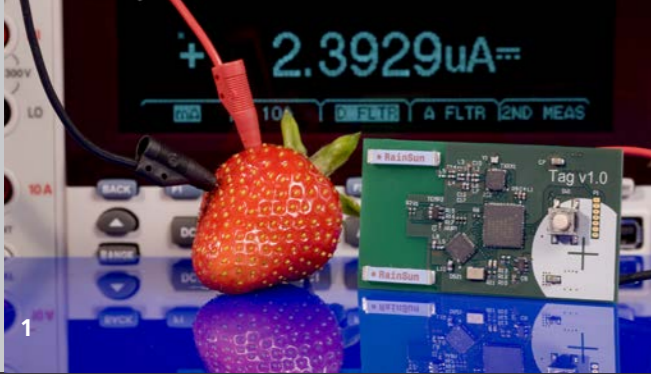
More and more data, smaller and smaller antennas, less and less power demand – a lot is expected of transmission technologies in mobile satellite communications. As part of the Heinrich Hertz satellite mission, the German Aerospace Center's (DLR's) Space Administration coordinates the development and operation of the Heinrich Hertz satellite for exploring new kinds of communication technologies. The major thrust of this work is directed at the scientific and technical implementation and testing of payload and platform technologies in space.

Fraunhofer IIS is contributing an on-board processor (OBP) to the mission. What makes this OBP special is that unlike conventional transponders, it is both regenerative and reconfigurable. This facilitates the research and testing of new transmission techniques for satellite communications. One objective is to develop new communication protocols that allow direct switching of a transmission signal to the satellite and from there to the receiver, eliminating the need for signal processing in a ground station (single-hop transmission). Launch of the satellite is planned for 2020.

*The Fraunhofer OBP will be used on a geostationary satellite designed to operate for 15 years.*

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## RESEARCH IN NEW DIMENSIONS

### LEISTUNGSZENTRUM ELEKTRONIKSYSTEME ERLANGEN

For 30 years now, Fraunhofer IIS, Fraunhofer IISB, and Friedrich-Alexander-Universität Erlangen-Nürnberg have been working together in close partnership. Their latest joint initiative is the High-Performance Center for Electronic Systems (LZE) launched at the start of 2015. Working with industrial partners in the region such as Siemens, the center will carry out cutting-edge research on complex electronic systems. This cooperation is based on strategic partnerships with a long-term focus. The research topics at LZE range from extremely efficient low-power electronics for sport and fitness applications, Industry 4.0 developments, through to power electronics for energy-efficient smart power grids.

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1 The WakeUp Receiver is a wireless receiver without micro-controllers. It has a very low response time and is suited to the continuous monitoring of wireless sensor networks. The receiver can be powered by energy harvesting. In the photo, the chemical reaction in the strawberry supplies enough energy to power the receiver.

2 Contactless energy and data transfer in fast-moving systems replaces error-prone slip rings.

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