Fraunhofer magazine

1/14 special issue

Power reloaded

Fraunhofer magazine

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Prof. Dr. Reimund Neugebauer. © *Jörg Lange*

Efficiency pays off

There are significant challenges ahead for manufacturing industry – scarce and expensive raw materials, rising energy prices, and climate protection to name just a few. For countries poor in natural resources, like Germany, the need to find a new approach is particularly acute. Much more intelligent and efficient use must be made of finite resources as we all search for ways to decouple a still greater consumption of natural resources from the desire to drive forward our growth and prosperity.

Making better use of raw materials can already be turned to a company's advantage, as a recent study from the Association of German Engineers' Center for Resource Efficiency has demonstrated. In the sectors of the metalworking industry surveyed, energy consumption could be cut by five to 14 percent – equating to a cost saving of between 100 and 280 million euros in 2012 in Germany alone. And the potential for materials savings is between two and six percent, shaving up to 2.3 billion euros off expenditure. Coordinated by the Fraunhofer Institute for Machine Tools and Forming Technology IWU and Volkswagen AG, the Green Carbody Technologies innovation alliance (InnoCaT®) has been exploring the possibilities for minimizing resource consumption in automotive construction. In the past three years the over 60 partners within the alliance have participated in 30 specialist projects to work up innovative solutions for automotive manufacturing in the years ahead. The ambitious target is to cut the amount of energy and resources required to manufacture car bodies by up to 50 percent.

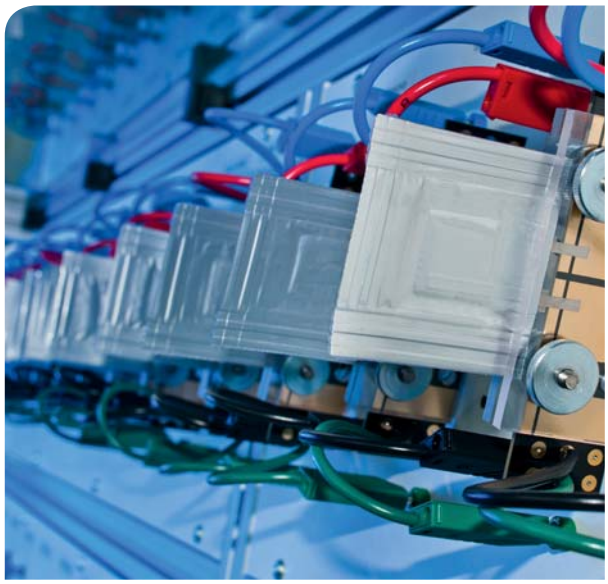
There is also significant room for improvement in energy-intensive sectors such as steel, cement, paper, and glass manufacturing, as well as in the chemicals industry. Researchers from the Fraunhofer Institute for Systems and Innovation Research ISI have authored a study entitled "Energy consumption and CO_2 emissions in industrial process technologies – potential savings, obstacles, and tools" in which they set out some 200 measures that could help reduce the energy consumption in German energy-intensive industry by almost 15 percent by 2035. The measures analyzed in the study amount to a total energy saving of 14 terawatt hours of electricity in a year. CO_2 emissions would fall significantly, too. To put this in perspective, 14 terawatt hours of electricity is equivalent to the power generated by two large coal-fired power stations.

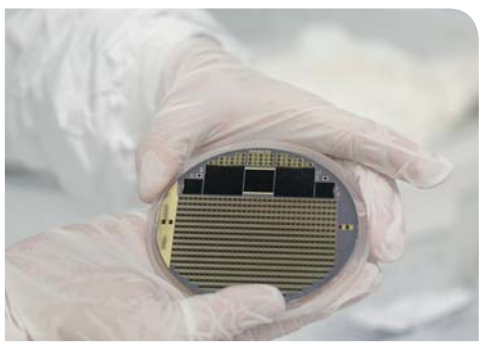
This goes to show that higher efficiency in production also benefits the environment. EU member states have agreed to reduce their emissions of greenhouse gases to at least 20 percent below 1990 levels by 2020. Germany wants to cut emissions by as much as 40 percent. If this target is to be achieved, emissions must be reduced by another 170 million tons of CO_2 equivalents a year. This is where using energy intelligently can make a significant contribution.

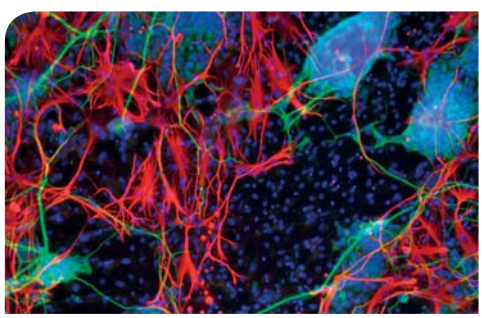
Energy efficiency has meanwhile developed into an attractive market. It generated revenues of some 146 billion euros in 2012 in Germany alone, and grew by 16 percent on the previous year. The number of workers employed in the energy-efficiency sector rose by ten percent in the same period to reach an extrapolated figure of 800,000 according to the German Industry Initiative for Energy Efficiency DENEFF.

Electric cars are an efficient alternative to vehicles that rely on an internal combustion engine. They boast an efficiency of 40 percent when powered by today's electricity mix – double that of a gasoline engine. But there is a lot of research and development work ahead before electric cars can establish themselves on the market. Battery performance is just one area where improvements are needed. The Fraunhofer Battery Alliance is conducting research into safe batteries with a high energy density for electric cars. Take a look at the lead article to learn more about what the next and subsequent generations of energy storage devices will look like.

Yours,







Content

OLEDs shine brighter

Unlike the liquid crystal displays in common use today, Organic Light Emitting Diodes OLEDs emit their own light, which means they do not need background lighting.

OLEDs are still very expensive to make, which is why large-scale OLED television screens are not yet commercially available. Until now, OLEDs have only been used for very small screens no more than a few square centimeters in size, such as cell phone displays, view finders in digital cameras, and the even smaller screens used in data glasses.

Researchers at the Fraunhofer Research Institution for Organics, Materials and Electronic Devices COMEDD in Dresden have managed to push OLED technology development one important step further. They are working with colleagues from VON ARDENNE Anlagentechnik GmbH, a German coating equipment manufacturer, to develop the technology for producing small OLED screens without color filters. Filters had always been required because it had previously not been possible to apply the red, green and blue subpixels needed for displaying colored images directly onto the electrode.

Now the scientists have redesigned the entire production process to allow direct application of the red, green and blue color pixels. Now that color filters have become redundant, OLEDs shine brighter and manufacturing costs are reduced.

Microdisplays are barely larger than the human eye.
© *Fraunhofer COMEDD*

Compact radar

The human eye cannot see through wood, cardboard, or plastic. But a compact radar with a modular design now makes it possible to see the invisible: The millimeter-wave sensor penetrates material that is not transparent at optical wavelengths. It transmits signals in the high-frequency range between 75 and 110 GHz and has many different possible applications, from flight safety and logistics to industrial sensors and medical technology. For instance, radar technology is an ideal landing aid for helicopters as it is able to precisely measure the aircraft's movement and altitude in relation to the ground, regardless of unfavorable conditions such as snow clouds, dust or fog.

Researchers at the Fraunhofer Institutes for Applied Solid State Physics IAF, Manufacturing Engineering and Automation IPA, and Reliability and Microintegration IZM are working together to develop a compact and cost-effective radar able to identify small objects at a distance even in poor visibility conditions. The system can be used in any situation where other sensor technologies fail on account of high temperatures or limited visibility. In contrast to x-ray scanners, it does not pose a health hazard, and it works with short-wave beams in the millimeter range. It has a transmission power of 10 milliwatts, compared with the 1000-milliwatt range of a mobile phone.

The system can be compared with that of a bat, in that the radar emits signals that are reflected by the objects under observation. With the help of numerical algorithms, the signals transmitted and received can be compared to one another. And this comparison makes it possible to determine the distance, size, thickness, and speed of the object.

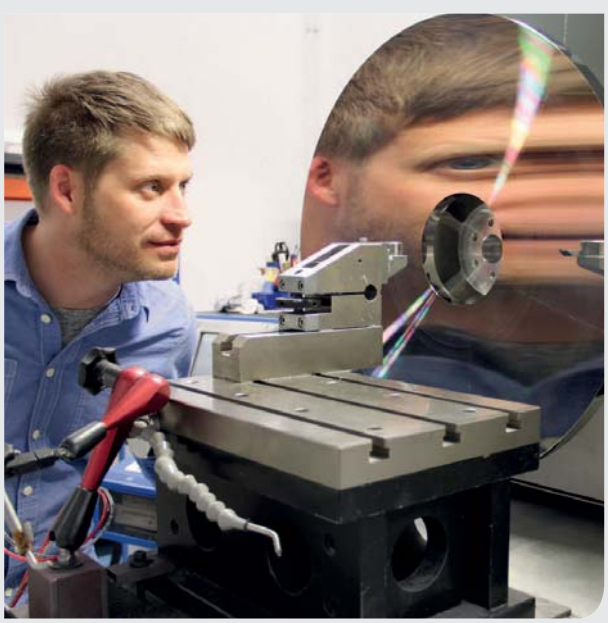
The W-band radar is equipped with a 3-channel broadband antenna with dielectric lenses. © *Fraunhofer IAF*

Precise optical systems for satellites

Telescope optics are used to conduct Earth observation from space. Images captured in orbit help us to predict the weather, locate natural resources, evaluate vegetation cover, detect natural disasters such as fire and flooding, and also improve our understanding of the composition of the Earth's atmosphere. These optical systems collect incident light just as a camera lens does, and sharply focus the incident radiation onto a sensor.

To prevent light dispersion, which is the separation of the electromagnetic spectrum into components of different wavelengths, telescopes are usually constructed out of mirrors. Manufacturing and aligning these reflective elements is very challenging, as they must be positioned in the beam path of the telescope's optical system with the utmost precision. This is only possible because researchers at the Fraunhofer Institute for Applied Optics and Precision Engineering IOF in Jena who produce the optical surfaces are able to achieve exact results using ultra-precise turning equipment featuring a diamond-tipped cutting tool. Further improvements to the quality of the final image are achieved during the lens polishing and correcting processes. The scientists use this process chain to develop high-output imaging systems for the infrared and visible spectra.

A researcher works on optical elements for telescopes using a monocrystalline diamond as a cutting tool. © *Fraunhofer IOF*



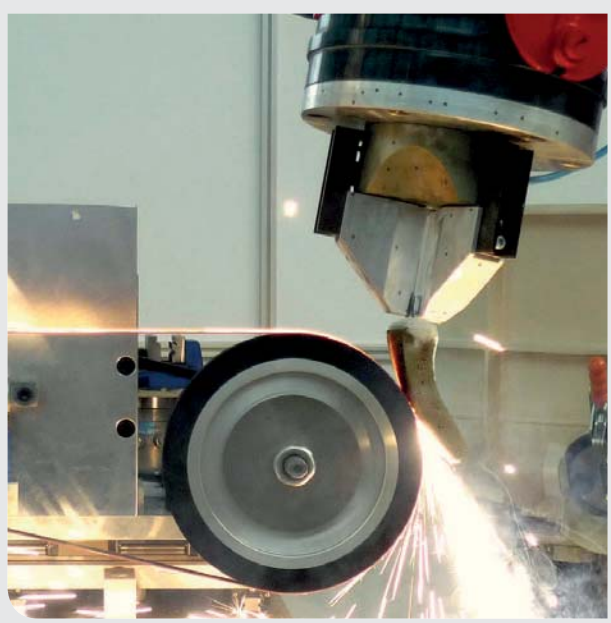
Robots repair turbines

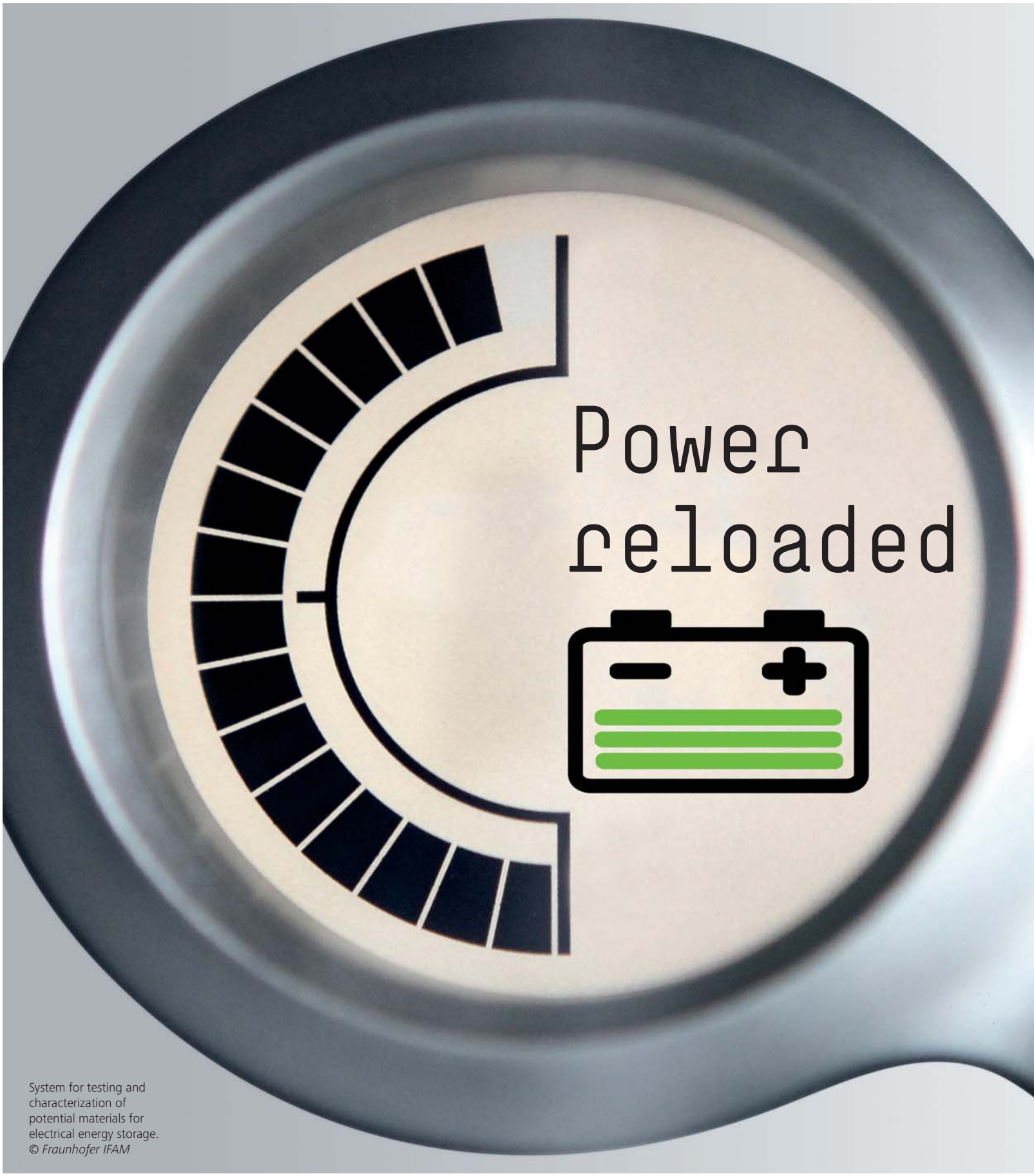
Compressor and turbine blades are important components in aircraft engines and gas turbines. Turbines convert fluid energy into mechanical energy. They ensure that aircraft engines generate the required thrust and that power plant generators produce sufficient electricity. Wear and tear, erosion, hard landings and large objects striking the engine all take their toll. This causes the geometrically complex components, which are mostly made of titanium- or nickel-alloy steels, to bend or crack.

A single turbine blade costs several thousand euros. With an airplane needing up to 80 blades, the costs can stack up very quickly for aircraft operators if these become damaged. Repairing blades may only cost half as much as buying replacement parts, but the repair processes involved are very complicated and elaborate. Specialists process the workpieces by hand or with specially adapted machine tools.

Researchers from the Fraunhofer Institute for Production Systems and Design Technology IPK in Berlin and the Institute of Institute for Machine Tools and Factory Management IWF of the Technische Universität Berlin have been working with specialists from turbomachinery manufacturers such as MAN, MTU, Rolls-Royce, and Siemens to develop an automated, robot-assisted technique. The scientists not only managed to make individual process steps suitable for automation, they also developed a procedure that allows the robot to pass through several repair stations inside a single production cell. It cleans the component, measures its geometry, locates the faults, and carries out machining repairs.

A robot automatically restores the damaged sections of a turbine blade at a grinding station. © *IWF TU Berlin*





System for testing and characterization of potential materials for electrical energy storage.
© *Fraunhofer IFAM*

Batteries are the heart of many products: they start our cars, power our pacemakers and allow us to communicate using smartphones and tablets. Batteries are also a key technology for electromobility and the new energy economy, which means that these chemical energy stores are soon going to have to raise their game. Scientists are already working on the next generation of batteries – and beyond.

Text: Birgit Niesing

If you own a smartphone, cordless drill or a tablet then you also own a lithium-ion battery. Lightweight, high in energy and unimpeded by the memory effect, lithium-ion batteries were brought to the market by Sony in 1991. And despite being a relatively young technology, these batteries are found in almost every mobile device around today. Thousands of lithium-ion cells are even used to power Tesla's electric sports car. More sophisticated lithium batteries are also seen as being key components for electric cars.

And the forecasts are as promising as you might expect. Lux Research is predicting that the lithium-ion battery market will grow by almost fifty percent over the next five years. The turnover of 28 billion US dollars seen this year is set to rise to 41 billion by 2018. Experts believe that it is mainly our love of mobile devices that will drive up the demand for lithium-ion batteries. But the potential growth in this area is being outstripped by that of electromobility: the market for lithium-ion batteries used in electric bikes and plug-in hybrid cars is expected to grow by 22 percent annually, and for hybrid vehicles that growth accelerates to 34 percent.

There's still a long way to go

Lithium-ion batteries do, however, have one major drawback: they are expensive. At the moment, lithium-ion batteries designed to power electric vehicles cost more than some compact cars. But this is going to change according to a study by management consultants McKinsey. Experts predict that technical advancements, improved manufacturing processes and lower margins will set prices toppling.

But before we can afford to have our cars fitted with these power packs as standard, several challenges must still be overcome. In addition to holding more charge, future batteries will also have to be safe, lightweight and robust. "They will also have to last longer and function reliably at both high and low temperatures," adds Dr. Jens Tübke from the Fraunhofer Institute for Chemical Technology ICT in Pfinztal near Karlsruhe. Dr. Tübke is an expert in electrochemistry and the spokesman for the Fraunhofer Battery Alliance, in which 19 institutes have joined forces to pool their expertise in battery research and development (see box). Much of the alliance's work focuses on improving lithium-ion batteries so that they can fulfill the diverse specifications previously mentioned. Its scientists are also working on the next generation of batteries and battery systems, and even the generation that will in turn succeed these products.

Batteries might not look very interesting from the outside, but their inner workings are rather complex. A battery's individual components – the anode, cathode, separator and electrolyte – are important factors in the battery's performance, along with how these components are best matched with each other. "Batteries feature different combinations of materials; they work with solid, liquid or gel-based sub-

stances; their electrodes may differ in shape or have different coatings; and they vary in their geometric structure," explains Dr. Tübke. This gives a host of parameters that can be researched and improved upon to put together the perfect package.

A key factor in creating the battery of tomorrow is safety. This is another of lithium-ion batteries' weak spots: their organic electrolytes are inflammable. If a battery overheats, it can easily catch fire. Scientists from the Fraunhofer Institute for Silicate Research ISC in Würzburg and the Fraunhofer Institute for Silicon Technology ISIT in Itzehoe are working on lithium-polymer batteries. These are safer because polymers do not burn. The ISC has already taken electrolytes a step farther by developing glass electrolytes, paving the way to high-performance batteries that are also very safe. Safety is also at the heart of the "SafeBatt" project that was launched in July 2012. Here the focus is on developing semiconductor sensors using new materials such as graphene in order to establish the safety parameters of battery cells. These include chemical processes, an increase in pressure, and the temperature profiles within the cells. The German federal government has named SafeBatt as one of the nine flagship projects under its National Platform for Electromobility program. A total of 15 partners from the German automotive industry and the scientific community, including the ICT, are investigating how to optimize battery cell chemistry.

But just how safe are battery-powered vehicles in an accident? What goes on inside the battery when an electric car is parked for hours in the blazing sun? Are the electrolyte and the battery materials compatible? How does a battery behave during charging and discharging? To find answers to these and many other questions, Fraunhofer has established the Battery Storage Systems service center. "The testing and verification of energy storage systems represent a fundamental link in the vehicle technology development chain," emphasizes Dr. Tübke. "The various aspects of testing energy storage devices are covered by the service center's four partners, allowing us to model the entire development chain." Researching the batteries' crash safety is a job for the experts at the Fraunhofer Institute for High-Speed Dynamics, Ernst-Mach-Institut, EMI in Freiburg. At the ICT, scientists are testing how a cell's chemical composition and structure, or ambient temperature, affect a battery's quality and service life. They are also investigating what happens when a battery is overcharged or suffers a short circuit. Researchers from the Fraunhofer Institute for Solar Energy Systems ISE in Freiburg are contributing their expertise in battery system technology, in performance and aging tests as well as in modeling and simulating battery and energy systems. Experts from the Fraunhofer Institute for Structural Durability and System Reliability LBF in Darmstadt are applying their specialist knowledge also to batteries.

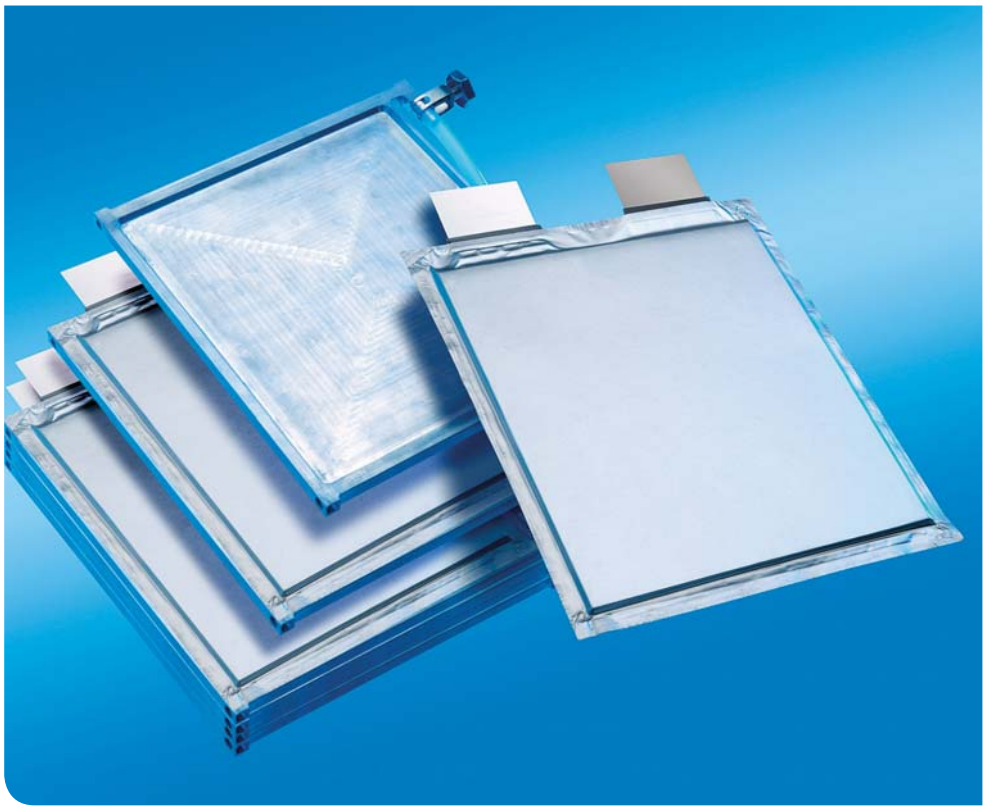
In backing the "Lithium-Ion Battery LIB2015" innovation alliance, the German Federal Ministry of Education and Research (BMBF) is promoting the development of higher performance lithium-based energy storage systems. Working alongside BASF, Bosch, Evonik, LiTec and Volkswagen in the alliance are numerous Fraunhofer Institutes. The alliance's "KoLiWIn" working group has been charged with generating concept studies for new kinds of lithium-ion cells based on material innovation. In collaboration with their colleagues from the Fraunhofer Institute for Mechanics of Materials IWM in Freiburg and the Fraunhofer Institute for Ceramic Technologies and Systems IKTS in Dresden, ISC scientists have been working to make lithium-ion batteries that are faster, safer and smaller. A special feature of this collaboration is its use of the IWM's high-performance quantum chemical simulations, which help the scientists to understand fundamental material properties and to develop targeted optimization strategies.

Making advancements in lithium-ion battery technology is at the heart of the BMBF-funded project "TopBat", which stands for "temperature-optimized battery modules with in-cell sensors". Taking part in this research project are Adam Opel AG, SGL Group and the Fraunhofer Institutes for Silicon Technology ISIT and for Industrial Mathematics ITWM. The ISIT is in charge of manufacturing the lithium battery cells for the battery modules and fitting them with sensors that allow temperature and charge conditions to be determined precisely. With the help of simulation models, the ITWM's experts are optimizing the interaction between batteries and thermal systems.

Storing more energy

Experts have great hopes that using new materials will lead particularly to the development of batteries that deliver more power. One extremely promising material is sulfur. Using sulfur in batteries provides them with a much higher energy density. Unlike cobalt, which is the cathode material most commonly used in lithium-ion batteries, sulfur is available in virtually unlimited quantities. This also makes sulfur a much cheaper alternative. The catch here is that sulfur's low conductivity means it has to be integrated into a conductive matrix to improve its electrochemical properties. In the "AlkaSuSi" project, ICT scientists and their colleagues from the Fraunhofer Institute for Material and Beam Technology IWS in Dresden are developing new concepts for lithium-silicate and lithium-sulfur cells. Their idea is to use carbon nanotube (CNT) electrodes as the sulfur or lithium sulfide carrier: sulfur infiltrates the vertically aligned CNTs to produce stable, compact electrodes without the need for any binders or other additives.

The great advantage of these new, lithium-sulfur batteries is that they can store more than twice the amount of



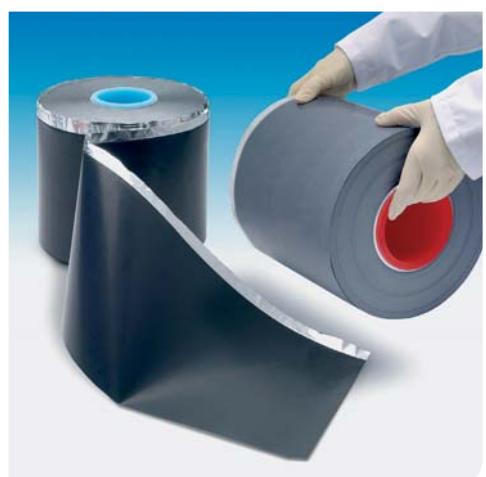
Small-scale series, high-performance lithium batteries with heat-dissipating elements. © *Fraunhofer ISIT*

Fraunhofer Battery Alliance

A total of 19 institutes have joined forces in the Fraunhofer Battery Alliance. Not only do its scientists develop and optimize materials and manufacturing processes for batteries, they also work on economic and efficient system solutions for mobile and stationary applications. Other areas of focus include performing safety tests on energy systems, as well as the simulation of batteries on the atomic scale and of their behavior in practical applications.

www.batterien.fraunhofer.de

A battery module. © *Fraunhofer ICT*



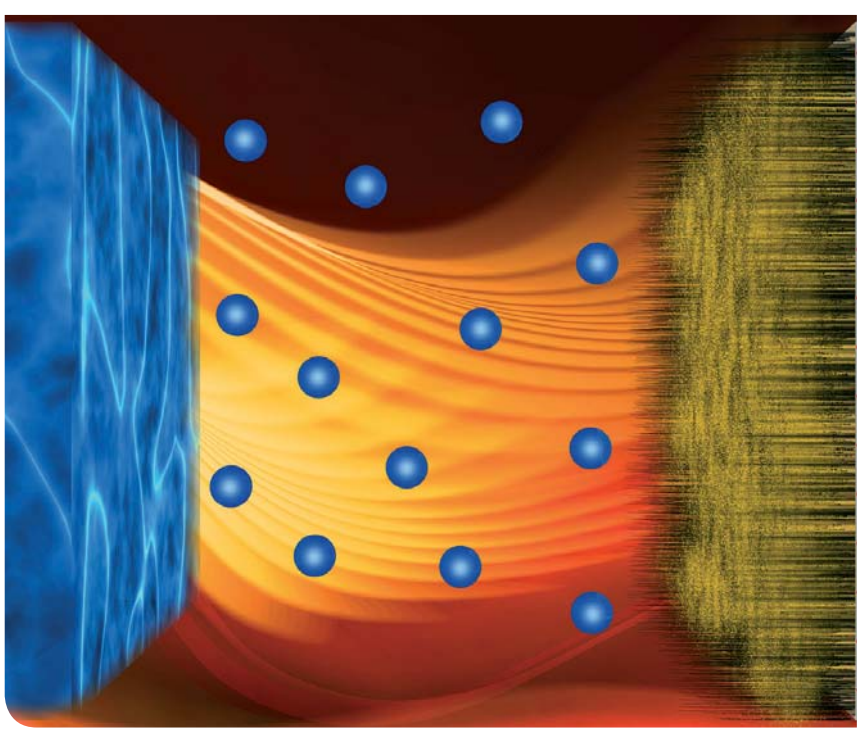
Industrially manufactured electrode films designed for lithium-polymer batteries. © *Fraunhofer ISIT*

energy compared to conventional batteries in the same space. Lithium-sulfur batteries should sometime in the future even achieve an energy density of up to 600 watt-hours per kilogram (Wh/kg), which compares with a mere 250 Wh/kg maximum energy density for lithium-ion batteries currently in use. The downside is that such systems have so far only managed 50 to 200 charge cycles. They will need to manage a whole lot more.

And this is what scientists are about to change. They have developed a new design that increases the charge cycles of lithium-sulfur batteries by a factor of seven. "A special combination of anode and cathode material allows us to extend the lifespan of lithium-sulfur button cells to 1400 cycles," reports Dr. Holger Althues, head of Chemical Surface Technology at the IWS, on his team's breakthrough. The anode of the team's prototype is not made from the usual metallic lithium, but from a silicon-carbon compound instead. And to improve the stability of the sulfur cathode, the scientists use porous carbons.

Future generations of metal-air batteries could deliver even more energy, with a theoretical energy density of more than 1000 Wh/kg. Featured here is a porous electrode that acts as the cathode in contact with air. Until now, this principle has mainly been used in zinc-air single-use batteries to power hearing aids. The ISC is currently working on ways to transplant this technology to larger rechargeable battery systems for use in stationary applications. Research is currently underway in Bavaria into an overall concept that will allow the air cathode and the zinc anode to be perfectly synchronized, resulting in high cycle stability. Lithium-air batteries have enormous potential, but as these still only exist as single-use cells, much R&D work remains to be done. In any case, it has not yet been possible to demonstrate a holistic material concept that would make cells sufficiently stable for repeated use. Scientists working in the "Electric Energy Storage" project group at the Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM in Oldenburg are working to change this through their research into new concepts for electrodes, cells and battery stacks.

Diagram of a lithium-sulfur battery cell.
© *Fraunhofer IWS*



But when will these technologies be sufficiently developed to be put into practice? What kind of battery is going to power electric cars in the years to come? Scientists from the Fraunhofer Institute for Systems and Innovation Research ISI in Karlsruhe explored these questions in the "Technology Roadmap Energy Store for Electromobility 2030". They concluded that first up will be high-voltage lithium-ion systems above four volts: these third-generation batteries will play an important role in electromobility over the next ten years. It will be some time before the fourth generation of lithium batteries is ready. The experts see the first breakthrough for electromobility in around 2020 through lithium-sulfur technology, followed by the lithium-air battery sometime after 2030. Summarizing the Roadmap's findings, project manager Dr. Axel Thielmann says that "genuine technological leaps in energy density that will allow us to travel far and wide belong to a post lithium-ion battery era that is far beyond the year 2020." This is why, at least in the medium term, lithium-ion batteries should be seen as complementary technologies to fuel cells.

Recycling batteries

Some 1.3 million electric bikes took to the roads in Germany in 2012. In the PEDELEC project, ISC scientists are working closely together with industrial and research partners to examine the actual load profiles of e-bike batteries used by commuters. In order to better understand the factors that affect the batteries' long-term reliability, they are subjected to a controlled aging process and subsequent post-mortem analysis. The findings not only help improve battery design and the further development of materials, but are also relevant to recycling issues moving forward.

Just how do we recycle these batteries? Can we find a way to recover and reuse their valuable constituent materials and reduce their carbon footprint? Researchers working in the "Automotive Battery and 2nd Life" project, funded by the German Federal Ministry of Economics and Technology (BMWi), are looking into these questions. Scientists from the ISC and the Fraunhofer IWKS Project Group for Materials Recycling and Resource Strategies in Alzenau/Hanau are

applying insights into cell chemistry and the degradation of recyclable materials to battery recycling.

Powerful electricity storage systems are not only important to a breakthrough in electromobility. They also play a key role in the new energy economy. Last year, almost 23 percent of Germany's gross electric power consumption was covered by renewables. And by 2020, wind, solar, biomass and hydroelectric power are to deliver 35 percent of Germany's electricity. Unfortunately, the wind does not always blow and the sun does not always shine during periods of peak energy demand. This calls for new types of electricity storage that can bridge the gap between intermittent power generation and fluctuating demand.

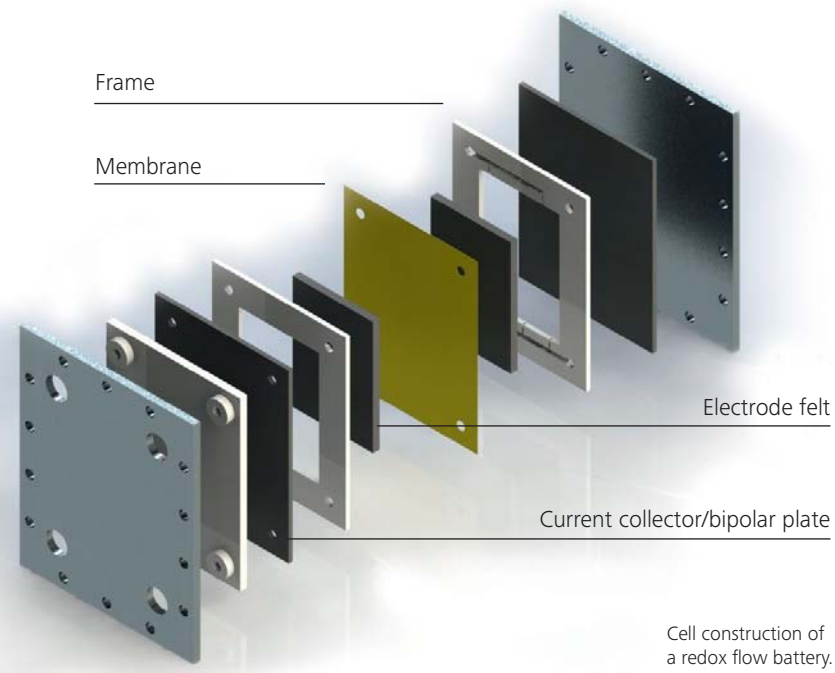
Batteries for a new energy economy

One solution comes in the form of redox flow batteries that store electrical energy in liquid electrolytes. The electrolytes are charged and discharged in electrochemical cells, whereby several of these cells are lined up behind each other in stacks. The cells currently on the market are about the size of a sheet of A4 paper. Depending on how many cells are put in to a stack, these batteries can store between one and three kilowatts (kW) of energy. Thanks to a new design, scientists from the Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT in Oberhausen have succeeded in greatly increasing the size of the stacks; at a surface area of half a square meter, these can store up to 25 kW.

Finding out just how redox flow batteries could be used to store electricity generated by wind power is the subject of the ICT's RedoxWind project. ICT scientists are building a test facility to provide electrochemical storage of energy generated by a purpose-built, two-megawatt wind turbine. This will allow the team from the ICT to study the interaction between fluctuating wind-energy and stationary storage. Industrial processing technology will be used in the project to develop cost-effective battery stacks. An innovative electric connection that combines power electronics from the turbine and the battery promises not only to raise the efficiency of the storage system, but also to lower costs even further.

In order to be able to store energy from wind or solar power, ISC scientists combine lithium-ion batteries and supercapacitors. Although lithium-ion batteries can store lots of energy, they take a rather long time to charge. Supercapacitors can be charged quickly, but have low energy densities. The new "Li-Cap" system unites the advantages of both technologies and can be flexibly adjusted to demand at any given time.

But can decentralized solar energy storage systems also help to integrate renewables into the grid and establish smart grids? This is indeed the result of a test conducted by the Fraunhofer Institute for Solar Energy Systems ISE in Freiburg on behalf of the German Solar Industry Association.



Cell construction of a redox flow battery.
© *Fraunhofer ICT*

In addition to creating a more flexible power-generation infrastructure and expanding the grid, energy storage systems are an important part of building a sustainable supply of electricity. There is no other way forward towards implementing the transition to a new energy economy in the long term.

An evaluation drawn up by the ISE demonstrates that when the operation of decentralized storage systems is organized in the right way, these stabilize grid voltage and improve the capacity to connect further renewable energy sources as the transition to a new energy economy takes hold. "Providing their operation is geared to demand from the grid, this kind of solar energy storage system can reduce feed-in peaks by up to 40 percent," says Dr. Christof Wittwer from the ISE.

Making energy from renewables available whenever we need it is a lucrative market. The demand for short-term energy storage is set to double by the year 2025. This was the conclusion drawn by the Deutsche Bank's "DB Research" think tank study entitled "Modern electricity storage systems – indispensable building blocks for the Energiewende". Over the next two decades, the total capital investment required for new energy storage facilities in Germany will amount to some 30 billion euros. And by no later than 2040, there will be a regular need to store 40 TWh of electricity generated in times of temporary oversupply. It's high time, then, to forge ahead in the development of new battery concepts. ■

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Light, electric and mobile

Tomorrow's cars will be lightweight, powered by electricity, and safe - all at the same time. The Fraunhofer Institute for Structural Durability and System Reliability LBF in Darmstadt is among those working to make this a reality.

Text: Birgit Niesing

Fraunhofer's FreccO 2.0 e-concept car on the whole-vehicle test rig.
© *Fraunhofer LBF*

The world's roads are already teeming with more than one billion vehicles – and that number is growing all the time. Experts are predicting that by the year 2050, the total will have reached 2.7 billion vehicles. Nowhere is the number of new vehicle registrations higher than in developing and emerging countries. The story is very different in industrialized nations: Germany's car market, for instance, is all but saturated. "In Germany today, there are more than 500 vehicles for every 1000 people," says Professor Holder Hanselka, who until October 2013 was director of the Fraunhofer Institute for Structural Durability and System Reliability LBF in Darmstadt. Experts from consulting company Frost & Sullivan are predicting a drop in the number of vehicles per 1000 inhabitants in cities such as Tokyo, London or New York by 2025. This phenomenon is also known as "peak car."

Why is this? It can be traced to the growing problems associated with rising traffic densities in metropolitan areas: noise and emissions are taking their toll on people and the environment. For mobility not to damage the environment or waste resources in future, it will take new

concepts – for instance electric cars. These are significantly more efficient, less noisy and more eco-friendly than gasoline- or diesel-powered vehicles. "There are also smarter ways to use finite petrochemical resources than to burn them. They are also used to manufacture medicines or plastics," explains Hanselka.

At the moment, electric cars are still a niche market – but one that is growing fast. Only 41,000 electric cars were sold around the world in 2011, but that number reached 110,000 just the following year. Frost & Sullivan is predicting that 2.2 million electric cars will be sold in 2017. In Germany, too, the market for electric cars is gathering momentum. According to the German Automobile Association (VDA), the country's automakers plan to release 16 new models of electric car over the next year. But before electric vehicles can establish themselves as a genuine alternative to conventional cars, there are several challenges to be overcome. For one, we are going to require reliable and high-performance batteries (see also lead article) capable of supplying cars with the electrical energy they need.

Safe electric cars

But just how are we going to build safe, reliable electric cars? Scientists from the LBF are among those on the hunt for answers. "Since it was founded 75 years ago, the institute has been testing the structural durability of safety-critical components in cars, planes, trains and ships. Until now, the focus has been on mechanical components that cannot be allowed to malfunction. But electric cars feature new kinds of safety-critical component, such as the vehicle's power electronics or battery. This has prompted the LBF to expand the topic of 'reliability and measuring reliability' to reflect today's electromechanical, electrochemical and electrothermal world," says Hanselka. This is also the thinking behind the ZSZ-e Center for System Reliability with a Focus on Electromobility, which is currently being set up.

One component in particular must not fail: the battery. But how do these electrochemical devices react to extreme temperatures, and what happens to them when cars go over potholes or the curb? How can we design battery systems capable of withstanding a high degree of stress, and how do we test them? To help answer these questions, LBF scientists are developing a new test rig.

75 years of Fraunhofer LBF

The origins of the Fraunhofer Institute for Structural Durability and System Reliability LBF date back to 1938, when two engineers founded the Bautz-Bergmann Werkstoff- und Konstruktionsberatung GmbH consultancy in Darmstadt. Here they worked on developing new testing and computation methods, which they used to measure various kinds of structural stresses in operation and to evaluate their effects on service life. In 1950, Bautz-Bergmann GmbH merged with Dr. Gaßner's physical/technical laboratory to become the Laboratory for Structural Durability LBF, and twelve years later the LBF became part of the Fraunhofer-Gesellschaft. In 1982 Fraunhofer LBF launched its first biaxial wheel/hub test rig (ZWARP). This test rig was patented for road vehicles in 1984 and for rail vehicles in 1987.

In 2001, Professor Holger Hanselka became director of the LBF, bringing in a thoroughly new approach. The Fraunhofer Adaptronics Transfer Center opened its doors in 2010. That same year, a whole-vehicle test rig was put into operation. This allowed the LBF to test a vehicle's entire body and chassis – all the way through from compact cars to lightweight electric transporters and small buses. Last year, the Deutsches Kunststoff-Institut (German Plastics Institute – DKI) was incorporated into the LBF. Alongside structural durability, system reliability and adaptronics, engineering and functional plastics has now become the institute's fourth core competence. In 2012 the institute's staff of some 500 generated 27.3 million euros in revenue, 60 percent of which came from industry.

Even electric cars cannot escape the fact that the heavier they are, the more energy they will consume; in other words, they are going to have to slim down. But just how light can individual components become before their reliability is compromised? LBF scientists are researching a number of components affected by this problem. These include wheel hub motors, which alongside the electric motor also feature power electronics, cooling, and assembly and interconnection technology. And since they are located so close to where the car comes into direct contact with the road, they need to be particularly safe. The scientists have an array of rigs on which to carry out qualification testing to ensure such parts perform safely.

One way of achieving light yet reliable wheel hub motors is to build them out of fiber reinforced plastic (FRP) composites. Scientists at the LBF have developed just such an FRP wheel that features an integrated electric motor. "With the right design, using FRP enables us to achieve improved rigidity, structural damping and damage tolerance while producing a lighter part compared to using metal," explains Hanselka.

New lightweight construction solutions are also required for drivetrains. The LBF belongs to NELTA, the Network for Lightweight Traction Engines, in which the institute is collaborating with industry to develop innovative materials that can improve the performance of electric cars. Given the complexity of in-vehicle stress scenarios, key considerations include reliable component design and durability testing.

Reducing weight

The European Union is also committed to making sure that future generations of electric car are more lightweight. To this end, the EU is funding two projects, ALIVE (Advanced High Volume Affordable Lightweighting for Future Electric Vehicles) and ENLIGHT (Enhanced Lightweight Design). These projects share an ambitious goal: a 50-percent reduction in bodyweight – not counting the engine – for electric vehicles.

At the end of the day, electromobility will only really succeed if it manages to get drivers excited. So it is crucial for the electric cars of tomorrow to look good and sound good. Replacing the internal combustion engine with an electric drivetrain alters the car's sound, just as having a lightweight body affects the vehicle's acoustics. Thinner materials let more noise through and even produce some of their own if forced to vibrate. LBF scientists plan to use adaptronics to remedy this and are working on creating self-adjusting mechanical structure systems capable of actively reacting to their environment.

Fraunhofer's experts are committed to keeping us all mobile in the future – a mobility that is lightweight and electric. ■

Your carpark valet is a robot

Hunting for a parking spot at Dusseldorf Airport could soon be a thing of the past: transporter robots will do it for you. Fraunhofer IML helped develop the system that is also attracting great interest from the automotive industry.

Text: Boris Hänßler

An inspection carried out by the German automobile club ADAC at the end of 2012 found that many of the country's parking garages are in poor condition: cramped, dark and unsafe. But it is really the size of the parking spaces that irritates most drivers. "Cars are getting broader, so the bays are no longer big enough to accommodate them," says ADAC test coordinator Andreas Pohl, who also criticizes inadequate safety measures: emergency alert systems, walkways and special parking spaces for families with children are all too rare. Lane markings are often worn away, and the spaces themselves are poorly lit. Moreover, two thirds of parking garages fail to offer sufficient spaces for disabled drivers.

So how are we to remedy these shortcomings? Surely making the spaces larger will just mean getting fewer cars in the garage? serva transport systems, a company based in Grabenstätt in the Chiemsee region of Bavaria, collaborated with the Fraunhofer Institute for Material Flow and Logistics IML in Dortmund to find an alternative solution. They developed a system involving automated guided vehicles (AGVs) that collect and automatically position cars to make best possible use of the total parking area. Customers benefit from "no longer having to hunt for an empty space because their cars are parked for them," says Guido Follert from the IML.

But how does the system work? Drivers deposit their cars at the next available Vehicle Transfer Station (VTS). Each VTS is made up of four pillars with linear axes that use laser scanners to measure the precise height and width of each vehicle. "The system then determines the position of the vehicle's wheels and takes into account its full physical profile," explains Follert. After all, an SUV's wing mirrors tend to be higher up than those of a sports car. "This information prevents the AGVs from damaging the cars."

Transporter robots park cars automatically

Once you have deposited your car at a VTS, you take a ticket from the terminal, and a transporter robot will do the rest. Although it in some ways resembles a fork-lift truck, each of the AGV's four wheels can turn a full 360 degrees, allowing it to maneuver in the tightest of spaces. Approaching from the side, the AGV scoops up the car by sliding one set of forks each under its front and rear wheels. The car is then transported carefully to the parking spot preselected by the system's software. When you want to collect your car, just pay the ticket and your car will be brought to a VTS for you.

The system has already passed its first practical test with flying colors, wowing customers when it was put through its paces at a parking garage managed by SITA Airport IT GmbH at Dusseldorf Airport in 2012. Rupert Koch, managing director of serva transport systems, was encouraged by customers' feedback: "They especially appreciated having plenty of

Automated parking using a parking robot. © *serva transport systems GmbH*

room to get into and out of their cars. The VTS bays are large enough for customers to comfortably open any door. Plus, drivers no longer have to remember where they parked." And using a special smartphone app, drivers can even tell the system exactly when they wish to pick up their cars. The system makes sure their car is ready to be collected at the VTS at the appointed time.

Drawbacks such as tight parking spaces, a lack of walkways, or poor lighting simply no longer exist. But not only does the new parking system offer drivers better service, it also has distinct advantages for parking garage operators, who can accommodate a significantly higher number of vehicles within the existing infrastructure. "This technology is especially handy during peak times," says Dr. Christian Jahncke, managing director of SITA Airport IT. "Instead of spending millions of euros to extend our garages, we could simply make better use of the space we already have."

The smart guidance system divides up the parking lot to ensure cars are positioned to make the best possible use of space, for example by grouping together cars of a similar size. Moreover, the system can reshuffle the arrangement of cars at any time if it recognizes that a different arrangement would make more efficient use of the space. "Installing our system in a conventional parking garage can raise spatial efficiency by up to 60 percent," says Koch.

Koch founded serva transport systems with two former school friends three years ago. The trio had an idea for a system that would pick up and park cars in a garage, and set about finding a qualified partner to help with development. "Fraunhofer IML was a perfect match because its scientists already had considerable experience with the driverless systems used in logistics," says Koch. The IML also held a patent for a form of laser navigation and Koch and his colleagues were quick to recognize that all this expertise would help them achieve their goal.

The system uses laser navigation

Installing the parking system is simple: "It can be incorporated into virtually any parking garage around," stresses Guido Follert from the IML. "Under ideal circumstances, the system can be set up in just three days." Operators only have to establish the VTSs and affix reflective markers to the garage's pillars or walls, enabling the system to navigate the AGVs around the space. Each AGV is equipped with a rotating laser. Every time the laser light bounces off a reflector, a sensor on the AGV measures the light reflected. By determining the light received from three reflectors simultaneously, the system's software can use triangulation to determine the exact position of each AGV in the room.

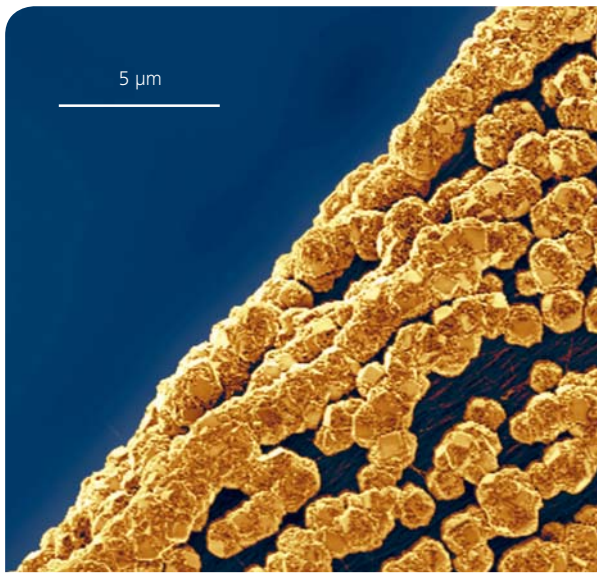
This thoroughly convincing new parking system took serva transport systems to the finals of the German Founders Award (Deutsche Gründerpreis), sharing the StartUp category with two other companies. There is an excellent chance that this way of parking will find its way into a good many garages. Starting in December 2013, the operators of the garage at Dusseldorf Airport want to make the serva system a permanent premium feature.

The technology is also of interest to the automotive industry, which produces five million vehicles every year in Germany alone. After rolling off the production line, each car is stored first at the plant before being transported, perhaps to a harbor collection area and then loaded on to a ship. It will then be stored for a while at the destination port and again once it reaches the dealership. "Our technology would be a sensible addition to every one of these steps," says Koch. Vehicle towing companies and parking violators could benefit, too: the system could be used to automate parking of impounded vehicles. As soon as drivers pay their fines, the robots would collect the cars. But it might be cheaper to make use of an automated parking garage in the first place. ■

Intercontinental diamonds

In January 2013, Germany and Australia signed a declaration of intent confirming their strategic partnership into the future. Fraunhofer researchers are already working on new production technologies in cooperation with their counterparts from CSIRO in Australia.

Text: Monika Weiner



You can't saw without producing sawdust. But sometimes this can be quite expensive. If, for example, the "dust" comes from wafer manufacturing in the photovoltaic and semiconductor industries. For a long time generating a relatively high kerf loss from the precious material has been accepted as an unavoidable, if highly regrettable, fact of life. But now scientists from the Fraunhofer Institute for Mechanics of Materials IWM in Freiburg together with colleagues from Australia's Commonwealth Scientific and Industrial Research Organisation CSIRO have developed a saw wire that is set to achieve dramatic reductions in kerf loss: in place of diamond-impregnated steel wires, the researchers use ultra-thin and extremely stable threads made of carbon nanotubes coated with diamond. A patent application has already been filed for the method.

The success story is not just based on good German-Australian cooperation, but owes its existence to a few coincidences too. For example, the Brazilian mechanical engineering student Vinicius Amaral came to Freiburg to write his degree dissertation at Fraunhofer IWM. While there, he got to know the scientists from the Tribological Coatings group. Two years later, the German Federal Ministry of Education and Research BMBF started a program to promote bilateral cooperation between Germany and Australia. By that time Vinicius Amaral had moved to Australia to do a PhD at the CSIRO Materials Science and Engineering CMSE division. When he heard about the tender for the new program, he told his CMSE colleagues about his experiences in Freiburg. Thanks to e-mail and Skype, the Australian and German teams were soon involved in interesting exchanges.

They decided to put forward an application for a joint project: the development of a method for coating carbon nanotubes with boron nitride. This is exciting because boron nitride is very similar to diamond and there are huge difficulties involved in applying diamond itself to carbon nanotubes, which has severely restricted the range of possible applications.

Joining forces to attempt the impossible

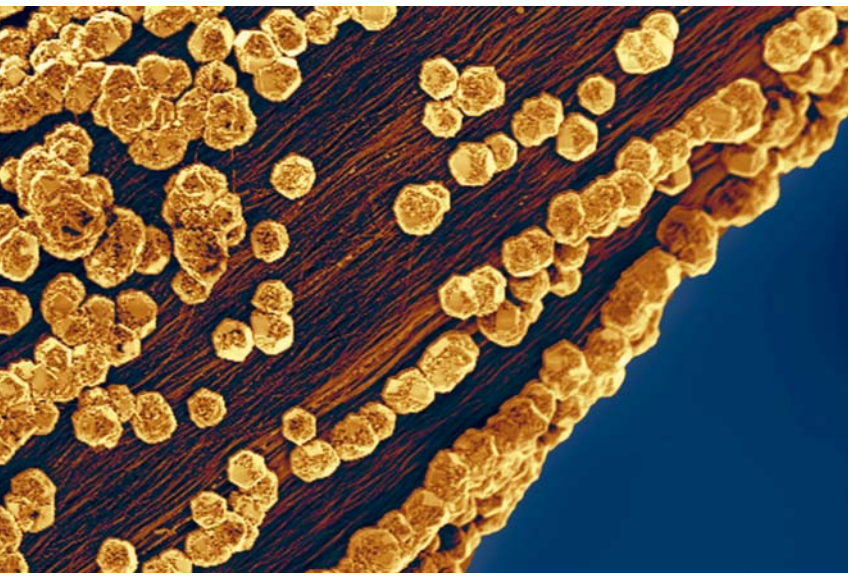
Experts have long understood the potential of coated carbon nanotubes: possible applications include its use as a hard and tough composite material or as a component of highly sensitive sensors and thermoelectric generators.

However, coated carbon nanotubes are extremely difficult to produce. Diamonds only grow under extreme conditions – at temperatures of around 900 degrees Celsius in an atmosphere containing hydrocarbons. Growing diamonds on nanotubes turns out to be a tricky proposition, because carbon tends to form graphite. In order to catalyze the formation of the diamond phase, it's necessary to use reactive hydrogen to prohibit the deposition of graphite. However, this process also damages the graphitic carbon nanotubes.

Striding into the future together

German and Australian researchers are set to cooperate even more closely in the future. On the occasion of the 60th anniversary of diplomatic relations between the Federal Republic of Germany and Australia, the two countries signed the Berlin-Canberra Declaration in January 2013. The strategic partnership planned in this declaration is designed to strengthen bilateral cooperation between the countries in the fields of politics, business, education, science, and research. Fraunhofer and CSIRO are fulfilling this very promise. Researchers from both organizations are working together on numerous projects. The main areas in which joint research is underway are renewable energy and materials science and engineering.

In spring 2011, the CSIRO researchers Vinicius Amaral and Jürg Schütz brought a suitcase full of samples over to Germany, where the carbon nanotubes were to be coated. The first attempts were sobering: it looked like the fine threads, which grow like forests on a substrate, were not up to the harsh conditions of diamond synthesis. It required a further coincidence for Fraunhofer IWM's Manuel Mee to find the solution: he noticed how fused silica from the reaction chamber, which had accidentally come into brief contact with the coating plasma, had



Diamond-coated yarn made from spun carbon nanotubes.
© *Fraunhofer IWM*

settled on the substrate covered with carbon nanotubes and protected it against the aggressive hydrogen. And to his surprise, diamonds actually grew on this layer.

Research across 9 time zones

What followed was careful, painstaking work. "We had to study the silicon oxide layer, which was deposited in an undefined manner, and find a method of controlling the deposition and optimizing the process," recalls Mee. In the late summer of 2011, he flew to Australia to examine the first diamond-coated carbon nanotubes with the aid of CSIRO's transmission electron microscope. "This was the only way of finding out if the nanotubes were actually preserved under their protective layer," explains Mee. "The images showed that we were on the right track. And from that point it was clear that we would continue with our research."

Continue yes, but in which direction? The inspiration came to Mee and his group manager Sven Meier, who had also come to the CSIRO research laboratory for a few days: if they found a way to coat with diamond the nanothreads that the CSIRO specialists make from nanotubes, these diamond-coated nanothreads could be used to manufacture ultra-thin saws capable of cutting through silicon wafers. Moreover, the Australian team at CMSE is one of the few in the world with the ability to manufacture yarns from carbon nanotubes. The manufacturing process requires special carbon nanotube "forests", in which the nanotubes are the right length and diameter and possess a specific number of contact points. The nanotubes stick together at these contact points on account of van der Waals forces, such that if you move them apart, the neighboring nanotubes are dragged along with them. This creates an ultra-thin "felt" of carbon nanotubes which is transparent and conductive. This felt can be twisted into a very thin yarn of between ten and twenty micrometers in diameter.

Theoretically, this diamond-coated yarn was the ideal material on which to base a new generation of saws, which could be used in the solar industry for example. As Mee explains: "The new saw wires held out the promise of being far superior to traditional steel wires. Because of their high tensile strength, they can be manufactured much thinner than steel wires – and that means significantly less kerf loss."

Over the following months, Mee demonstrated that the method actually worked in practice: back in Freiburg, the physicist began to modify the process for coating nanothreads until he found the solution. A joint patent application by Fraunhofer and CSIRO has been filed for the method and corresponding products. Mee and his colleagues are currently carrying out sawing tests. "To be able to show our partners in industry the potential the technology holds," says Mee, "we have to demonstrate how it can help solar companies to save material when processing wafers." ■

Multicolored Asian lady beetles.
© *Andreas Vilcinskas/Fraunhofer IME*

Fighting malaria with ladybugs

Multicolored Asian lady beetles are advancing round the globe and driving out native species in the process. Their methods amount to no less than biological warfare: the invaders infect their opponents with deadly parasites against which they themselves are immune.

Ladybugs are not only pretty to look at; they also serve a useful purpose, as their diet includes aphids and other botanical pests. The multicolored Asian lady beetle or Harmonia axyridis (also known as the Japanese ladybug, the Halloween ladybug or the Harlequin ladybird) is an especially voracious eater; this little glutton can munch its way through up to 200 aphids a day. Its sizeable appetite led organic farmers to import Harmonia axyridis decades ago as a natural method of biological pest control. They initially introduced the insect onto fields and into greenhouses in North America before bringing it over to Europe – but from the 1990s onward, these little helpers started to become a problem in their own right. The beetle has reproduced uncontrollably, and is now considered a primary example of an invasive species.

The alien invaders also gained a foothold in Germany, where they are making life difficult for the 80 or so native ladybug species. This could have worrying consequences, as Professor Andreas Vilcinskas, biologist and joint head of the Institute for Phytopathology and Applied Zoology at Justus Liebig University Giessen, explains: "If things continue at this rate, many of these species will disappear." Professor Vilcinskas also set up the Bioresources project group at the Fraunhofer Institute for Molecular Biology and Applied Ecology IME in 2010, an initiative that is funded to the tune of 4.5 million euros by the Land of Hesse through the LOEWE research promotion program ("State offensive for the development of scientific and economic excellence"). "Our aim is to utilize the enormous potential that the insect world holds for us. Insects are an incredibly diverse class of animals in possession of many biomolecules that could have all manner of medicinal and biotechnological applications," Vilcinskas adds.

Fraunhofer research scientists consider invasive species such as the multicolored Asian lady beetle to be very promising. "If a species is able to successfully spread across the planet, then it must have a very strong immune system, else it would not be able to withstand the various pathogens it encounters every time it enters a new habitat." Comparing the invading beetle with two native species, the seven-spotted ladybug (Coccinella septempunctata) and the two-spotted ladybug (Adalia bipunctata), gives credence to the biologist's argument: laboratory tests indicate that the blood of the foreign insects has much greater immunity to disease than the blood of either European species. Vilcinska's team identified the active agent as harmonin, a substance that is exclusively produced by Harmonia. In experiments, this substance proved to be an effective antibiotic that is capable of combatting tuberculosis and malaria pathogens, among others.

But harmonin is just one of many chemical weapons the multicolored Asian lady beetle uses to defend itself against microorganisms. Its armory also contains over 50 types of peptide with which it can fight off massive bacterial attacks, as revealed by Dr. Heiko Vogel's in-depth molecular biological analyses conducted at the Max Planck Institute for Chemical Ecology in Jena. "This makes Harmonia a record breaker. We know of no other animal that produces so many antimicrobial peptides," says Vilcinskas. That gives the interlopers a distinct competitive advantage over their seven-spotted rivals and other ladybugs. But having a strong immune system still doesn't explain their incredible assertiveness – for these little fighters invariably come out on top when they go head-to-head with their local relatives, too. A startling observation made by the Fraunhofer team led them to discover the secret to Harmonia's success. When competing for food and space in their natural habitat, it's not unusual for ladybugs to eat their rivals' larvae and eggs. If a seven-spotted ladybug tucks into the young of its exotic opponent, then it's a deadly meal: the hungry native dies. When a multicolored Asian lady beetle gobbles up the offspring of its local relation, however, it suffers no ill side-effects whatsoever. The answer to the mystery is contained within the invaders' blood, which is filled with spore-like parasites. Some 18 months of molecular biological detective work finally identified the organism as belonging to a group of fungi-like unicellular parasites called Nosema, a microsporidian.

"Since making the discovery, we've examined multicolored Asian lady beetles from all over the world. We found microsporidia in every single animal in every population, even in the eggs," explains Vilcinskas. This means that whenever a seven-spotted ladybug eats a Harmonia egg, the insect is infected with the pathogens the egg contains. The microsporidia then multiply and kill their new host. Researchers at the IME do not yet know why the Asian ladybugs aren't affected by the microsporidia they carry – but they're hot on the heels of a promising lead, as Vilcinskas reveals: "Presumably the beetles protect themselves using harmonin. We think that they use it to limit the rate of microsporidia reproduction, thus keeping levels harmlessly low." The IME scientists published the results of their study in Science Magazine, the academic journal of the American Association for the Advancement of Science. ■

The plant factory

Molecular farming is an easy, fast, and safe method for producing vaccines and therapeutic agents in plants. Now a team of Fraunhofer researchers from the USA has achieved an important breakthrough in the progress toward industrial production: a GMP-certified plant factory.

Text: Beate Koch

Professor Vidadi Yusibov (left) and Professor Andre Sharon (right) in the fully automated plant factory. © *Dirk Mahler*

The vaccine shortage during the swine flu pandemic in 2009 showed that although chicken-egg production is a reliable method, it takes too long in a global emergency and does not yield enough vaccine. What is required are alternative methods with shorter production times and bigger yields, such as the production of vaccines and therapeutic agents in plants. Molecular farming, as this method is formally known, is easy, fast, and safe: the genetic information needed for protein formation is introduced into the plant via viral vectors that are harmless to humans.

"We use tobacco plants because they are well suited to reproducing viral vectors. In addition, they quickly grow a lot of biomass and therefore a large quantity of the desired proteins," says Vidadi Yusibov from the Fraunhofer Center for Molecular Biotechnology CMB in Newark. It has already been demonstrated in the laboratory that the method works well. But can molecular farming be scaled up to mass production? The researchers have already cleared the first hurdles: they have developed a completely automated plant factory that has been certified according to Good Manufacturing Practice (GMP) criteria. GMP regulations govern quality assurance in drug manufacturing, and certification is a fundamental prerequisite for the production of vaccines or proteins. In recognition of this achievement, one of this year's Joseph von Fraunhofer prizes was awarded to two Fraunhofer researchers from the United States: Prof. Andre Sharon from the Fraunhofer Center for Manufacturing Innovation CMI in Boston (partner institute of the Fraunhofer Institute for Production Technology IPT) and Prof. Vidadi Yusibov from the CMB (partner institute of the Fraunhofer Institute for Molecular Biology and Applied Ecology IME).

"As engineers, our biggest challenge was to get our heads round the biological processes involved – just as the biologists had to understand the mindset of an engineer. Together we were able to design the automated plant production facility. Now we have plants that consistently grow and make proteins to the same predictable quality, time after time, whenever and wherever we like," reports Andre Sharon from the CMI. This is made possible by having shelf containers with functions for dispensing water and nutrients, where the plants grow in hydroponic cultures of mineral wool as opposed to soil. Light, water, and nutrients are precisely dosed and distributed in specially designed growth modules. Purpose-built robots bring the plants from station to station to carry out the various steps – from inserting the tiny seeds and vacuum infiltration, to harvesting and extraction.

Vacuum infiltration is the centerpiece of the plant factory. This process goes as follows: a robot picks up a container, turns it over, and dips the tobacco plants headfirst into water. "This water holds the biological carrier (viral vector) containing the genetic information that tells the plants which protein they should produce. Then a vacuum is created by drawing the air from the water and the plants. As soon as we switch off the vacuum, the plants "gasp" for air and suck in the water together with the vector. This takes just a few seconds," explains Professor Sharon. The plants are returned to their shelves, where they take about a week to produce the proteins. Once harvested, the leaves are cut into small pieces and homogenized in fully automated processes. The end product is a clear liquid.

The pilot facility is capable of producing up to 300 kilograms of biomass a month, which roughly corresponds to 2.5 million units of vaccine. ■

Asteroids hurtle toward the Earth at speeds of between five and 30 kilometers per second. Thousands of Near Earth Objects (NEO) have been discovered in the past 20 years. © *NASA/JPL-Caltech.*

Impact protection for Mother Earth

In the EU-sponsored project NEOShield researchers are developing strategies to protect our planet from asteroid impacts.

Text: Monika Weiner

Asteroids can be deadly: a single impact 65 million years ago was enough to trigger the fall of the dinosaurs. When a slightly smaller meteorite hit in 1908, the East of Siberia was utterly destroyed. And last summer NASA reported that the Earth had just escaped a collision with an asteroid measuring nearly three kilometers across. Theoretically the next cosmic projectile could be upon us at any moment. What effect would such an impact have on humankind? And what could we do to avert catastrophe?

These are the sorts of questions that have long interested the authors of science fiction novels and disaster movies. Now scientists are looking for answers, too: within the EU-sponsored project NEOShield – NEO stands for Near-Earth Objects – an international and interdisciplinary team of researchers is working to develop defense strategies to counter the threat posed by asteroids.

An anonymous rock that becomes a lethal threat

These dangerous rocks come from far away, in the space between Jupiter and Mars, where there are millions of potential missiles orbiting the sun. The fragments of rock comprising the asteroid belt are believed to belong to an unknown planet that broke up in the distant past. As long as this debris remains where it is, there is no need for concern. However, asteroids are continually being thrown off course as they collide with other asteroids or are influenced by their gravitational pull. This is how bodies of rock in the cosmos come to assume new orbits around the sun and from time to time – albeit rarely – find themselves on a collision course with the Earth.

"Most meteorites that get close to the Earth originate from this asteroid belt and that is why we concentrate our efforts on these objects," explains Frank Schäfer from the Fraunhofer Institute for High-Speed Dynamics, Ernst-Mach-Institut, EMI in Freiburg. The scientist has been simulating collisions for years both in the laboratory and on the computer. At first he was interested in protecting satellites, the casing of which can be ripped and melted by space debris and meteoroids. Along with partners from industry such as Thales Alenia Space, OHB System AG, and Astrium GmbH, Schäfer's team developed a protective shield consisting of fabric layers that distribute the force of the impact and so minimize the damage caused. For some months now the researchers have been using their knowledge to investigate how asteroids react when they are struck by – or collide with – an outside force along their trajectory. The experiments are part of the NEOShield proejct, which is being coordinated by the German Aerospace Center's Institute of Planetary Research. Specialists from France, Germany, Ireland, Russia, Spain, Switzerland, the UK, and the USA have joined forces to develop defense strategies to counter the threat of asteroids that get close to the Earth.

There is no single solution. The decision about what to do when a rock from space comes dangerously close to our planet depends on a variety of factors. Key are the size of the asteroid and the point in time we discover that the asteroid is on a collision course with the Earth.

– For instance, objects with a maximum diameter of a hundred meters located over 20 years before any potential collision can be repelled relatively easily. Model calculations indicate that a heavy satellite flown alongside the asteroid would be capable of pulling the asteroid onto a new course. This is caused by gravitational pull which, in accordance with Newton's law, ensures that the two high-mass objects attract one another. If this

An artistic's portrayal of an asteroid impacting with the Earth. © *Donald Davis*

If an asteroid should ever hit the Earth, the consequences are clear. The Barringer Crater in Arizona is 1200m wide and was made by an asteroid 50 meters in size. © *Stefan Seip/DLR*

gravitational pull can be utilized strategically, the asteroid can be guided gently past the Earth.

– In contrast, large asteroids of over 1,000 kilometers in diameter call for brute force, though they can be repelled at relatively short notice. According to the calculations a nuclear warhead would have to be detonated either at the surface of the asteroid or somewhere in close proximity in order to alter its course. The detonation and the atomization of material on the surface would generate a forceful shove, directing the asteroid away from the Earth.
– Then again, asteroids measuring some hundreds of kilometers across can be catapulted off course using high-mass satellites. This "kinetic" form of defense causes the momentum of the satellite to be transferred to the cosmic object – in the same way one might imagine one pool ball colliding with another and setting it into motion.

In theory, these defense strategies sound extremely simple. But will they work in practice? This is the question the NEOShield researchers are trying to answer with reference to calculations, experiments, and models. "The problem is that we need data that are very hard to come by," admits Frank Schäfer. "Where exactly is the asteroid, how fast is it travelling and how big is it, what is it made of, what is its porosity and density?"

Astronomers can help with locating the asteroids – though only if they are in the light of the sun. If they are flying in the dark they will remain undiscovered. That is why there are always asteroids cropping up near to the Earth that nobody had yet seen. Nonetheless, the National Aeronautics and Space Administration (NASA) has located 9944 potential projectiles close to the Earth. Pictures can be used to calculate size, while investigating the spectrum of light allows experts to draw conclusions about mineral composition. If scientists get the chance to observe an asteroid as it passes a planet, its mass can be extrapolated from its course. The mass, size, and composition can then be used to determine porosity.

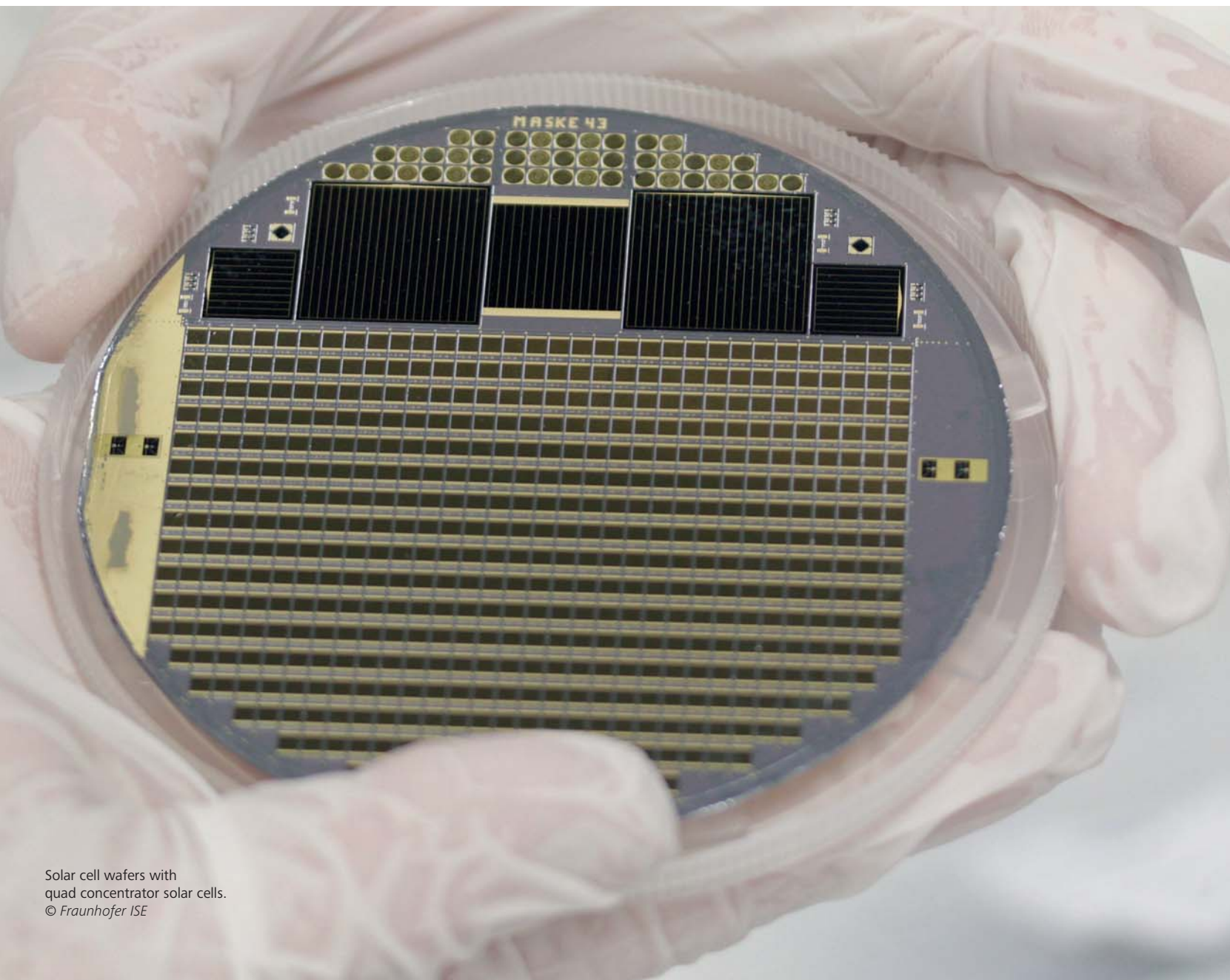
www.neoshield.net

The rest is an unknown: nobody knows how an asteroid will react when we try to push it off course, bombard it, or blow it up. "The answer depends on the internal structure, which we don't know," says Schäfer. "If an object is compact, it will behave differently than one which consists of fragments that fly apart but quickly gravitate together again." Scientists are therefore using a variety of materials to simulate firing a satellite at a cosmic object. The model asteroids in the laboratory at the Fraunhofer Institute in Freiburg are small blocks made out of dense quartzite, porous sandstone, and aerated concrete. These blocks are bombarded with aluminum pellets – representing miniature satellites. The displacement of the sample block upon collision allows researchers to deduce how much momentum has to be transferred to the asteroid and how much mass and velocity is required to do it if the asteroid is to be diverted slightly from its course. The parameters are astronomic in the true sense of the word: to divert an object that is 300 kilometers across and travelling at a velocity of ten kilometers per second requires a satellite of several tons capable of achieving an equal velocity. Building such a satellite, launching it into space, and accelerating it to the required velocity is far from easy. Nevertheless, the NEOShield experts are confident that they will be in a position to present a design for the impactor satellite by the time the project reaches its conclusion in 2015. This satellite will be capable of flying between the planets and diverting an actual asteroid from its course. ■

Full concentration on solar cells

Fraunhofer researchers are working on a new generation of multi-junction solar cells in an industrial project with the French firm Soitec. These have the potential in the future to attain efficiency levels of over 47 percent under concentrated sunlight.

Text: Monika Offenberger



Solar cell wafers with quad concentrator solar cells.
© *Fraunhofer ISE*

A bright summer's day, a magnifying glass, and a sheet of paper – nothing more is needed to demonstrate the enormous energy of sunlight. With the magnifying glass, the sun's rays can be focused on a point strongly enough to ignite the paper. The amount of solar energy concentrated at the focal point and how it can be utilized depends in the end on the properties of the lens and of the illuminated surface. Researchers at the Fraunhofer Institute for Solar Energy Systems ISE in Freiburg have optimized both of these for effective generation of electricity. The result is a new generation of multi-junction solar cells that attain efficiencies twice as high as the best silicon cells.

The idea of concentrating light to increase the energy yield is as old as the field of photovoltaics itself. For with a good lens – which is considerably less expensive that any semiconductor material – the solar radiation can be focused on a very small area saving money on solar cell material. At the same time, the energy conversion efficiency climbs under concentrated light. At Fraunhofer ISE, the largest solar research Institute in Europe, a team led by the Institute's Deputy Director, Dr. Andreas Bett, has been engaged in developing concentrated photovoltaics for a long while. They demonstrated just how efficient this new technology can be by developing a triple-junction solar cell with an efficiency of 41.1 percent under a concentration of 500 suns – chalking up the new world record in 2009. Since then, this figure has been increased repeatedly and is still headed upwards. "In contrast, silicon cells have hardly improved in the past decade. The best of them has an efficiency of around 25 percent, already very close to the theoretically achievable limit of 29 percent," says Dr. Frank Dimroth, who heads III-V – Epitaxy and Solar Cells at ISE.

Effective semiconductor crystals

The name of Dimroth's area refers to high-performance semiconductor crystals that are outperforming silicon. They contain compounds of gallium, indium, aluminum, arsenic, or phosphorus – i.e. chemical elements that belong to Groups III or V in the periodic system. These materials are comparatively expensive. Still, they operate reliably even under concentrated sunlight and are therefore highly suited to concentrator photovoltaics. III-V semiconductors have yet another advantage over silicon. Depending on III-V semiconductor, they are capable of absorbing somewhat different regions of the solar spectrum and converting them into electricity. "Unlike lasers or LEDs that have only one wavelength, solar radiation arrives on Earth at many different frequencies of the spectrum. The solar spectrum ranges from 300 nm to several thousand nanometers," says Dimroth. If you combine several different semiconductor crystals, then you can simultaneously utilize a larger portion of the solar spectrum for generating electricity than if just one crystal were used by itself.

Although the concept is simple, the implementation is extremely complex. "The problem is that the various III-V crystals are not actually compatible with one another because they have differing lattice constants," says Dimroth. Despite this, the physicists have been able to incorporate four different semiconductor crystals in one solar cell. As a result, the usable part of the solar spectrum could be increased again in comparison to the triple-junction cells. This elegant piece of work succeeded using the following trick. First, two sub-cells are deposited on two different III-V substrates. The two resulting tandem solar cells are pressed together using a wafer bonding process – so tightly that atomic bonds form at their interface, enabling current to flow. Nearly 40 semiconductor layers are connected to each other. "With this combination of materials, we can efficiently utilize the solar spectrum from 300 to 1800 nanometers," emphasizes Dimroth. By comparison, silicon cells make use of wavelengths up to only 1200 nm.

The new type of cell takes up an area of only five square millimeters (.0077 sq in.). They will be employed a few years from now in the photovoltaic concentrator modules of French firm Soitec that concentrate sunlight up to 500 times using high-performance lenses. Soitec and Fraunhofer ISE share a long history. The concentrator photovoltaics area stems from the company Concentrix Solar, which was spun off from Fraunhofer ISE in 2005 to help bring the new technology out of research laboratory and into the market as rapidly as possible. Soitec brought the concentrator photovoltaic modules into production and today is the world market leader in this technology. Solar power plants in 14 countries are already employing this technology, preferably in locations that receive especially high solar radiation. The first solar farms were built in Spain and additional ones followed in New Mexico, USA. Numerous smaller systems of a few hundred kilowatts are operating in Italy and France, while a large facility to supply 30 megawatts is being installed in South Africa at present.

Collaboration with SOITEC

The collaboration between Soitec and Fraunhofer ISE in Freiburg intensified in 2009 through the SolarBond project, supported by the German Federal Ministry of Education and Research (BMBF) and its French counterpart, the National Research Agency (ANR). The third member in league with them is CEA-Leti, headquartered in Grenoble – one of the largest institutes for application-oriented research in microelectronics and nanotechnology in France. The cooperation partners made a big step towards commercializing the new four-junction solar cells inside of two years. They were the first to process ultra-thin III-V solar cell layers on reusable substrates. They received the Franco-German Business Award (Deutsch-Französischer Wirtschaftspreis) for this achievement.

Since that time, the ISE has been developing the high-efficiency solar cells further under contract from Soitec. "The cells being employed commercially in concentrator modules today reach an average efficiency of 39 percent. In contrast, the best four-junction cell lies at 44.7 percent presently," explains Dimroth. However, the Fraunhofer experts are not satisfied with that. There is still some fine tuning that they could carry out. Dimroth believes, for instance, that the specific properties of the crystal layers can be improved and the optical transparency of the intermediate layers increased. He continues: "I am confident that we can still get a notch better. Our next milestone is 47 percent – and there is still room beyond that." ■

Fraunhofer in Brazil

Not only is Brazil the sixth largest economy in the world – and rich in natural resources – it's a growth market, too. Increasingly, German companies are trying to gain a foothold in the market and Fraunhofer, with its many years of local experience, is on hand to provide them with assistance.

The Fraunhofer-Gesellschaft is currently advising the Brazilian government as it goes about setting up its "Embrapii" innovation program, through which it intends to build up its own structures for a coordinated process of innovation. At the same time, in the Project Centers in Campinas and Salvador, Fraunhofer researchers are working alongside Brazilian partners to develop new technologies for use in software engineering and for obtaining bioenergy. Since 2012, Fraunhofer has also had a Senior Advisor in São Paulo, whose liaison office in the German Chamber of Commerce (AHK) is very close to the German House of Science and Innovation (DWIH).

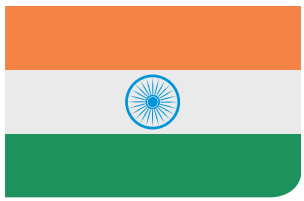
What's more, many Fraunhofer Institutes have projects underway in Brazil. The Fraunhofer Institute for Applied Polymer Research IAP in Potsdam-Golm, for instance, is working with Brazilian company Flexsolar in Joinville to set up an organic photovoltaics facility.

A futur city for all

If the forecasts are correct, by 2030 five billion people will be living in cities. These people all need energy, raw materials and ways to get around, and of course they will also be producing waste and emitting pollutants. In the Morgenstadt innovation network, researchers from several Fraunhofer Institutes have teamed up to develop sustainable urban technologies and systems. Now, Russian company RTI has also joined the initiative.

"RTI has extensive practical experience implementing ready-made solutions that ensure stable and effective urban development in Russia. Many of these solutions meet the international standards already being implemented in modern megacities. Together with our partners outside Germany, we will be able to take our developments for designing and spreading 'secure and intelligent cities' and successfully adapt them to current trends and impulses," explained Sergey Boev, General Director of RTI, at the signing of the cooperation agreement.

In collaboration with the Fraunhofer Institute for Factory Operation and Automation IFF in Magdeburg and other Fraunhofer Institutes, the experts at RTI intend to examine innovative methods for rethinking cities along sustainable lines and to combine urban technology systems, commercial models and management systems into an overarching approach.



The soft energy path

India's Ministry of New and Renewable Energy is to work closely with the Fraunhofer Institute for Solar Energy Systems ISE in Freiburg. A memorandum of understanding was signed in May 2013. The collaboration will be coordinated by the Solar Energy Center SEC in New Delhi.

"Joint projects and research exchange programs have given us long-standing links with India," said head of the ISE Prof. Eicke Weber on the day the memorandum was signed. Scientists on the India One project have already been working together for two years to develop a one megawatt solar thermal power plant. The plant relies on parabolic dishes that trap sunlight and are able to store heat. The finished power plant should provide electricity 16 hours a day.

Now the experts from India and Germany want to develop more technologies together. One example is concentrated photovoltaics that help produce hydrogen, which in turn can be converted into electricity using fuel cells. The researchers are currently building a mobile test facility for up to 30 fuel cells as part of a pilot project. There are also plans to develop further demonstration facilities for sea water desalinination using solar thermal techniques as well as to develop hydrogen technology for stationary and mobile applications.

Emergency action plan

What to do when there's a power cut? Or when transport or telecommunications networks go down? Damage to our critical infrastructure can have knock-on effects that reach across Europe, which means emergency services, authorities and politicians need to cooperate at a superregional level. Now, partners from research, business and industry associations have come together in the EU-sponsored Critical Infrastructure Preparedness and Resilience Research Network (CIPRNet) to establish a European competence center for simulating and analyzing critical infrastructure. The aim is to come up with optimized strategies, techniques and methods that allow a quick reaction time in emergency situations.

"If we are to achieve the best possible response time – and maintain it – both the technologies we develop and the players involved must be able to adapt quickly to constant changes in critical infrastructure," says Dr. Erich Rome, project coordinator at the Fraunhofer Institute for Intelligent Analysis and Information Systems IAIS. "CIPRNet will provide forward-looking methods in terms of modeling, simulation, and analysis for decision makers to support catastrophe and emergency management on the European scale." Five European research institutions, the International Union of Railways, four universities and a Swiss company are all working alongside Fraunhofer in the research project. The partners will first develop a virtual competence center; this will then serve as the basis for a planned European Infrastructures Simulation and Analysis Centre.

Clean water

Most of Europe's rubbish ends up in landfill. The disadvantage is that landfill sites often produce highly polluted leachate that releases harmful substances into the environment – substances that are resistant to degradation and often toxic. Removing these harmful substances from landfill leachate calls for special purification techniques.

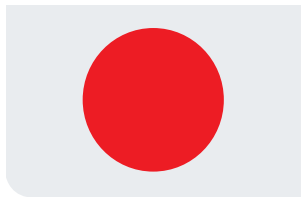
Experts from the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB in Stuttgart have joined forces with an international team of researchers to develop a process for purifying polluted landfill leachate. The technique was worked up within the EU project CleanLeachate and is based on a combined anode and cathode process. A membrane splits an electrolytic cell into two separate chemical reaction chambers. Applying a voltage at the anode produces hydroxyl radicals, while the cathode is used to break down constituent substances. One of the project's main concerns has been to select the appropriate material for the electrodes. Specialists are currently testing the process in continuous operation at a landfill site in the Czech Republic. The process has already been sufficiently optimized to ensure that chemical oxygen demand and total nitrogen concentrations fall under the limits prescribed by the law as well as adhering to waste water requirements. The scientists are currently carrying out further work on an automated and transportable prototype system.

More and even better

Scientists in Germany and South Africa want to collaborate more closely in the future. Numerous Fraunhofer Institutes already work with South African partners. The Fraunhofer Institute for Chemical Technology ICT, for instance, has teamed up with the South African Council for Scientific and Industrial Research (CSIR) to develop thermoplastic, natural-fiber-reinforced plastics as part of the German Federal Ministry of Education and Research (BMBF)'s "NF Pul" project. Also collaborating with the CSIR are researchers from the Fraunhofer Institute for Optronics, System Technologies and Image Exploitation IOSB as part of the EU project "EO2Heaven" – short for Earth Observation and Environmental Modeling for the Mitigation of Health Risks. For several years now, the Fraunhofer Institute for Machine Tools and Forming Technology IWU has been working alongside three South African universities on projects targeting the high-performance machining of titanium, financed by the Department of Science & Technology South Africa (DST).

As well as CSIR, Fraunhofer Institutes also work with other institutions such as the National Laser Center NLC, the Tshwane University of Technology TUT in Pretoria and Stellenbosch University.

During the German-South African Year of Science 2012/13, Fraunhofer appointed a Senior Advisor South Africa, Prof. Dimitri Dimitrov.



Identifying markets

Germany and Japan have a lot in common: both are leading industrial nations, export-oriented, and interested in new technologies that could make production faster, better, cheaper, and more energy-efficient. German and Japanese researchers now want to work together more closely than ever before to reach these goals.

Last year Fraunhofer signed a memorandum of understanding with the National Institute for Advanced Industrial Science and Technology AIST, Japan's biggest and most respected research organization. The two institutions are now collaborating on several projects and developing new applications for medical technology, photovoltaics, and nanotechnology.

Researchers from the Fraunhofer Institute for Manufacturing Engineering and Automation IPA in Stuttgart, for instance, are working alongside colleagues from the Health Research Institute at AIST Kansai to develop carbon nanotube actuators. One result was already available for all to see at the Nanotech 2013 fair in Japan: a micropipette that makes use of carbon nanotube actuators to suck up and re-dispense tiny amounts of fluid exactly and efficiently. The Japanese and German experts are keen to develop these new actuator products further for applications in medical technology and the energy industry, and to bring them to market.

Goooaaal!

Did the ball cross the line or didn't it? At the Copa Amsterdam tournament held in May 2013, electronic goal-line technology was brought in to put the matter beyond doubt – a first in the history of European football. Developed by the Fraunhofer Institute for Integrated Circuits IIS in Erlangen, GoalRef™ was installed in the Olympic Stadium in Amsterdam and used for all 18 games.

GoalRef™ has been FIFA's goal-line technology of choice ever since the world soccer governing body's Club World Cup was held in Japan at the end of last year. The measurement technology makes use of a low-frequency magnetic field generated by an integrated antenna situated on the crossbar directly above the goal line. The ball is fitted with coils and an electric current is induced as soon as the ball enters the magnetic field. A signal is transmitted to the referee's watch and he is immediately able to decide whether the goal counts.

Working on the Columbus module. On the flight to the ISS, the external payload SOLAR was stowed in the interior of the space shuttle together with the Columbus Module. It had to be assembled space-side later. © *NASA*

Sun in sight!

Measurements taken by satellites are helping scientists understand the dynamics on the surface of the sun, its influence on our climate, and on our technology.

Text: Michaela Neuner

The sun is the source of all life. It provides the energy for photosynthesis and thus for the generation of oxygen. Solar radiation is also the engine of planetary weather events and therefore the most important of all the climatic factors. At the same time, the particles that arrive from the sun influence the orbits of satellites and the radio signals they transmit. Researchers throughout the world are therefore intensely interested in the dynamics of our star and their effects.

UV radiation plays an important part in this. The proportion of UV that arrives at the Earth's surface depends upon the ozone layer in the stratosphere and the adjacent troposphere. A large portion of the radiation is absorbed there, producing nitrogen oxide for example. Civilization also influences this protective UV layer to a small extent – for instance through the production of greenhouse gases, industrial emissions, and transportation. Short-wavelength extreme ultraviolet light EUV is completely absorbed and does not reach the Earth's surface.

It is exactly this part of the spectrum that especially interests scientists. The energetic EUV radiation lies between the soft X-ray and UV-C regions of the spectrum. As the main source of energy, it controls the processes in the thermosphere and ionosphere at an altitude of about 80 to 1000 km above the Earth's surface . This region has a large influence on the climatic conditions of the Earth's upper atmosphere as well as the propagation of satellite signals for navigation and telecommunications systems.

Experts from the Fraunhofer Institute for Physical Measurement Techniques IPM in Freiburg have been making measurements with the SolACES spectrophotometer – the abbreviation stands for Solar Auto-Calibrating EUV/UV Spectrophotometer – in the region of 17 to 150 nanometers since March 2009. Docked to the Columbus module of the International Space Station ISS, SolACES has been orbiting the Earth as part of the ESA instrument package named SOLAR for five years and will continue to observe the EUV radiation of the sun until the end of 2016.

Clever engineering compensates for aging

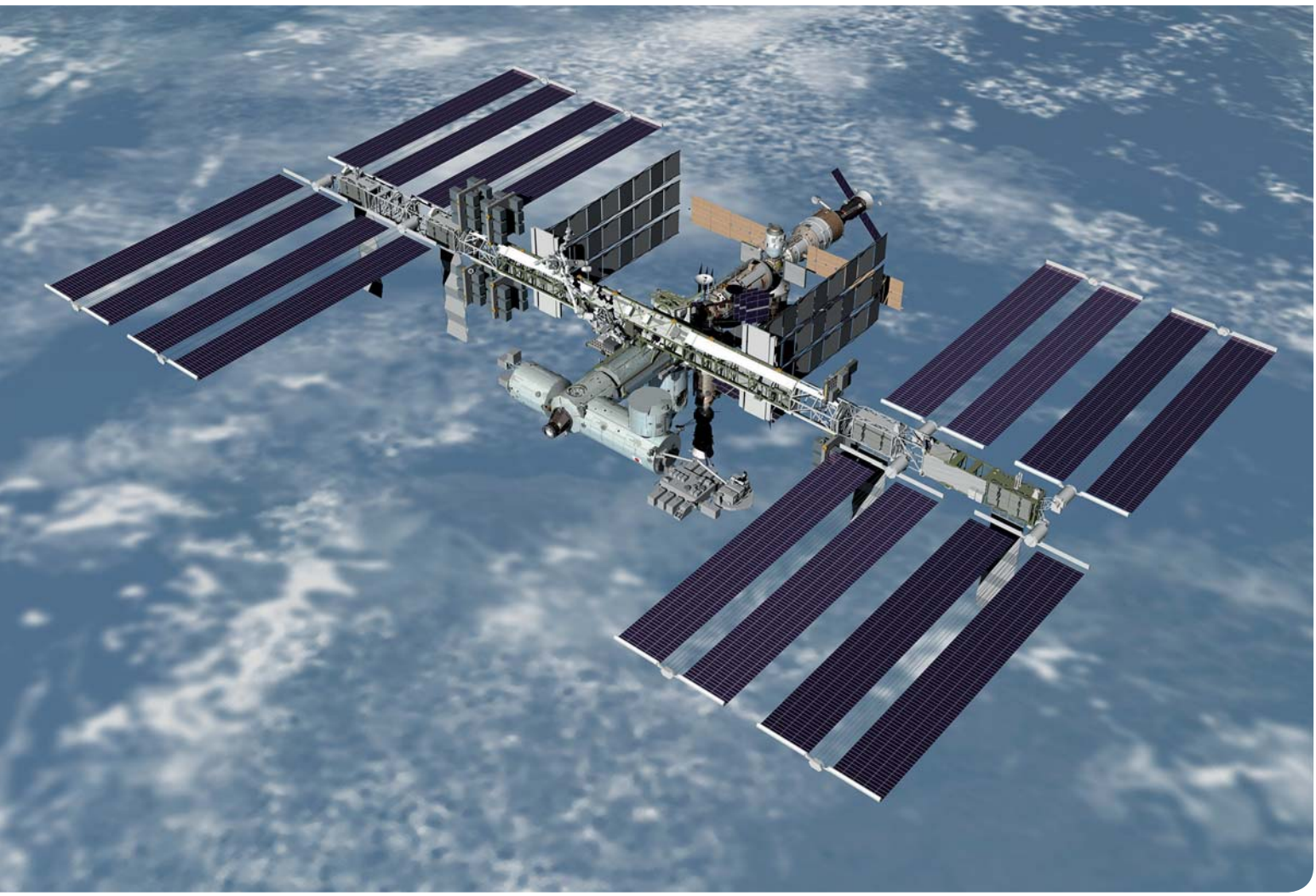
In contrast to other instruments that keep the sun in view from a near-Earth orbit, SolACES automatically calibrates itself at regular intervals with the help of specialized ionization chambers. In this way, aging processes and wear can be compensated for, which would otherwise distort the measurements over time. "This calibration works so well that our measurement accuracy is higher than those of all the other orbital measurement programs," emphasizes Dr. Gerhard Schmidtke, scientific head of the project. The exceptional quality of the data is one of the reasons that the European Space Agency ESA has since extended the SolACES mission for a third time. Originally, it was supposed to have ended after 18 months.

The longer operating life is facilitating new insights into the dynamics of our star. While the luminosity of the sun only changes minimally over an eleven-year average solar cycle in the long term, the EUV radiation can vary in several zones by more than a factor of ten. "Changes can be detected better this way. In addition, the EUV radiation is a good indicator of overall solar activity," says Dr. Raimund Brunner from the IPM, who developed the SolACES spectrometer with Schmidtke, and together with his IPM colleague Christian Erhardt, looks after the mission as well as the data gathered.

The EUV radiation correlates with solar activity and the resulting emissions from the sun, like electrically charged particles or plasma – these too are catapulted by solar eruptions or corona mass ejections towards the Earth. Arriving in the Earth's atmosphere, they influence the formation of clouds and the direction of geomagnetic storms. They create the aurora, interfere with the orbits of satellites and space debris, and delay radio signals of navigational systems such as GPS and Galileo.

Modelling the processes better

"Qualitatively speaking, we certainly understand the energy input to our upper atmosphere and what effects this has," says Schmidtke. "But if we can successfully model the processes with more accurate measurement data, then not only can satellite orbits be calculated more accurately and the navigational signals be detected more accurately. We also have the opportunity to work out even more exact atmospheric and climatic models, and separate cyclical processes from those that have been initiated by civilization. Relationships between the development of sun spots and



On the International Space Station ISS: the SolACES solar spectrometer measures variability of solar radiation with previously unattained precision. © *NASA*

climatic conditions on Earth have been discussed by scientists for several hundred years. A good three hundred years ago, solar observations and their documentation attained such high quality that the cycles of sun spots have been sequentially numbered beginning in 1749.

The Sun has been in its 24th cycle since January 2008 and is being more accurately observed than ever. With ring-side seats in space unhindered by the Earth's atmosphere, several other satellites besides the SOLAR instruments on the ISS are measuring the events on the sun, including NASA's Solar Dynamics Observatory SDO and the joint ESA/NASA Solar and Heliospheric Observatory SOHO.

www.solaces.eu

While these satellite observatories observe the sun round the clock from a stationary point located between the Earth and sun, SolACES orbits the Earth on the ISS. "We have visual contact with the Sun for just 20 minutes during each 90-minute orbit of the ISS, but only ever for a two-week period on average. Then we have to have up to a two-week break, due to the orbital path of the ISS," says Christian Erhardt, describing the usual measurement cycle. Twice a year though, this break is so short that SolACES is able to make measurements during an entire solar rotation, which lasts about 27 days. However, a specialized maneuver of the ISS is necessary for this. In order to permit "sun visibility window bridging", the entire space station must rotate slowly through several degrees. "SOLAR with SolACES and the SOLSPEC experiment is the first scientific payload for which this elaborate maneuver has been carried out," Brunner reports.

The earliest bridging for SolACES took place in December 2012, the second in July 2013. Negotiations are now taking place with the operators of the space station for a third maneuver this coming winter. "With a bit of luck, we will see the maximum in solar activity during the current solar cycle in addition to having seen the solar minimum," Brunner hopes. ■

New insulating plaster for Bamberg's old town

They have that "certain something" and yet unrenovated historic buildings are not energy efficient. Researchers in the European project EFFESUS, working jointly with partners from business and management, are working on how to improve these buildings with energy efficiency, and how to supply them with renewable energies.

Text: Michaela Neuner

Bamberg's old city buildings get new plaster.
© *Stadt Bamberg*

Bamberg, Santiago de Compostela or Budapest: their old towns spread charm, and cozy street cafés entice tourists as much as residents. But no matter how beautiful these historic buildings and districts might appear, there is a need for improvements to energy efficiency even here. Walls are poorly insulated in some parts, windows frequently allow drafts, and the heating systems are not exactly economical.

This balance needs to improve, so 23 partners from science, business and community administration from 13 different European nations have come together in the EFFESUS project, in order to help bring greater energy efficiency to historic city districts. Among the other institutions involved are the Fraunhofer Institute for Building Physics IBP in Holzkirchen and Kassel, as well as the Fraunhofer Center for Central and Eastern Europe MOEZ in Leipzig. The abbreviation EFFESUS stands for "Energy Efficiency for EU Historic Districts Sustainability." The total budget for the project is 6.7 million euros. Across national borders, these researchers are developing new technologies and materials for window repair and interior insulation, an insulating plaster and reflective coatings, among other things. "We link each technology to a case study – that is, a European city in which the technology is tested in an historic building," says Dr. Britta von Rettberg, Scientific and Technical Coordinator of the project. The seven cities where the case studies are taking place – Bamberg (Germany), Santiago de Compostela (Spain), Genoa (Italy), Budapest (Hungary), Istanbul (Turkey), Glasgow (Scotland) and Visby (Sweden) – represent a variety of climate zones.

Bamberg's old city buildings get new plaster

So the reflective coatings under the sun of Istanbul and the insulating plaster in Bamberg need to show what they can do. Bamberg residents are proud to take part in this project. "We want to show that Bamberg is not only a medieval city, but that we also think of ourselves as modern," says Michael Ilk, town councilman for the city of Bamberg. "The issue of saving energy is a nationwide issue – so if we can contribute just a tiny stone to the mosaic of the EFFESUS project, that would be great."

Yet why should you need a different kind of insulating plaster for historic buildings than for new buildings? "Conventional insulating plasters are really thick – up to ten centimeters. Prominent elements and other details become lost, or cannot be read clearly anymore. So, the goal is to develop an insulating plaster of just two to three centimeters in thickness," says Claudia Schindler, a scientist at the IBP. In addition, the Dutch manufacturer combines the plaster with insulating aero-gels – which are highly porous solid objects whose volume consists of up to 99.98 percent pores, and retains the warmth of the house well. However, before these insulating plasters are applied to Bamberg's historic façades, researchers still have to conduct scientific studies on test buildings constructed just for such tests. Once the plasters have achieved good results here, the scientists will apply an approximately hundred square meter wall of it to Geyerswörth, the Bamberg city hall. "Before we apply the plaster, we'll study the wall's condition. Then we'll add measurement sensors to the insulating plaster," says Schindler. By means of sensors, they can determine the temperature and moisture content of the plaster, in order to determine its influence on heat transmission. In addition, the researchers will analyze how the energy needs change for the space that lies directly behind the wall to be plastered.

Software to support decision-making

Another key task of EFFESUS is to engineer a software product that should make it easier for architects and other professionals to make certain decisions. For example, the software supplies them with definitive information about what options are available for energy production in the respective district – and which options can be excluded fom the outset, due to the structure of that city neighborhood. What data have to be entered into the system? Which data only serve to "refine" the results? How do you arrive at these data, and how do they have to be prepared? These are the questions that the IBP scientists in the EFFESUS project also want to clarify. ■

European diversity

Europe is becoming green. If everything goes according to plan, no buildings constructed after 2020 will waste energy. Researchers are working out the key data in an EU project that will become the specifications for low-energy buildings.

Text: Monika Weiner

Excellent Partners

Austria:
Energy Economics Group Institute of Power Systems and Energy Economics Vienna University of Technology (EEG) – Project coordinator

Belgium:
Buildings Performance Institute Europe (BPIE)

Bulgaria:
Sofia Energy Agency (SOFENA)

Czech Republic:
SEVEN, The Energy Efficiency Center

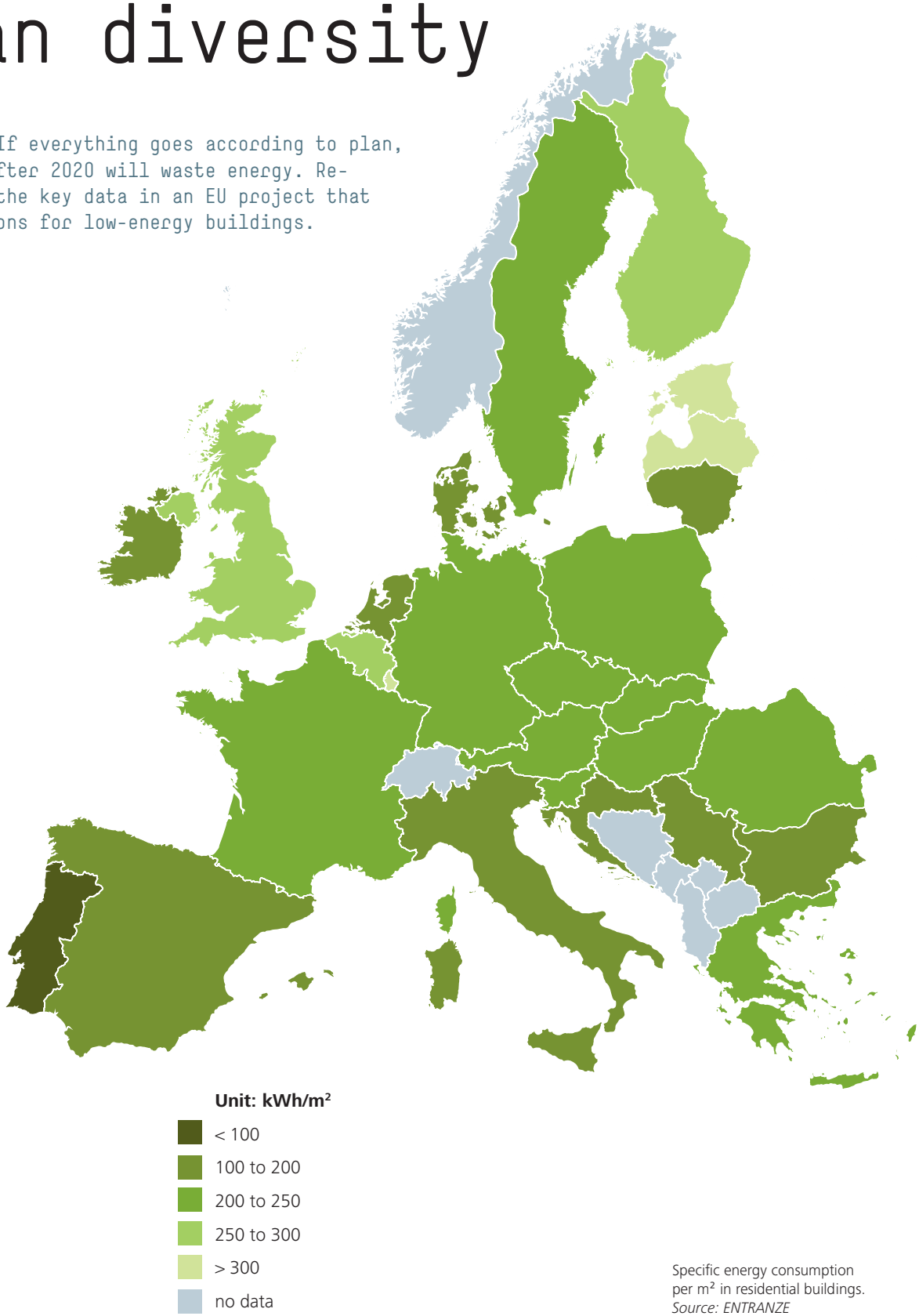
Finland:
National Consumer Research Centre (NCRC)

France:
Enerdata

Germany:
Fraunhofer-Gesellschaft Öko-Institut e. V.

Italy:
end-use Efficiency Research Group (eERG), Politecnico di Milano

Spain:
National Renewable Energy Centre (CENER)



Specific energy consumption per m² in residential buildings.
Source: ENTRANZE

Reductions and efficiencies are on the agenda: by 2020, Europeans are supposed reduce emissions of greenhouse gases by 20 percent and increase energy efficiency by 20 percent. These goals can be reached quickest if you apply the red pen to where the most energy is consumed: in buildings. According to projections of the International Energy Agency IEA, approximately 40 percent of energy consumed in industrialized countries has been for heating and cooling of homes. But that does not have to be: insulated windows and walls, alternative heating technology and/or solar collectors on roofs can drastically reduce consumption. However, there are no patent solutions for all Europeans.

Which technology is worthwhile depends on the locale. An investment in thermal insulation is amortized faster in Finland than in Greece, and efficient refrigerators in Spain permit more energy savings than in Holland. A solar-thermal energy installation on the roof in southern Italy pays for itself in a few years, while in Germany it takes longer. In short: someone wanting to build homes that utilize a minimum of energy – Nearly Zero Energy Buildings – has to develop specific designs for different climatic regions. How these could look is being investigated presently by an international research team under the EU project called ENTRANZE. The abbreviation stands for "Policies to ENforce the TRAnsition to Nearly Zero Energy buildings in the EU-27". Scientists began the work one year ago. Coordinated by experts in the Energy Economics group of the Institute of Power Systems and Energy Economics at the Vienna University of Technology (TU Wien), data from commercial and privately utilized buildings from 27 EU member states as well as Croatia and Serbia were collected and compiled. Consumer researchers from Finland have conducted interviews with experts and searched through databases, and French IT specialists have developed software with which the information can be quickly and comprehensibly presented.

In the meantime, the interactive database tool is online: with the click of a mouse, you learn that a citizen of the European Union in Luxembourg requires five times as much energy as one living in Malta. Or that gas is used for most heating in the Netherlands and Great Britain, while Swedes and Portuguese primarily use electricity. The "R-value", which corresponds to the thermal resistance or insulation of walls and how well they prevent heat loss, is especially high in Estonia, Sweden, and Finland thanks to good insulation, and very low in Malta by comparison.

Results by mouse
www.entranze.eu

"The regional differences are enormous," as Judit Kockat, a specialist in energy efficiency for buildings at the Fraunhofer Institute for Systems and Innovation Research ISI in Karlsruhe, sums up. "The causes are quite diverse – cultural, climatic, and demographic – but are also due to legislation. And in addition, there are interactions between all of these factors." In Germany for example, good thermal insulation in new construction and renovation is required by law. Nevertheless, Germany only achieves an average value in an EU comparison. There are several reasons for this: for one thing, the number of new buildings – and also therefore low-energy homes – is relatively low. For another, renovations of rental properties, which are particularly numerous in Germany, are only carried out with the consent of all of the owners. That is not true everywhere. In Austria, for example, you can override a minority – and the probability that redevelopment will be approved therefore increases. The age bracket of the occupants plays a part as well: someone living in their own home, knowing they do not have much longer to live, does not invest in energy-saving technology that only pays for itself decades later. Kockat is aware of this: "The survey makes clear how many factors are involved and how complex the interrelationships are."

There can be no standard solution for all of Europe: the new low-energy homes will look different everywhere," explains Jan Steinbach, an expert in sustainable technologies at the ISI. In southern Europe, you save by generating hot water with a solar-thermal energy installation on the roof, shading southern exposures, or only equipping individual rooms with efficient refrigeration and cooling, while in northern Europe you more likely invest in thermal insulation. "The determining criterion for everyone will be that new nearly-zero-energy homes must be carbon-neutral. In so far as energy is needed for heating and cooling, this must come mostly from renewable sources," according to Steinbach. In his view, distributed solutions like solar-thermal energy and photovoltaic installations on roofs, or heat pumps, as well as centralized community heating solutions, such as biomass thermal generating plants with combined thermal and electricity generation, are all conceivable.

And just how do you motivate people to build these kinds of homes? The researchers in the European Union project are presently comparing the statutory provisions that apply in the different countries and are analyzing the effects, reports Kockat: "The German energy conservation act is seen by many countries as exemplary because there are concrete values prescribed in order to guarantee the quality of the thermal insulation. At the same time, however, subsidies are also available for those measures that would be uneconomical for the individual owner of a small home. These grants are awarded through the market incentive program and various programs of the Kreditanstalt für Wiederaufbau KfW (the German government-owned development bank)."

The experts want to learn by the end of the project which legislation, regulations, and energy-saving incentives are best suited to reach the climate change goals. They will present the results to the European Commission and the governments of the member states in November 2014. The specialists at the ISI are currently modeling the effects that regulations have on the investment behavior of citizens and what the energy budgets of the Member States are. "The interest shown by the political decision makers is already strong and will become stronger still as the year 2020 approaches more closely," predicts Kockat. ■

The smartphone app is a cross between a digital paper chase and a quiz.
© *Fraunhofer FIT*

Dwarf chase!

Exhibitions don't just belong in museums. The show Zwergenwelten - "dwarf worlds" - crosses over into the virtual world, via the "portal" of a location-based cell phone game - a kind of digital paper chase and quiz available as a smartphone app.

Text: Tim Schröder

Seven-year-old Mats runs along the path holding a smartphone up in front of him. He peers intently at the screen as he goes. "The dots are getting bigger!" he calls out, trotting past a man strolling by. The man gazes after him with a puzzled expression on his face. Which dots is the child talking about? There aren't any dots to be seen! Not floating in the air, at least. The boy is the only one who can see them, as they are only visible on the camera image in his smartphone: little yellow dots that gradually get bigger as he runs towards them. Then he stops. The dots have drifted out of the image on his screen. "They're gone!" He carefully waves his cell phone around, moving it up and down, left to right. There! He's spotted the dots over there, in the bushes. Immediately, he darts off the path and jumps over a little ditch. "Bing!" The cell phone makes a triumphant little sound. One of the virtual dots has burst like a soap bubble. Success!

The yellow dots that the boy is chasing are called "magic orbs". And just like real magic orbs, they're only visible to those who have entered the magic kingdom. "Getting in" is easy. All you need is a smartphone and the right app, and you're ready to start your quest. The gaming application is called Zwergenwelten ("dwarf worlds"), and is part of an exhibition of the same name that runs until the end of October in the city museum in Hagen, Germany. Visitors to the exhibit can marvel at gnomes, trolls and dwarves from all over Europe. Children can crawl through little mining tunnels, listen to popular fairytales about dwarves in German or

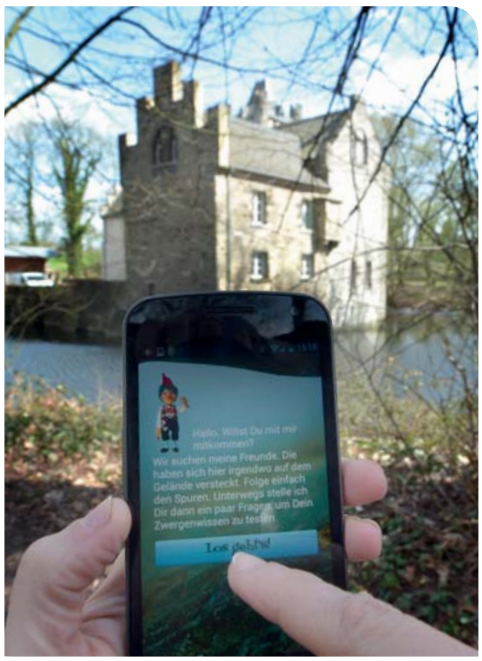
one of four other languages, and take part in an exhibition challenge. This involves following a trail of questions such as: "Are the hard-working little helpers from Cologne called Heinzelmännchen or Mainzelmännchen?" and "There are two soccer dwarves hidden in the exhibition. What jerseys are they wearing?" Anyone who gets the answers right is awarded a dwarf diploma.

But the exhibition's special feature is the Zwergenwelten app for children, designed to be used outdoors. After leaving the museum, it's a short car ride to Werdringen, a moated castle in a green and peaceful setting on the edge of the city. It takes two minutes to download the app and for the GPS receiver to locate the smartphone. Then a satellite map pops up, showing the moated castle and its immediate surroundings. A blue spot appears, marking the position of the cell phone, followed by another symbol: the first in a series of small red hats. This one hovers above the track about a stone's throw away – and so the paper chase begins. The aim of the game is to go from one hat to the next, tap it, and answer questions.

But this starts off being trickier than expected, as Mats is holding his cellphone the wrong way round. He should go left, but heads off to the right instead. It's his first time reading a map. The blue dot on the screen moves further away from the hat. But then he gets the hang of how the game works, turns the smartphone round and starts again. Slowly, he heads towards the hat. As he gingerly taps it on the screen, a message pops up: "You need to be closer." Only once Mats has gone a few more meters and the blue dot and red hat are touching on his screen does the first question appear: "Who reveals to the Queen that Snow White is more beautiful than she is? The court jester, or the mirror?" Mats thinks about it for a moment, and then remembers the famous line from the story: "Mirror, mirror, on the wall…" Correct!

Mats' challenge continues, taking him all round Werdringen castle and its moat, going from hat to hat. As soon as one question is answered correctly, the next hat appears on the satellite map. There are nine questions to answer, and three games for the children to complete by drawing copies of magic patterns or arranging puzzle pieces on the screen. Then the last hat appears. Mats taps it. The camera in his phone

One click is all it takes to start the game.
© *Jens Stubbe, Westfalenpost*



switches on automatically, and the hunt for the yellow orbs begins.

Children can use the Zwergenwelt app to hunt hats in other locations beyond Hagen, including the city of Bonn, the Rheinpark and green belt in Cologne, and Roßbach on the river Wied, a designated health resort. More locations are planned. The virtual open-air game is the result of collaboration between Christa Becker, an exhibition designer from Cologne, and researchers from the Fraunhofer Institute for Applied Information Technology FIT in Sankt Augustin.

Zwergenwelten is currently unique in more ways than one. While there are lots of gaming apps available, the majority are only played on the smartphone itself, without relating to the world around it. Geocaching, a kind of treasure hunt in which participants set out to find hidden notes or objects using GPS coordinates, may have become incredibly popular – but connecting up an entire gaming world with an exhibition and linking it to reality has never been done before.

The design of the Zwergenwelten app is so simple and unfussy that the complex technology behind it is barely noticeable. Certain coordinates within the application have questions assigned to them that the game is able to automatically retrieve from a remote data server. The system compares the current position of the cell phone against the saved coordinates, and activates a question as soon as the player reaches a certain location and taps the hat. In order for this geographical referencing process to work, coordinates must first be defined and linked to information, a puzzle game, or a question and answer.

But setting up this kind of link in particular is usually very tedious, as the links have to be specially created for each separate location. Nowadays, any smartphone featuring a GPS receiver is able to determine its own geographical position. But preparing the content that is then based around this takes a lot of work. App programmers normally use a separate program to write the accompanying texts, and treat any images that are to be linked to the GPS coordinates as separate data sets. Assembling everything into an app takes an incredibly long time, since a relationship between all the different objects has to be established from the outset and the software programmed in such a way that everything fits together. This is usually done by hand.

"There has to be another way," Dr. Leif Oppermann and his team of FIT researchers thought to themselves. This thinking spurred them to develop a software app that directly incorporates data captured in situ with the relevant

Zwergenwelten nominated for an eco Internet Award

The TOTEM software package and the Zwergenwelten app were nominated for a 2013 eco Internet Award in the Mobile category. eco, the Association of the German Internet Industry, has been awarding prizes for over ten years to recognize companies who help shape the internet by creating innovative technologies or offering impeccable service to their customers.

The nomination honors the practical value of the TOTEM authoring tools, which allow non-programmers to create mobile apps. Fraunhofer FIT markets the software under license. The jury also praised the novelty of connecting a special gaming app with a real-world exhibition.

The game has an interface that is easy to use. © *Fraunhofer FIT*

coordinates at the same time. They created the software together with French scientists as part of the Programme Inter Carnot Fraunhofer (PICF), a collaboration between the Fraunhofer-Gesellschaft and the French Carnot institutes that also involved standardization experts from the Carnot Institute Télécom SudParis in Evry. The FIT team's initial step was to develop new work processes for simple games programming, and to design the programming tools these processes require. Among other things, their work enables cell phone data such as sounds, images or GPS coordinates captured outdoors during the game's design phase to be seamlessly linked to the programming software, depending on which information is to be called up in situ later in the game. The French colleagues were responsible for testing ways of converting the FIT software to match industry standards in order to make it suitable for commercial application. These include the modern MPEG standards 4, 7 and 21, for instance. "TOTEM" is the name the scientists have given their French-German app software; it stands for "Theories and Tools for Distributed Authoring of Mobile Mixed Reality Games".

TOTEM has two components: TOTEM.Scout, for capturing data outdoors, and TOTEM.designer, which enables the data to be processed back in the office. Collecting data is incredibly simple. Users begin by installing TOTEM.Scout onto a smartphone or tablet PC. The software serves as a mobile input mask, recording geographical coordinates automatically at the touch of a button. It does so using GPS signals and, when inside buildings, WLAN antennas or near field communication (NFC) of the sort already used for cashless mobile payments. In addition, the input mask provides the user with text fields that can be filled with associated questions or text in situ. Images taken while the user is moving around setting up the game are automatically assigned to the right locations, for instance photos of statues that are to appear on the cell phone later and that are to be shown at the very location where they were taken. "All the data is then transferred directly via wireless link to TOTEM.designer, which is then used to pull all the geographical points and associated data together and edit them to make the game," Opperman explains. This new process makes the tedious copying of images, texts and GPS coordinates back and forth, the time-consuming analysis and the manual linking process all things of the past. It eases the workload for experienced programmers, too, as the structured data makes it very straightforward for them to continue working on it using standard internet formats.

Christa Becker has since become fully TOTEM-proficient, even though she has no programming experience. She opens a browser window on the computer screen in her office showing a map of the Rheinpark in Cologne. Small circles mark the spots where the children see little red pointy hats on their smartphones and get asked questions. Becker scrolls further down the screen. A table appears, with entries for "Fairy a" to "Fairy g" and "Dwarf a" to "Dwarf g". "This is where I enter the questions that go with the spots on the map," she says, adding that the system is easy to use.

"Most app games available today are programmed and filled with content by a single person or a small team," Opperman explains. Designing a game always required expert knowledge in the past. "TOTEM, however, breaks away from this rigid approach and divides the workload into three parts to be carried out by three distinct types of person: game designers, who work out the idea for the game; programmers, who build the app; and authors like Ms. Becker, who input the entire contents themselves." This means that, in future, new content can be integrated into TOTEM games by people who have no prior software knowledge whatsoever. Even an inexperienced person can extend and design a game. And the special thing about TOTEM software is that it is flexible enough to be used to create a host of other games and applications, too.

As far as Leif Oppermann is concerned, TOTEM has applications that go far beyond Zwergenwelten. One conceivable use, for instance, is as a digital tour guide for historic buildings and monuments, whereby the software could be used in situ to call up detailed information on the architecture or nearby monuments. Another idea is to use it to create digital guides for movie aficionados to lead fans to the locations where movies and TV series were filmed.

But from a child's point of view, it is games like Zwergenwelten that are the most exciting. Mats enjoyed hunting the virtual hats and orbs, but he is even more thrilled by the tangible goods he receives at the end: he is given a little dwarf-themed goody bag as a reward, containing a few stickers and a small plastic dwarf. "Look!" he says, beaming with joy. Zwergenwelten is not just for seven-year-olds, however. The game is also aimed at children up to 14 years of age, and contains several levels of difficulty designed to appeal to older children and teenagers. In Christa Becker's experience, the older children generally seem to have most fun discussing which might be the correct answers. Who is best at recalling the fairy tales and fantasy characters from their childhood days? "A comment made by one of the mothers perfectly captures the value of games like this," Becker adds, going on to quote the parent: "They play with computers and smartphones anyway. At least this way they're doing it outside!" ■

A safe success

Harmless letter, or a bomb? A new analytical device locates hidden explosives and drugs.

Text: Monika Weiner

"At first, none of us knew what we had gotten into – but that is exactly what made the matter so captivating," recalls Dr. Joachim Jonuscheit. Seven years ago, the researcher from the Fraunhofer Institute for Physical Measurement Techniques IPM in Kaiserslautern, Germany, drove to Kassel for the first time in order to meet Thorsten Sprenger there. Sprenger is head of R&D at Hübner GmbH, a company that traditionally has produced vehicle components for buses and streetcars, as well as local and long-haul trains. "In addition to this core area of our business, we wanted to build another pillar for the company in the security sector," recalls the engineer. "We examined the market thoroughly and eventually came across the terahertz engineering that the IPM is working on." A few months later, Jonuscheit and Sprenger sat down together for the first time.

In the meantime, Hübner has launched the terahertz spectrometer T-COGNITION in the market. The device can quickly and reliably identify explosives and drugs in mail. Envelopes can be inserted into the instrument through a door and are then exposed to terahertz waves in the interior. Detectors capture the reflected and transmitted waves and compare the spectra with those in a database. In a few seconds, measurement indicators on the display screen of the device glow red or green, depending on whether hazardous material was discovered or not. Employing terahertz technology in this application has several advantages. Terahertz waves, which lie in the electromagnetic spectrum between the infrared and microwave regions, are non-hazardous, they penetrate packing materials and, depending on the substance they encounter, create characteristic spectra that can be rapidly analyzed with the help of intelligent software.

The antennas in the interior of the apparatus were jointly developed by researchers at the IPM and the Carnot Institute IEMN (Institut d'Electronique, Microélectronique et de Nanotechnologies) in Lille, France, while the software for recording the signature was developed at the IPM. Both components are results of the EU project ARTEMIS (the abbreviation for Antenna aRrays for TErahertz Material Identification and Security applications). Here the researchers miniaturized the system and adapted it for broader application. "For detection, you need high-performance antennas that are reliable yet economical, and are able to generate and receive wavelengths in the terahertz region," explains Jonuscheit. The systems consist of small units that are mounted directly on a gallium-arsenide substrate that can then be combined into large arrays. The electronics for the system – which were external for the first prototype – are no larger than a shoebox now and are integrated into the scanner. The electronics were significantly simplified, which also reduced the price of the entire system. At the same time, it has also been possible to increase the speed of the data analysis.

"The new detector system is more capable, faster, smaller, and simpler to operate than previous systems," explains Sprenger. The technology has already been greeted with great interest by penal institutions wishing to make sure that letters to inmates do not conceal drugs hidden in envelopes. Embassies and government offices concerned about incoming mail containing explosives can also benefit in the future from the joint research between Hübner and the IPM.

Jonuscheit still drives regularly to Kassel, though today he knows what is in store for him: he is developing the technology further together with engineers at Hübner and providing customer support for marketing. Jonuscheit and Sprenger visit customers together and present T-COGNITION at exhibitions and congresses. They both agree: what seemed like a big adventure with an uncertain future in the beginning has become a fruitful partnership. ■

Non-hazardous and effective

Terahertz waves are part of the electromagnetic spectrum. They penetrate all packaging materials without any problem. The frequency lies between the infrared and microwave regions. The terahertz waves created in the T-COGNITION device are many times smaller than the natural radiation emitted by the human body itself.

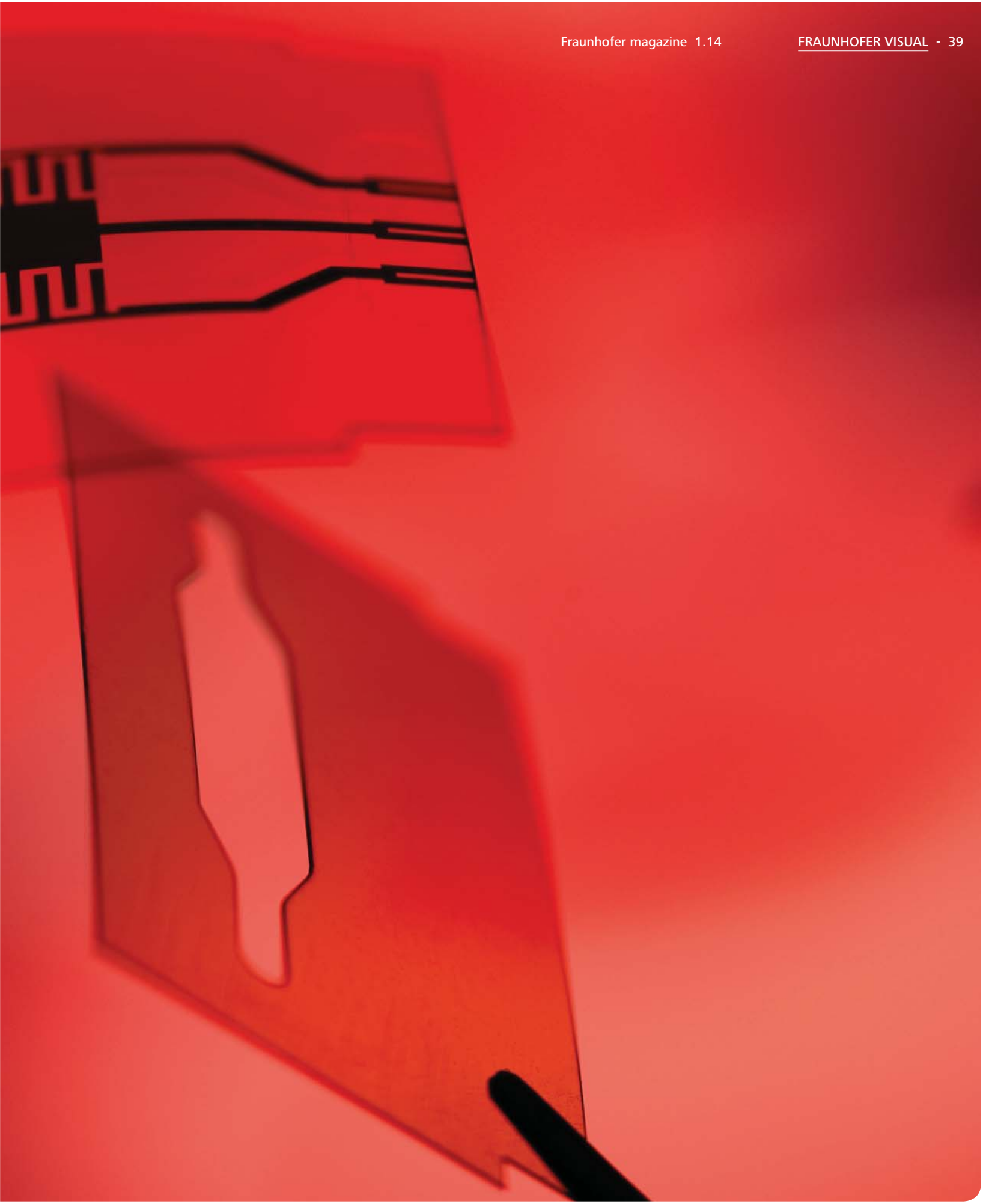
Measurements from "T-COGNITION 2.0" are initially presented on the monitor as red or green dots (detected / not detected). If detected, the substance identified can be displayed by mousing over it. © *Hübner GmbH*

Fraunhofer visual

Pocket-sized laboratory

For diagnostic systems such as the lab-on-a-chip to be disposable, manufacturing them in large numbers must be economical. In the PolyOpto project, Fraunhofer researchers developed a multifunctional analysis system that makes use of polytronics to incorporate electrical, optical and fluidic functionalities on a plastic foil. These systems can be printed cheaply and easily using roll-to-roll production techniques.

Photo: Bernd MÜller/Fraunhofer EMFT



Mobile task force deployed in the brain

Scientists are working to change the course of brain disorders. They plan to take ordinary skin cells and turn them into neural stem cells, which can then be matured as needed to produce brain and nerve cells.

Text: Monika Offenberger

Stem cells are a little like people: when they are young, they live in a world of possibility. They inevitably end up finding a particular specialty, choosing to pursue only little of the potential open to them and neglecting some talents in favor of developing others. Just as young people decide on a career, perhaps by choosing a certain kind of training or study, stem cells mature into specific cell types. Once each has found its calling, whether that be working in a kidney or the liver, heart or brain, it has become a specialist. It is now completely devoted to the highly complex organ it has chosen to serve.

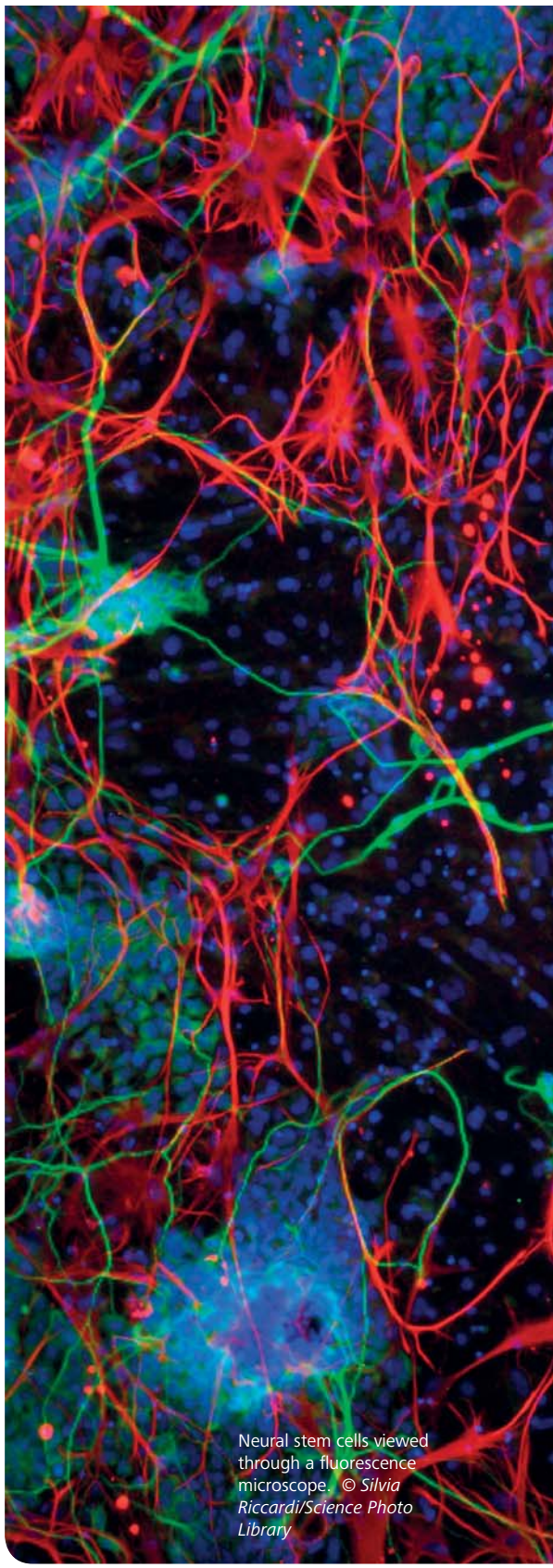
An exception exists in the form of a particular group of stem cells that, despite having chosen a particular direction, appear to give up half way and remain in an immature, progenitor stage. One place to find such progenitor cells is in the human brain, where they are known as neural stem cells. Dr. Daniel-Christoph Wagner and his team from the Fraunhofer Institute for Cell Therapy and Immunology IZI in Leipzig are examining just what role such cells play. Their research also aims to discover whether the cells could have therapeutic applications, such as treating brain damage inflicted by a stroke.

The very existence of neural stem cells in adult brains and their potential to mature into new brain and nerve cells was discovered only a few years ago. "For hundreds of years, we stuck to the dogma that our brains contain no such thing. But we've since discovered two areas of the brain that are indeed home to such progenitor cells.

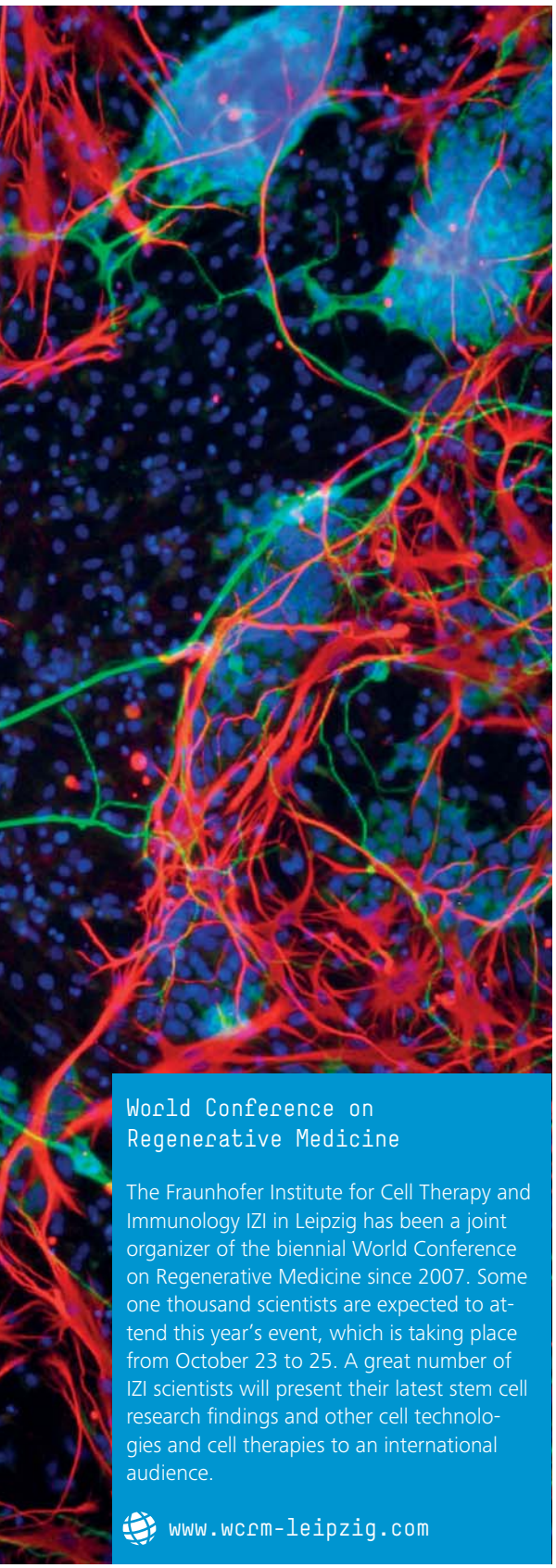
Over the course of our lives – even at a ripe old age – these cells continue to transform into neurons or other cells that make up our central nervous system," explains Wagner.These changing cells can also change the course of brain disorders. This was observed in 2005 by a team from the University of Milan studying mice suffering from a chronic form of brain inflammation similar to multiple sclerosis (MS). After transplanting neural stem cells into the subjects' brains, the scientists were able to establish a marked decline in inflammation. "The obvious assumption was that neural stem cells replace damaged or necrotic brain tissue," says Wagner. However, further investigation by the Italian scientists showed that this is not the case: what these cells in fact tend to do is migrate to inflamed blood vessels, take position along the vessels' outer walls, and act upon the inflammation process from there – all the while remaining in their progenitor cell state.

The studies generated yet another insight: to help track down the site of inflammation in the brain, neural stem cells are programmed to be attracted to the same messenger substances, or semiochemicals, as cells belonging to the body's immune system. Both groups of cells will invariably head toward where the concentration of semiochemicals is at its peak, with this steepening chemical gradient providing the quickest way for the cells to reach their target. "When someone has a stroke, the brain releases semiochemicals that are similar to those released during an MS attack, initiating similar inflammatory processes. This leads us to assume that we can also deploy neural stem cells as part of therapeutic interventions designed to positively influence the immunological effects of a stroke," says Wagner.

Provided it is not triggered by infection, an inflammation in the brain is not necessarily harmful. But the way each of us responds to inflam-



Neural stem cells viewed through a fluorescence microscope. *© Silvia Riccardi/Science Photo Library*



mation is more complicated than it might seem: the body's innate immune system unleashes a cascade of cells to eliminate any necrotic tissue and to kick off regenerative processes. This results in a vast array of interactions between immune cells and brain tissue. Some of these interactions have positive and some negative effects on the damaged area of the brain.

"An inflammation of this kind will play out differently depending on each individual's immune status. This means that in order to develop the concepts for new therapies, we have to understand the exact sequences involved," Wagner points out. The model organisms for his studies are mice that are killed after suffering an artificially induced stroke. All the major elements of the endogenous immune system – in particular the lymph nodes, bone marrow, blood and spleen – are then examined in detail in order to track the natural immune reaction following brain damage.

Alongside this research, the IZI scientists hope to shed light on the role of neural stem cells. "This naturally raises the question of where we source the cells, first for our studies and later for any therapies we develop," says Wagner. The obvious sources were ruled out from the very beginning: the two areas of the brain that produce neural stem cells throughout our life are accessible only by way of risky surgical procedures. One alternative would be to use pluripotent stem cells, which retain extensive developmental capacity and can be cultivated in the lab to become neural stem cells. But this would mean obtaining cells from aborted fetuses, which is against the law in Germany. Another option would be to extract neural stem cells from fetal brain tissue – which is allowed, but which raises ethical questions.

The IZI scientists are not using any of these sources. "We set out to transform ordinary skin cells into neural stem cells," explains Wagner's colleague Alexander Deten. The groundwork for this had already been laid by John Gurdon and Shinya Yamanaka, which won last year's Nobel Prize in Physiology or Medicine. Using just four different biomolecules, Gurdon and Yamanaka were able to stimulate skin cells to regress, as it were, back into their original unspecialized states.

Such "induced pluripotent stem cells" – or iPS for short – can mature into neural stem cells provided suitable biomolecules are used as stimulants. Deten was able to achieve this two-part transformation from skin cells back to iPS and then into neural stem cells. His next task was to find a way to bypass the iPS stage and create a recipe for direct transformation that would save both time and money. What is more, this would avoid the known risk that some iPS turn into cancer cells – a persuasive argument when considering future therapeutic applications.

From skin cells to stem cells

Whether specialized skin cells would even be able to make such a direct journey was the subject of fierce contention among molecular biologists and cell biologists. "Although a definitive answer continued to elude us, I was sure one was just around the corner," says Deten. He identified five biomolecules that together are capable of reactivating any gene program abandoned by the cell during its development. But this was not enough for Deten: "You can have the best reactivating factors possible, but that won't mean anything if you can't get them to the parts of the genome where they can have the desired effect. This is why we set about designing the culture conditions so that we would end up with programmable cells."

After two years of hard work, Deten is now in a position to report success: "We have been able to transform skin cells directly into neural stem cells." However, he is hesitant to talk of breakthroughs before each individual stage of genetic reprogramming has been subjected to thorough quality assurance tests. As Deten puts it: "Only when something looks like a duck and quacks like a duck can we say that it really is a duck." Should Deten's method of producing neural stem cells prove practicable, he will have succeeded in tapping an inexhaustible and ethically unobjectionable source of these much sought-after cells. This would make it easier to research the potential of neural stem cells and whether they could offer medical benefits.

And IZI scientists are by no means running out of questions: "What is the natural role of these cells in the brain? Which semiochemicals do they use to intervene in the body's immune response? How do they influence an inflammatory response? Finding answers to these questions would enable us to use these cells or their products to develop new pharmaceutical and therapeutic concepts." ■

World Conference on Regenerative Medicine

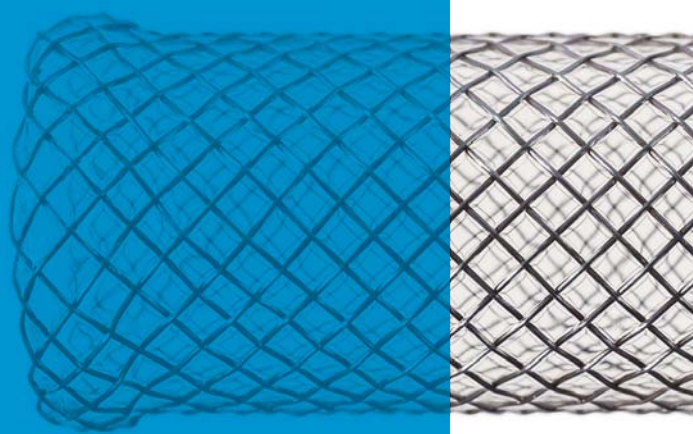
The Fraunhofer Institute for Cell Therapy and Immunology IZI in Leipzig has been a joint organizer of the biennial World Conference on Regenerative Medicine since 2007. Some one thousand scientists are expected to attend this year's event, which is taking place from October 23 to 25. A great number of IZI scientists will present their latest stem cell research findings and other cell technologies and cell therapies to an international audience.

www.wcrm-leipzig.com

Non-slip tracheal implants

If a person's windpipe is constricted, surgeons insert a stent to enlarge it. But the implant can slip out of position and, at worst, close off the windpipe altogether. Researchers are working on a special surface coating for the stents to keep them in place.

Text: Britta Widmann



Little Lisa had to be rushed to hospital in a serious condition; the cartilaginous tissue in her windpipe had softened, constricting her airway and putting her at risk of asphyxiation. An emergency operation was her only hope. Inserting a small latticed tube to reopen her airway and keep it clear meant she was quickly out of danger and able to breathe again on her own.

This technique is modeled on the stents used in cardiology, whereby small mesh-like implants are inserted into constricted coronary blood vessels to widen them, in order to prevent a heart attack. The small, meshed tubes – referred to as stents – stabilize the arteries, improve the flow of blood and prevent vascular obliteration (in medical terms: filling up of a space with fibrous tissue or through inflammation). A lesser known fact is that stents can also be used to treat pathological constriction of the windpipe. This kind of respiratory stenosis, which may be caused by tumors, chronic infections, congenital deformities or softening of the cartilaginous tissue, as in Lisa's case, can be life-threatening. The metal or plastic stents are designed to enlarge the trachea and prevent it from closing up altogether.

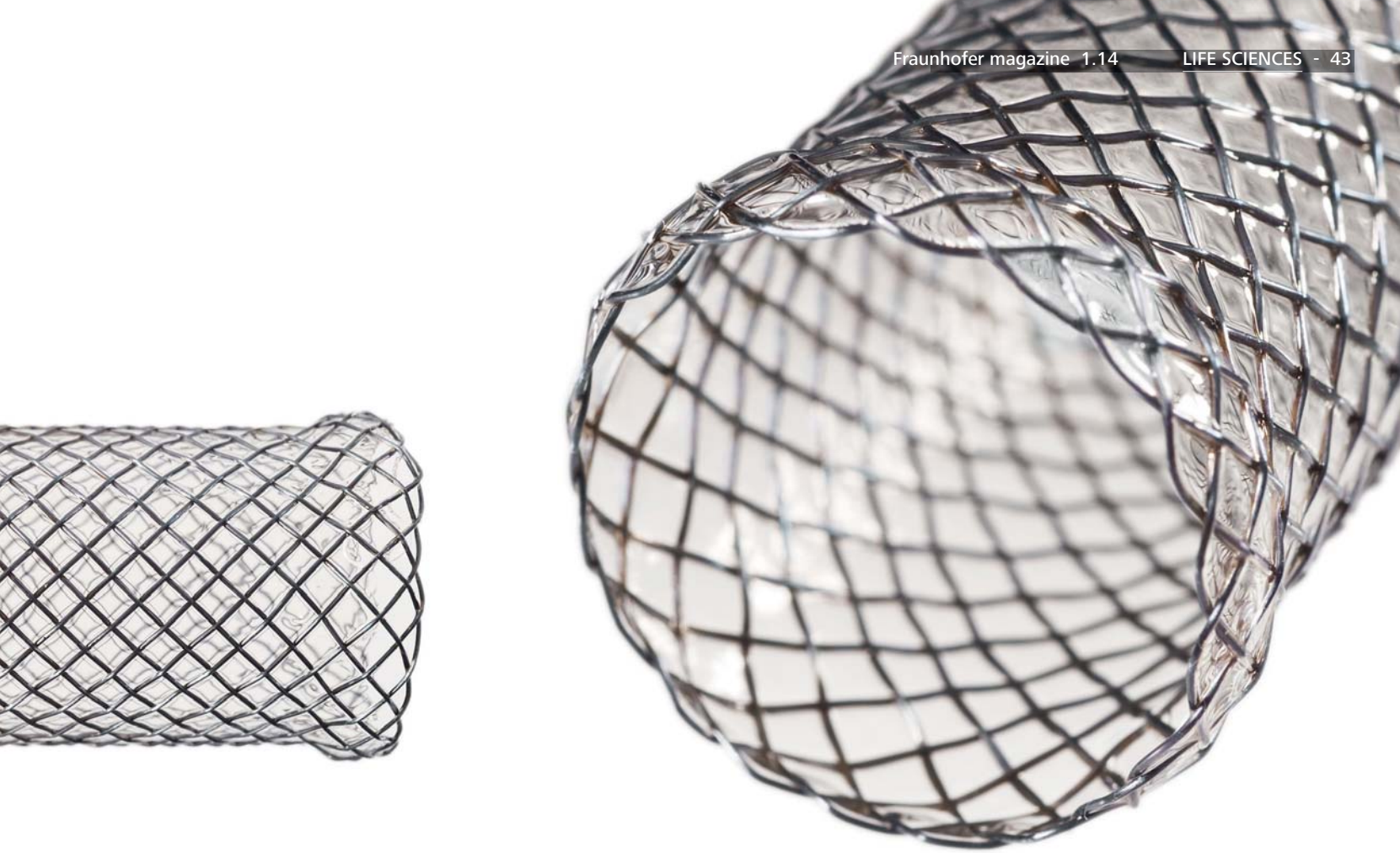
Complicated operation

But complications can arise when the implants are inserted. Firstly, there is the danger that the stents will shift and partially or completely obstruct the respiratory tract. Secondly, bacteria can colonize the stents; certain strains are known to cause bad breath, for example. Other strands of bacteria are pathogenic, and can trigger illnesses such as pneumonia. Stents have no barrier-forming cells of the kind usually present in the respiratory system, whose task is to fend off bacteria and inhaled substances such as fine dust particles.

"The windpipe has an important barrier function, with goblet and cilia cells purifying the inhaled air. That's why it's very important that cells like these can be made to adhere to the stents, in order to maintain the air-purifying effect of the damaged section of the windpipe and simultaneously promote the incorporation of the stents into the surrounding tracheal tissue," says Dr. Maria Steinke, a scientist at the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB in Stuttgart. Together with Prof. Dr. Thorsten Walles, head of the department of thoracic surgery at the University Hospital of Würzburg and a visiting scientist at the IGB, Dr. Steinke and her team took part in the "REGiNA" project. It aims to develop surface coatings that enable the stents to be incorporated in the surrounding tissue, thus reducing the risk that they will move. REGiNA, a German acronym for Regenerative Medicine in the Neckar-Alb and Stuttgart Region, is funded by the German Federal Ministry of Education and Research BMBF (see box).

Bioactive coatings reduce patients' risk of infection

The scientists used stents lined with a polyurethane (PU) film, produced by Aachen-based Leufen Medical GmbH. In the ensuing tests, a wide variety of different coatings were applied



A new protein coating has been developed to ensure that respiratory stents are able to attach themselves better to the surrounding tracheal tissue, and to reduce the danger of infection for the patient.
© Leufen Medical GmbH

to the PU film: in addition to synthetic polymers composed of organic acids, the researchers also tried out biological proteins such as fibronectin and type-1 collagen. The coating was modified again using plasma technology, with vacuum-ionized gas being used to treat the surface.

The experts used an untreated PU film for control purposes. "In order to find out which of the surface coatings was the most suitable, we brought both lab-cultivated cell lines and human primary tracheal epithelial cells into contact with the films in cell culture vessels. What we wanted, of course, was for the primary respiratory cells from human tissue to attach themselves to the film," explains Steinke.

The researchers achieved their best results with the protein-coated film, on which the primary tracheal epithelial cells grew particularly well and multiplied. "The respiratory cells proved to be more vital on bioactive films than on ones treated with plasma. By contrast, polymer-coated film turned out to be completely useless," says Steinke.

The laboratory tests have since been completed, and animal tests are now in preparation. If the good lab results are confirmed in these tests, the next step will be to conduct clinical trials of the modified stents at the Schillerhöhe specialist lung clinic, part of the Robert Bosch Hospital. "We hope that, within just a few years, our well-tolerated, cell-compatible surface coatings will be used for other biomedical prostheses such as pacemaker leads, tooth implants and replacement joints," says Steinke. ■

What is REGiNA?

The REGiNA project supports regenerative medicine, one of the most promising fields of medicine in the years ahead. The aim is to regenerate damaged cells, tissues or organs, either through substitution with biological material or by encouraging the healing process. Rather than using standardized medicines, therapies and products are specifically developed and produced for this purpose.

The project combines the knowledge and experience of 30 partners from institutes, clinics and industry, who together form a regional center dedicated to such applications between the Neckar-Alb and Stuttgart. Doctors, industry partners and scientists share their specialist expertise by working together to develop completely new therapies for wounds, bone defects and intervertebral disk defects or vascular obliteration, for example. Latest treatment methods and medical devices are to be introduced into general patient care for four key areas that have been selected, these being the musculoskeletal system, skin and wounds, the genito-urinary system and the heart, circulation and respiratory system. The partners are also examining the cost-effectiveness of these new processes, in close collaboration with health insurance companies.

The ‘forever young’ tobacco plant

Tobacco plants bloom when they are just a few months old - and then they die. Now, researchers have located a genetic switch that can keep the plants young for years and allows them to grow ‘forever’. In short, an ideal source of biomass.

Text: Janine von Ackeren

The life of tobacco plants is short. They grow for around three to four months, bloom and then die. Their size is also limited, with plants only growing to about one-and-a-half to two meters tall. Now, researchers at the Fraunhofer Institute for Molecular Biology and Applied Ecology IME in Münster and the University of Münster have located the tobacco plant’s very own fountain of youth. The Münster-based researchers discovered a genetic switch which can prevent the plants from blooming. This also averts the plants’ early demise – and suppresses the factor that halts growth.

“The first of our tobacco plants is now almost eight years old but it still just keeps on growing and growing,” says Professor Dirk Prüfer, head of the Department of Functional and Applied Genomics at the IME. “Although we regularly prune it back, it’s six-and-a-half meters tall. If our greenhouse were a bit larger, it would probably be even bigger. Its stem is already ten centimeters in circumference – the equivalent of quite a chunky Cohiba.” And this is not the only factor to set the plant apart from its fellows: whereas in normal tobacco plants the leaves, which grow from the bottom of the stem, soon turn yellow and drop off, the IME plant’s leaves stay healthy and green. This is why the scientists have christened the modified species ‘forever young’.

But what exactly do researchers do to give the plants eternal youth and make them capable of unbounded growth? “We modify the expression of a certain gene so that the plant’s flowering is deregulated,” explains Prüfer. Researchers then insert the modified gene back into the plant using a bacterium. The role of the bacterium is to act as a sort of shuttle service for the modified gene.

The principle is transferable and could be used on other species; at the moment, the scientists are working on potato plants on behalf of a Japanese chemical company and have been able to attract funding amounting to some 700,000 euros. The researchers use their knowledge and the appropriate technique to get crops to yield a far greater amount of biomass. In the case of potatoes, this means a great deal more starch. “If we want to guarantee security of supply for foodstuffs and plant-based raw materials, the yield per hectare will have to double by 2050, claims the German Bioeconomy Council. This new technology brings us a great deal nearer to that target,” reckons Prüfer. “However, our method is likely to deliver success only as long as the flowers of the plant in question play no significant role – potatoes or sugar beet, for instance. It would make no sense to use the technique on rapeseed.”

Other kinds of plants also capable of unbounded growth

There is also another curious feature to these modified plants – flowers emerge when the hours of daylight are few, as on a typical

Dirk Prüfer in the greenhouse with colleagues Gundula Noll (right) and Lena Harig (left) along with their tobacco plants.
© Fraunhofer IME

winter's day when there are eight hours of daylight and 16 hours of darkness. In the laboratory, researchers can purposefully trigger the plants to flower by recreating these short days in the greenhouse. This yields seeds that the researchers can use to propagate plants in a controlled manner.

The researchers are yet to discover the full secret to the eternal youth of the tobacco plant. Why does it flower only when the hours of daylight are few, given that most other plants flower when there is an abundance of sunlight? The researchers' investigations have led them to another possible way to prevent tobacco plants from flowering. "We have discovered the tobacco plant's central regulator – that is to say, the gene responsible in a variety of plants for triggering the growth of flowers. This gene is known as Flowering Locus T, or FT for short," says Dr. Lena Harig, scientist at the IME. "It is interesting to note that there are in fact two of these FTs, one that triggers the growth of flowers and another that prevents flowering and so controls the growth of the plant." When the researchers induce tobacco plants to produce a particularly large amount of this inhibiting FT, the plants grow just as tall as their 'forever young' cousins. The only – and crucial – difference is that FT variants no longer flower when the days are short.

But how do you propagate such a tobacco plant? Till now, scientists have been cutting off individual branches, cultivating them in a culture medium, and waiting until they have developed roots. However, the experts are already at work on a more elegant solution. "We would like to combine the 'forever young' and FT varieties of tobacco plant," reveals Dr. Gundula Noll, project leader at the University of Münster. "Then we could obtain seeds by controlling the flowering of the FT tobacco plants."

More specifically the researchers would like to take the flowering switch from the 'forever young' plant and introduce it into the FT plant. "We hope that we will be able to regulate this trigger not only by light exposure but also perhaps by applying a chemical substance. That way we could make the FT plant flower when we want it to produce seeds in the greenhouse, while making sure that plants in the field cannot produce flowers," says Noll. This would stop any unplanned propagation of the modified plants.

In the future, the researchers want to go further and disable growth limits using chemical mutagenesis as well – that is to say, using normal growing techniques. The advantage is that a plant grown in this way would no longer be genetically modified. "But in order to be able to do that, we first need to gain a better understanding of the deregulation of genes," says Prüfer. ■

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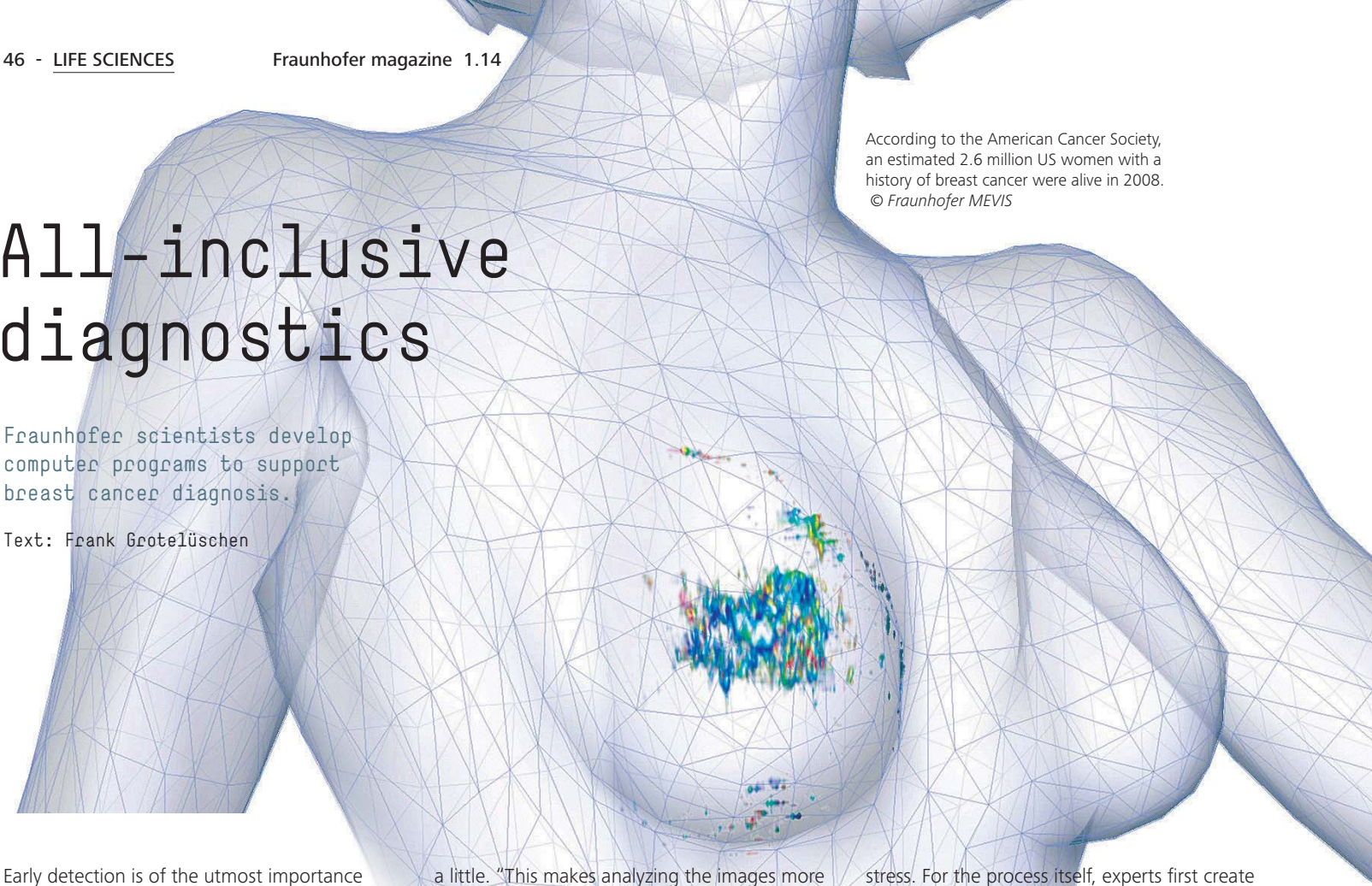

According to the American Cancer Society, an estimated 2.6 million US women with a history of breast cancer were alive in 2008.
© *Fraunhofer MEVIS*

All-inclusive diagnostics

Fraunhofer scientists develop computer programs to support breast cancer diagnosis.

Text: Frank Grotelüschen

Early detection is of the utmost importance when it comes to treating cancer. The sooner a tumor is detected, the higher the chance of recovery. There are a wide variety of diagnostic procedures used to identify, for example, breast cancer in its earliest stages. In mammography, the breast tissue is X-rayed, while magnetic resonance imaging (MRI) produces images from strong magnetic fields, and ultrasound imaging from echos of sound waves. Doctors decide on the treatment based on a biopsy, where a tissue sample is taken with a fine needle. The Fraunhofer Institute for Medical Image Computing MEVIS in Bremen develops software systems that improve the speed and precision with which physicians can evaluate the resulting images.

Cleverer computing, clearer image

Take a breast MRI examination, for instance. Patients are given a contrast medium that accumulates in the tumor tissue. By comparing images taken before and after the medium is administered, doctors are able to recognize even very small abnormalities or tumors. But one of the drawbacks of this procedure is that it can take up to 15 minutes to carry out, during which time this timespan the patient must lie perfectly still in the MRI scanner. Only a few can manage that for so long – most people move a little. "This makes analyzing the images more difficult," says Prof. Dr. Horst Hahn, director of MEVIS. "Any movement results in a shift in the pictures captured before and after the contrast medium is administered, which distorts the results."

Fraunhofer researchers in Bremen are developing a computer process able to correct this deformation and thus cancel out this interference. In principle what the software does is recalculate the images and shift them back to their original position as though nothing had moved. To demonstrate how it works, MEVIS scientist Markus Harz points to a laptop. On the screen are two MR images of a female breast, one with, one without the corrective algorithm. "In the uncorrected images, the edge of the skin stands out," Harz explains. "It is thicker and brighter in color than it should be because the patient moved during the scan."

Of greater concern to doctors is that movement has made some patches in the tissue appear brighter, which can lead to diagnostic misinterpretations. Correcting the deformation limits this source of error: in the corrected image, the edge of the skin appears narrower, and the patches in the tissue are now noticeably darker. Behind it all lies a sophisticated algorithm based on theoretical elasticity equations, which describe how a material is deformed under stress. For the process itself, experts first create a three-dimensional computer model of the tissue they wish to examine, which they then subdivide into lots of small boxes. The computer simultaneously works out how much each of the little boxes has moved during the scan, and uses this data to calculate any deformations in the total image. The outcome displayed on the screen is a corrected image that looks as though the patient had never moved.

The software has been in use in clinics and doctors' surgeries for several years. In their latest development the researchers make it possible to correct images from scans that were carried out months apart, rather than just minutes. Fabian Zöhrer, one of the experts at MEVIS, shows two breast MR images of the same patient, one taken a year after the other. The pictures are clearly incongruent. "Evidently the woman was placed in a different position during the older scan than she was during the more recent one," Zöhrer says. "It's also possible that her weight changed in the interim." Sometimes the differences are so great that it is difficult to locate a particular section from an older image in one taken more recently. This problem is also solved by the new software. Zöhrer uses his laptop to demonstrate, pointing at a bright patch in the tissue. "If I click on this spot in the older picture, the software immediately indicates the location

of the same spot in the newer one. The software has met with keen interest from radiologists," says Zöhrer. "We're currently negotiating with industrial partners to make the software commercially available."

Helping to solve difficult cases

Another project being developed is multimodal position correction or deformation correction. Increasingly, female patients are being examined using a set of different imaging technologies. The reason for this is explained by Kathy Schilling, Medical Director of Breast Imaging & Intervention at Boca Raton Regional Hospital in Florida, and one of the project's cooperation partners: "Mammography is often significantly less accurate in women with extremely dense breast tissue. In such cases it is expedient to carry out additional examinations, for instance using ultrasound or breast MRI."

While each of these methods provides a valuable piece of the overall picture, the problem is that the patient is placed in a different position for each examination – sometimes lying on her stomach, sometimes sitting up – and the position she is placed in can dramatically alter the location of a tumor or suspect area. This often makes it more difficult to compare the different images. Correcting the deformation effectively cancels out this particular drawback. "It enables us to automatically translate the position of a tumor from one dataset to another," explains MEVIS expert Joachim Georgii. "This makes it easier for radiologists to find their way around." The doctor marks a particular area of tissue on an ultrasound image on the computer. Depicted next to the ultrasound picture is a mammography image of the same patient. A small circle appears on the mammography – the same spot as in the ultrasound, automatically identified by the new MEVIS software. MEVIS experts are also working on another method that could one day prove even more important. They are developing a way to combine breast MRI and mammographies with the information pathologists derive from tissue samples to discern between benign and malignant cells. One basis for this is digital pathology, which is gradually making its way into clinics. Specialists no longer look at tissue samples under the microscope, but instead examine a digitized dataset on the computer screen. Fraunhofer researchers from MEVIS are working on ways to correlate this information with mammography and breast MR images for each patient as part of the VPH-PRISM project funded by the EU.

"As things stand, doctors still view these images separately. Mammography and breast MR images are shown on one monitor, pathological data on another," explains Horst Hahn. "Our aim is to integrate both datasets into one piece of software." Among the other benefits of such a computer program is that it can document where precisely tissue samples originate – an important step towards improving the correlation of information from radiology and pathology in support of treatment. "For instance, our system will help physicians evaluating a particular case to decide whether chemotherapy or radiation therapy is the more promising option," says Hahn. "Furthermore, it should indicate to surgeons which tissue they should remove and which they can ignore during an operation." This would bring them closer to their aim of ensuring that as much breast tissue as possible is conserved during surgical interventions. The researchers envision a system that brings together all information relevant to the therapy of a particular patient. "Our work would be significantly more efficient if we could see all the data on a single screen, from mammography, breast MRI and ultrasound images to information on relevant risk factors, through to microscopy images of tissue samples," explains Kathy Schilling. "This would be a fantastic help to us radiologists and is bound to increase the accuracy with which we are able to make our diagnoses." ■

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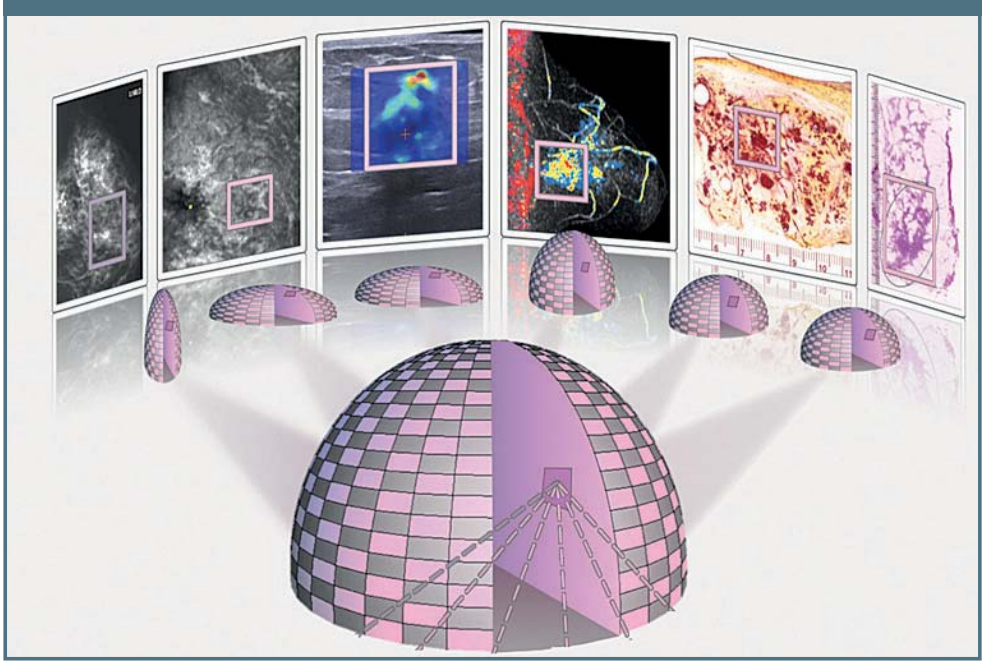
Breast cancer diagnosis and early detection methods

Schematic representation of a central undeformed breast model – the smaller illustrations show examples of an approximate breast compression of the respective images. The various deformations are synchronized with and translated onto the undeformed standard model, enabling all positions from all images to be shown on one single model. This process also enables the positions to be transferred between each of the individual pictures
© Fraunhofer MEVIS

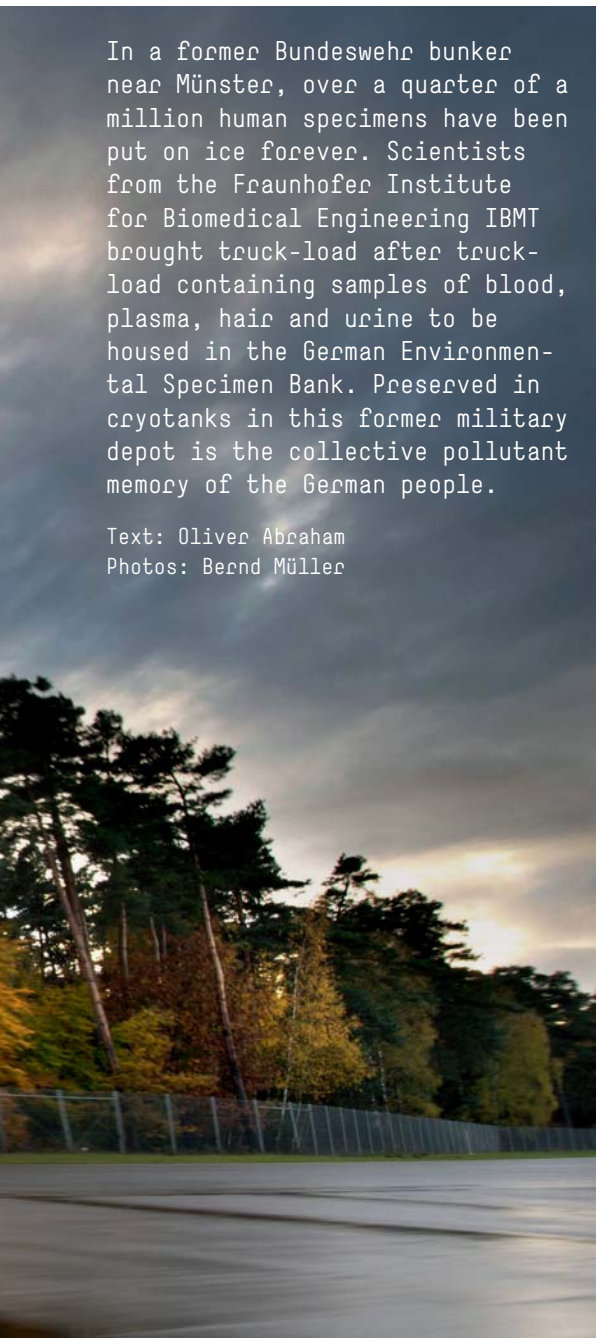
Images above from left to right:
1) Mammography – standard method used in screening and diagnosis.
2) Ultrasound (Automated Breast Volume Scanner ABVS, 3D) – good clarification of cysts and no radiation.
3) Ultrasound (plus elastography = color, 2D) – also evaluates tissue stiffness.
4) MRI with contrast medium (several images taken in sequence over a period of time, 3D) – used to clarify and to plan surgery, very sensitive.
5) 3D histology – tissue sample taken from the breast. Tissue classified as benign or malign.
6) Histology – tissue sample taken from the breast. Tissue classified as benign or malign.



Cold storage

The mobile epidemiological laboratory provides enough space to take blood samples directly adjacent to a laboratory and the units in which they are stored.

Samples are taken and stored under standardized conditions.



In a former Bundeswehr bunker near Münster, over a quarter of a million human specimens have been put on ice forever. Scientists from the Fraunhofer Institute for Biomedical Engineering IBMT brought truck-load after truck-load containing samples of blood, plasma, hair and urine to be housed in the German Environmental Specimen Bank. Preserved in cryotanks in this former military depot is the collective pollutant memory of the German people.

Text: Oliver Abraham
Photos: Bernd Müller

The German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety commissioned the country's Federal Environment Agency to manage the German Environmental Specimen Bank ESB. The German ESB is a national archive of suspended matter, animal specimens taken from rivers and lakes, sea creatures, plants and birds, as well as specimens of land animals and plants. This biobank is also a journey through time, chronicling the history of pollutants. Experts have been collecting samples of human body fluids and hair since the 1980s. The collection has now moved to its new home in the bunker facility near Münster, where the specimens enjoy excellent protection from external influences. IBMT scientists are in charge of collecting and archiving the human specimens stored here.

www.umweltprobenbank.de/en

"The new location is large enough to store specimens even more safely and to monitor them continuously at least until the year 2040. This bunker additionally facilitates further technical developments in cryotechnology," explains Dominik Lermen, the Fraunhofer scientist now leading the IBMT environmental specimen working group. This group joined the German ESB consortium in January 2012, when its scientists were commissioned by the UBA to manage the area of human samples.

Lermen has the keys to the former bunkers. Behind one of the bunkers' double steel doors is a 500-square-meter hall. In a former life this hall was used to store medical supplies and was built to withstand air raids. Now bathed in cold light and clinically clean, its walls are lined with silver freezer tanks and there is the constant low hum of electronics.

On his way in, Lermen had to go through security – just like the temperatures in the human specimen tanks, the site is monitored around the clock. Computers as tall as Lermen himself are working away in a side room, transmitting data to the technology center at the IBMT's branch lab near Münster. If any parameter falls outside of its permissible range or should anything at all malfunction, staff can be in the bunker within 20 minutes to remedy the situation.

But why all this fuss? "The German ESB is at the heart of the government's mission to monitor and document pollutants affecting people and the environment. The human sample section of the archive tells the story of what people have been exposed to," explains Lermen. Scientists and politicians have been aware that people and the environment must be protected from harmful substances since at least as far back as the 1970s – the Seveso disaster in 1976 came as a real shock: until then dioxin was not seen as posing any real risk.

So what was and is hiding in the average German? What routes do substances take? "In terms of monitoring and regulating chemicals, the importance and relevance of storing human specimens is growing," says Lermen. "This makes the German ESB an important and effective tool for identifying and evaluating potentially hazardous substances. In the past ten years, human biomonitoring data have made it possible to develop and refine laws designed to regulate harmful substances."

Does it also help to ban certain substances? "A look at the statistics shows how effective it has been to regulate heavy metals, certain pesticides and a great many plasticizers. We've seen that banning a substance leads to less harm to people and the environment," says Lermen. And the human sample bank does more than bolster this argument; it provides evidence, too. One of the best examples is lead: after Germany enacted a law to reduce air pollution caused by lead compounds in gasoline (Benzinbleigesetz), lead levels detected in its citizens also dropped.

The German ESB also allows scientists to check damage inflicted in days gone by. "Human samples are stored at deep frozen temperatures below minus 150 degrees Celsius. At such temperatures, biological, chemical and physical processes happen only extremely slowly, effectively reaching standstill. This means that the samples remain virtually unchanged in storage," says Lermen. Storage at these temperatures also means that the concentration of almost all substances remains practically unchanged over the years.

But the Fraunhofer scientists do more than manage the bank. "We are in charge of planning and organizing the annual collection of samples," says Lermen. The UBA commissions the IBMT's Environmental Specimen Bank ⊣⊢ Human Samples working group to collect samples of blood or urine from around 500 volunteers. "In addition to the actual sampling, our key duties are to collate the relevant data relating to the volunteers' living environment and to identify any potential exposure to harmful substances,

Liquid nitrogen is used to freeze the samples.

including whether donors smoke or live near an industrial area," explains Lermen. We conduct our sampling at four university towns: Münster, Halle(Saale), Ulm and Greifswald and we choose mainly students as volunteers. Their tendency to move around allows us the best possible coverage of the country, which in turn gives us an accurate picture of what the average German has been exposed to." People who are routinely exposed to harmful substances – painters, for instance – are not sampled.

A portion of each year's samples is immediately handed over to the University of Erlangen's polyclinic for environmental medicine, where they are examined for environmentally toxic properties. The scientists transport the rest of the samples under standardized cryogenic conditions to the ESB. Until this year, sampling was carried out at institutes belonging to the cooperating universities. Since January, however, a "mobile epidemiological lab" in the form of a 16-meter-long articulated trailer travels to the sampling locations. Lermen is thrilled about this mobile laboratory, which "constitutes a fully equipped medical analytical laboratory operating at biosafety level 2 while also providing sufficient space to carry out the medical examinations. And for the first time ever, we have identical sampling conditions in all four locations."

www.labor-der-zukunft.com

"Unlike the rooms we previously used for sampling, our mobile epiLab is equipped with the latest lab technology and as such fulfills the required quality criteria for sampling and on-site analysis," says Daniel Schmitt, manager of both the IBMT's Group on Lab Technologies and the "Laboratory of the Future" project that is funded by the Saarland state government. Once taken, the samples are stored in a cryotank located in the vehicle's rear. This tank can be brought directly to the ESB, thus avoiding the need for the samples to be unloaded. "In order to validate even the slightest environmental change, it is essential that the techniques we use to obtain, prepare and conserve samples do not vary," explains Lermen. This is why the scientists have automated the documentation and freezing processes under standardized conditions.

We are exposed to chemicals our entire lives and new substances are being discovered in our environment and in the human body all the time. Thanks to the Environmental Specimen Bank, we can now investigate which chemicals are involved and the concentrations in which they exist. ■

Life Cycle Assessment for aircraft

Contact: Dipl.-Ing Robert Ilg, robert.ilg@ibp.fraunhofer.de

By 2020 the European aerospace sector hopes not only to reduce its emissions of harmful pollutants – carbon dioxide by 50 percent and nitrogen oxide by 80 – but also to lessen the impact its aircraft have on the environment. Methodically itemizing the environmental impact of the components used is what experts call a Life Cycle Assessment (LCA). Gathering this data calls for powerful software.

Researchers from the Fraunhofer Institute for Building Physics IBP have joined forces with colleagues from the Fraunhofer Institute for Computer Graphics Research IGD and the University of Stuttgart to develop a computer program that allows you to factor in the environmental impact of aircraft components at the design stage, while still planning a new model. The Eco-Design Software Tool ENDAMI is based on an aerospace database that contains environmental data for a variety of aircraft components. For instance, one kilogram of aluminum sheet metal puts around 140 megajoules (MJ) in your "ecological backpack," incurred from extracting the bauxite, transporting it from overseas and processing it in Europe.

Users can also set up scenarios where they vary the components to get an immediate idea of the impact that various materials, design parameters, or processes have on the environmental assessment of each component.

The Airbus production facility in Hamburg. Now the Eco-Design Software Tool ENDAMI allows environmental impact to be assessed at the design stage. © *EADS*

Predicting landslides with accuracy

Contact: Dr. Oliver Krol, oliver.krol@iosb.fraunhofer.de

In hilly areas, waterlogged earth on hillsides can easily slip, burying cars and houses – and if the worst comes to the worst, even people. Now for the first time an early warning system couples geological data and regularly updated high-resolution weather forecasts, known as nowcasts. The system issues warnings to the emergency services when potential dangers are recognized.

Until now experts have used maps marked with danger areas to determine the probability of a specific slope succumbing to a landslide. The problem is that these maps cover only a specific point in time, and consequently do not take current weather conditions into account.

Authorities will soon be able to call on support from the ELDEWAS early warning system. It makes use of regularly updated weather data and forecasts, coupling these with regional information on elevation profiles, slope gradients and land use so the system can issue an early warning in case of danger. ELDEWAS stands for "Early Landslide Detection and Warning System" and is being developed by research scientists at the Fraunhofer Institute of Optronics, System Technologies and Image Exploitation IOSB in Karlsruhe. The system will undergo initial testing in the state of Burgenland in Austria, with Austria's national meteorological service ZAMG providing the latest weather data.

The sensor-fitted glove turns blue when there is a hazardous substance on the container. © *Fraunhofer EMFT*

Glove warns of danger

Contact: Dr. Sabine Trupp, sabine.trupp@emft.fraunhofer.de

Employees in chemical production, the semiconductor industry or in laboratories are frequently exposed to harmful substances. And many of those that are aggressive remain imperceptible to the human senses. This has led to a whole range of solutions designed to protect employees, ranging from highly sensitive measuring equipment to thermal imaging cameras. Researchers from the Fraunhofer Research Institution for Modular Solid State Technologies EMFT in Regensburg have now added to the range by engineering a glove that can detect toxic substances in the surrounding atmosphere and flag them up by changing color.

Researchers apply sensor-activated dyes to the garment using the customary dye and print processes, before setting the dyes in an immersion bath, for example. The biggest challenge is customizing the sensor dyes. The dye molecule must be made to detect a specific analyte, only then triggering a chemical reaction. Precautions must also be taken to ensure that the dye does not wash out. When it comes to the color the experts comply with the customer's wishes. There are also other potential areas of application. For instance, color indicator systems integrated in foils or bottle tops can help to visualize the condition of packaged food at any given time.

Clever clothing

Integrating electronics into clothing is no easy task. Soft materials and hard, fragile electronics need to be combined in such a way that clothes are not only comfortable to wear but also easy to care for.

Text: Helga Eisch-Hagenauer

Electronics in fabrics open up new applications.
© *Fraunhofer IZM*

The idea of adding electronic functions to clothing came about around ten years ago, and it was then that the first wearable technologies appeared on the market. But no such product has really managed to become established as yet. It's not for want of ideas as to clever functions. Rather, the problem is that electronic clothing needs to be suitable for everyday use if it is to succeed in the marketplace. Whenever a new item of smart clothing is presented to the public, the very first question is always: "Can you wash it?" So the answer really needs to be: "Yes, you can."

It is a real challenge to blend electronics with textiles in such a way that the very different materials involved adapt to each other's characteristics. The electronic components need to be just as hard-wearing as the cloth into which they are integrated, while the garment must still be comfortable to wear. Rigid bits of electronic gadgetry that rub against users' skin or give up the ghost at the first sign of rain will never catch on.

Stretchable circuits

There have been some big advances in making electronic clothing wearable. One problem that researchers had to overcome was how to attach the electronics to the fabric in a reliable, robust way. Whether it is better to use stretchable circuits or to weave or sew electrically conducting yarn into the fabric will depend on the intended application. Another important consideration besides the attachment technology is how to seal the delicate electronics to protect them against moisture or mechanical stresses.

At the Fraunhofer Institute for Reliability and Microintegration IZM in Berlin, sealed electronic components are put through around four weeks of laboratory stress testing, during which they are exposed to pressure, moisture and swings in temperature. Electronic textiles are tested by undergoing 40 to 60 wash cycles at various temperatures. "Astonishingly, the electronics aren't particularly affected by the water and detergent; it's more the mechanical stresses in the drum that do the damage," explains Dipl.-Phys. Christine Kallmayer, who leads the System on Flex working group at the IZM. Only once a piece of clothing has survived these tortures

The Sporty Supaheroe cycling jacket provides safety in the dark. © Elisabeth Grebe

can it be deemed fit for everyday use. Resolving these problems of hardware opens up a fascinating world of possibilities – and not just for fashion designers. Dresses, jackets, coats and T-shirts that feature sensors and LEDs are just a few examples of interactive clothes. Smart clothing is able to react to the wearer's movements or vital signs and offer assistance during sport or in medical applications.

One example is designer Wolfgang Langeder's Sporty Supaheroe cycling jacket, which features a set of LEDs that make up a display area on the front and the back. The IZM's System on Flex working group developed an electronic system that registers the wearer's movements and synchronizes the pattern of light given off by the LEDs with them. The faster the cyclist moves, the faster the sequence of flashes of white light to the front and red light to the rear.

The jacket's lighting display can also act as a decorative element. In "disco mode" the light sequence takes on a variety of colors, covering the entire display area at adjustable speeds. This is made possible by 64 RGB smart pixels that can produce all colors and can flow smoothly from one color to the next, with each individual pixel controlled via a 4-wire data bus. Another feature of the jacket is that it generates a light signal to alert the cyclist to an incoming call on their smartphone. Further development work will enable the Sporty Supaheroe to signal to other road users when the cyclist wishes to turn. It will even have mobile data connectivity so that text or images can be integrated into the display.

"The basis of the jacket's electronic system is a stretchable circuit on a flexible film substrate made of thermoplastic polyurethane that we developed here at the IZM," explains Dipl.-Ing. Philipp Foerster. Kitted out with sensors, copper conductors and LEDs, this circuit is laminated onto a fabric backing. Stretchability is a prerequisite for using electronic systems in clothing, as the wearer's movements would break a rigid circuit board in no time at all. Since the stretchable circuit can be produced using conventional circuit board manufacturing processes, there is nothing to stop it entering series production.

A key consideration was system safety and robustness. The circuit is impervious to moisture and mechanical stresses; all that needs to be done before washing is to remove the attached battery. There are a number of safety mechanisms in place to prevent short circuits. With its maximum operating voltage of 5 V, the system is safe to touch, while its design takes into account the effects of the fabric being charged with static electricity. The Sporty Supaheroe cycling jacket will be making its début in February 2013 with fashion label Utope at the ISPO Munich sports business trade show.

Smart fabrics for physio

Smart textiles can be expected to play a major role in health sector applications, for instance in movement analysis for physiotherapy exercises at home or in monitoring for at-risk patients. The Fraunhofer Institute for Integrated Circuits IIS in Erlangen has developed Fitnessbegleiter, a prototype assistant for patients or elderly people performing exercises at home. It consists of a jacket containing a network of accelerometers, which the user wears while exercising. The sensors detect the wearer's movements during the exercises, while a control module wirelessly transmits the measurement data to a receiver station for further analysis. The user then receives feedback on the performance of the exercises via a smartphone or a television. This scenario can be complemented by FitnessSHIRT. This special garment features electrically conducting areas of fabric with which to record an electrocardiogram (ECG). A stretchable monitor strap worn around the chest measures how the ribcage moves during breathing. The sensor signals are processed and analyzed by a detachable electronic unit; this might warn the user of over-exertion or help to focus on a particular breathing technique, or it can store the data for subsequent analysis.

There are many possible applications for electronics in fabrics, whether for continuous recording of performance in competitive sports, as special clothing with additional safety functions for firefighters and rescue crews, or as designer clothing with new features. Widespread uptake in the marketplace, however, will depend not just on these garments' value-added functions but above all on the manufacturing technology, as only if this is automated can wearable products be manufactured at affordable prices. The developments to date certainly look promising. ■

Smartphones can send digital keys by email thanks to the Key2Share app. © *Fraunhofer SIT/ istockphoto (m)*

How smartphones open doors

Initial solutions offering to turn your cellphone into a key have already reached the marketplace - but they have so far failed to find widespread acceptance. Now, researchers from Darmstadt have developed a particularly secure adaptation of the technology. The "Key2Share" app will even send electronic keys by email and allows you to limit how long they can be used.

Text: Tobias Steinhäußer

Key app

Three questions about the Key2Share app put to Professor Ahmad-Reza Sadeghi from Fraunhofer SIT.

What's ahead for Key2Share?

We are currently in discussions with companies considering whether they might like to offer the technology as an app – alongside conventional locking systems. The next step is to test Key2Share in cloud-based applications.

What other application scenarios do you foresee for your development?

In theory, any situation which calls for keys to be issued securely, remotely, and for limited time periods could be considered a potential area of application. Facility managers, estate agents, or security services immediately spring to mind.

Key2Share is particularly secure. What security tips would you give to us smartphone users?

One basic rule that anyone can follow is to have a close look at each app and its rating before downloading it. It's also helpful to use established app stores where possible. It's often enough just to do a little internet research to get an idea of the situation. Quick and easy downloads mean we are often too blasé in these matters. Of course, the ideal would be for us to use an extra innovative security technology such as BizzTrust. In most cases, the cost is far less than the potential damage inflicted by a hacked app.

Darmstadt, a few years from now: Professor Ahmad-Reza Sadeghi has a long day ahead of him. It begins early in the morning as he receives a delegation of researchers at the nearby Fraunhofer Institute for Secure Information Technology SIT. A meeting is followed by a tour of the laboratories. Then there is time for a quick lunch before picking up a hire car and heading off for a business meeting near Frankfurt. His hotel room has already been booked. All in all, quite a routine day for Sadeghi, though one thing is different: the IT security expert has left his keys at home. With his smartphone in his pocket, he no longer needs them. The name of the software that makes a key out of your cell phone is Key2Share – and you can use it today, if not yet on the doors of the institute in Darmstadt then at least in the laboratory. "All a private individual needs to make use of the technology is an NFC-enabled smartphone and the Key2Share app. NFC stands for Near Field Communication, a transmission standard that allows data to be exchanged wirelessly over short distances of a few centimeters," explains Sadeghi as he holds his smartphone over the door of a replica of a small safe. The door mechanism springs open as if by magic; the electronic key had already been e-mailed to him beforehand in the form of an encrypted token.

Then comes the proof that the researcher has actually been using a perfectly ordinary smartphone as the mysterious door opening device starts to ring. It is his colleague, Alexandra Dmitrienko, who wants to be granted access to the small test safe. But Sadeghi doesn't show any signs of leaving for the laboratory or arranging a meeting place. Instead he simply sends his colleague an email containing the electronic key. "This is another of Key2Share's advantages: digital keys can be issued remotely and assigned specific user permissions. It is even possible to limit how long the key can be used," says Sadeghi as he describes this extra feature of the technology.

In Sadeghi's view we are not all that far away from the future scenario depicted above: "Many of the locks that already work wirelessly are NFC-capable and are able to recognize solutions such as Key2Share. NFC is also a standard feature in the majority of current smartphones," stresses the head of the Cyber-physical and Mobile Systems department at the SIT. Key2Share can also be integrated very easily into existing access control infrastructures. Built-in antennae or microchips can be used to make modern cell phones emulate the smart cards businesses now used as stanard to open doors that lock electronically. "This technique of card emulation is still predominantly software-based. However, it is generally believed that hardware-based solutions are more secure. Such solutions do exist, though still few and far between, but it won't be long before smartphones also have this capacity," says Sadeghi. To return to the scientist's fictional day at work, we witness another way in which this technology could simplify our daily lives. Imagine that the meeting has finished earlier than expected and that Sadeghi is already halfway through his laboratory tour. Once more all the doors open as if by magic. The group passes through various departments, floors, and security areas, and each time Sadeghi has the right key to hand. Yet none of this is accompanied by the jangling of keys. All the information is stored on Sadeghi's cellphone: all he needed to do was to get his IT department to send the relevant access permissions via QR code.

Access to departments at the institute must surely call for far more stringent security than private applications? We put the question to the IT security expert, now sitting opposite us in the SIT's canteen. "Key2Share can easily be adapted to suit various levels of security as the software we have developed is open source and based on standards," replies Sadeghi. Not only were he and his team able to refer to state-of-the-art cryptographic technologies during the programming, they are also in a position to flexibly integrate any new features in the future.

Each key is sent from a central server. Communication with the cell phone is protected using established security protocols. The access tokens are encrypted and personalized, and work only on the user's cell phone. "For extremely high-security applications we would recommend you take steps to secure your smartphone's operating system. This could take the form of security software add-ons, for instance," explains the Darmstadt researcher. Here too the SIT has a solution ready: "BizzTrust" creates two virtually demarcated partitions on your cell phone. This means that sensitive data are protected against access by private apps.

After lunch we have to part ways as the professor is in a hurry: he actually does have to pick up a hire car and head off toward Frankfurt. We don't ask how he will be getting into his car and hotel room – we would rather imagine Sadeghi entering with an elegant wave of his smartphone. ■

Organic lights straight from the printer

Flexible organic light-emitting diode (OLED). © *Fraunhofer IAP*

Glittering façades, rollable displays, flashing clothes, luminous wallpaper - and all of them printable. This is no far-off vision: a new printing process for organic light-emitting diodes will make it possible soon.

Text: Chris Löwer

Time is slowly running out for bulky television sets, boxy neon signs and the square-edged backlit displays we all know from shops and airports. It won't be long before families gathering together to watch television at home will be calling out: "Unroll the screen, dear, the film's about to start!" And members of the public may soon encounter screens everywhere they go, as almost any surface can be made into a display. "These may just be ideas at the moment, but they have every chance of becoming reality," says Dr. Armin Wedel, head of division at the Fraunhofer Institute for Applied Polymer Research IAP in Potsdam-Golm. The technology behind it all? OLEDs: flexible, organic, light-emitting diodes.

But the potential offered by this technology extends beyond screens and displays for consumer electronics, according to Wedel. He believes OLEDs are also ideally suited to all kinds of lighting and to digital signage applications – that is to say, advertising and information systems such as electronic posters, advertisements, large image projections, road signs and traffic management systems.

Organic light-emitting diodes will increasingly feature among the items we use every day, something Wedel's team is striving to help make possible. The Fraunhofer scientists worked together with mechanical engineering company MBRAUN to develop a production facility able to create OLEDs and organic solar cells on an industrial scale. The innovative part is that it is now possible to produce OLEDs for large illuminated surfaces from a solution containing organic molecules, which makes printing them onto a carrier film very straightforward. Usually, printing them involves vaporizing small molecules in a high vacuum, making it a very expensive process.

Larger sample series

Scientists had previously only ever used the smart printing technology to design components on a laboratory scale. They can now produce larger sample series – and this is particularly advantageous for the applications that the IAP has in mind, as large illuminated surfaces and information systems require tailored solutions produced in relatively small numbers. "We're now able to produce organic components under close-to-real-life manufacturing conditions with relative ease. Now for the first time it will be possible to translate new ideas into commercial products," Wedel says.

The pilot plant basically works like an inkjet printer, in that a robot applies the OLED solution to the carrier material one layer at a time, with no need for vacuum deposition. This produces a very homogenous surface that creates an almost perfect lighting layer. "We're able to service upscale niche markets by offering tailored solutions, as we can print the organic electronic system to customers' specifications, just like in digital printing," explains Wedel.

Industry experts estimate that printed OLEDs hold out the promise of becoming a billion-dollar market – a view that was confirmed by a survey conducted in 2012 at Drupa, the leading trade show for the printing industry. This market extends beyond displays, manufactured predominantly in Asia, to include the entire spectrum of possible applications. "The focus in Germany and Europe is on OLED lighting because this is the home market for big players such as Osram and Philips," explains Wedel. The new manufacturing facility will help secure competitive advantages in this particular segment of the market. "We hope this will strengthen the German research community, and enable it to continue to compete effectively with American and Asian research institutions," says Dr. Martin Reinelt, CEO of MBRAUN. "We also want to demonstrate the capabilities of German plant engineering."

"The way I see it, we've not even tapped 20 percent of the potential offered by OLED technology," Wedel stresses. Market studies paint a similar picture. Consulting company Frost&Sullivan predicts a full-on boom, with global turnover quadrupling by 2016 and growing by 34 percent on average, while the number of units produced could even increase sixfold.

OLEDs have several advantages over conventional display technologies. Unlike liquid crystal displays they do not require backlighting, which means they consume less energy. As it is the diodes themselves that emit colored light, contrast and color reproduction are better. The electroluminescent displays also offer a large viewing angle of almost 180 degrees. And because they require no backlighting, they can be very thin, making it possible to create entirely new shapes.

OLEDs also have good potential for use in lighting. "In terms of efficiency, they are almost as good as fluorescent tubes these days," says Wedel. In contrast to traditional energy-saving lamps, organic lighting devices do not contain any mercury. OLEDs are made of materials that consist only of carbon, hydrogen and a few other elements such as oxygen, sulfur, metals, oxides and indium tin oxide semiconductors. The only regrettable downside, according to Wedel, is that solution-based OLED processes still feature chlorinated solutions.

Longer service life

There are still several challenges to be met before OLEDs can become firmly established on the market. Researchers are working on extending the service life of organic light-emitting diodes. The problem is that the red, green and blue dots of each pixel age at different rates, which can cause colors to shift. "Manufacturers may promote the fact that OLEDs can last for much longer than 100,000 hours, but these are just laboratory values that bear no relation to actual OLED service lifespans in applications," Wedel concedes. That being said, the actual service life is more than enough to satisfy the requirements of smaller displays.

As the organic material is very sensitive to water and oxygen, encapsulation poses a further challenge. The components must be very well protected from external influences – yet the encapsulation must also be flexible. Here, too, there has been some definite progress.

"The main hurdle, as far as I'm concerned, is the high level of investment required to set up manufacturing," says Wedel. This is why, at least where lighting is concerned, he expects OLEDs to complement rather than replace conventional lighting devices. His view of where OLED production technology could head is less modest: "My vision is that the day will come when all we need do is switch ink cartridges in our printers in order to print out our own lighting devices." ■

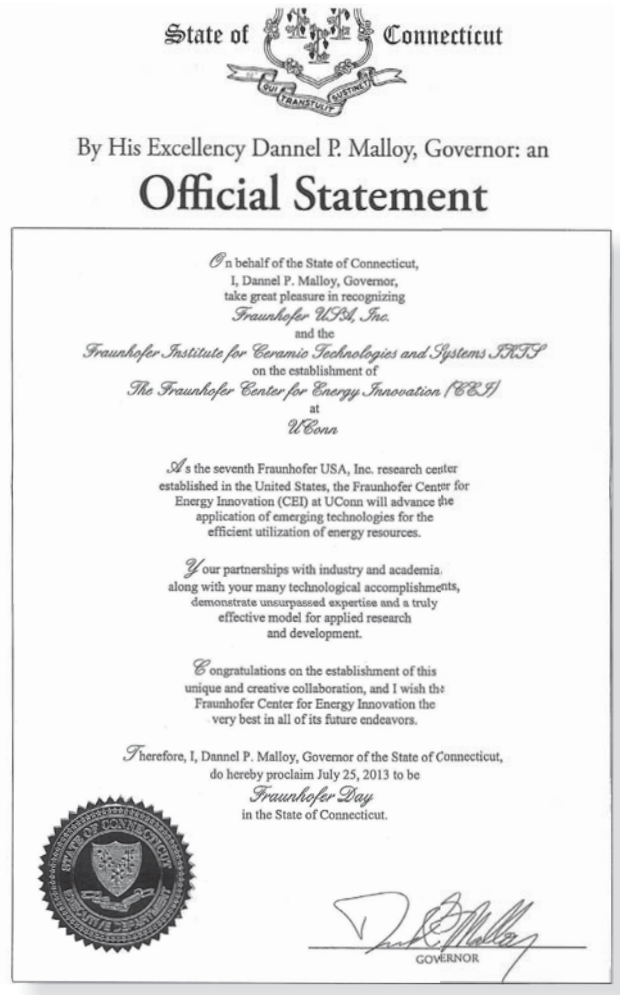
New Fraunhofer Center established in the USA

The mission of the Fraunhofer Center for Energy Innovation CEI at the University of Connecticut is to develop advanced technologies related to energy storage, fuel cells, in-stream hydro, power management and distribution through contract research.

"The sustainable, efficient and environmentally friendly use of energy is one of the major global challenges of the future," says Fraunhofer President Professor Reimund Neugebauer. "Consequently we are combining our advanced energy competencies in the USA with an excellent research partner, the University of Connecticut. The Fraunhofer Center for Energy Innovation CEI adds to Fraunhofer USA's portfolio of energy-related technologies and will closely cooperate with the Fraunhofer Center for Sustainable Energy Systems CSE in Boston."

Fraunhofer and UConn will cooperate in several areas. In order to develop highly efficient and cost-effective energy conversion and storage systems, the research will concentrate on modern functional materials, such as metals, ceramics, micro-and nanostructures, as components for fuel cells and electrolyzers. On the UConn campus, components and subsystems are validated and integrated into flexible microgrid architectures. New methods of membrane and catalyst preparation will be developed, particularly for energy-efficient biofuel production.

To realize common goals, the Fraunhofer Institute for Ceramic Technologies and Systems IKTS will closely cooperate with the UConn Center for Clean Energy Engineering and the Connecticut Department of Energy & Environmental Protection. "The Fraunhofer Center for Energy Innovation CEI combines the expertise of the founding partners for the development and commercialization of new materials and technologies to improve future energy production and storage through efficient use of resource," explains Dr. Prabhakar Singh, the director of the Center. His aim is to accelerate the global supply of affordable and sustainable energy technologies.



State of Connecticut

By His Excellency Dannel P. Malloy, Governor: an

Official Statement

On behalf of the State of Connecticut,
I, Dannel P. Malloy, Governor,
take great pleasure in recognizing
Fraunhofer USA, Inc.
and the
Fraunhofer Institute for Ceramic Technologies and Systems IKTS
on the establishment of
The Fraunhofer Center for Energy Innovation (CEI)
at
UConn

As the seventh Fraunhofer USA, Inc. research center established in the United States, the Fraunhofer Center for Energy Innovation (CEI) at UConn will advance the application of emerging technologies for the efficient utilization of energy resources.

Your partnerships with industry and academia, along with your many technological accomplishments, demonstrate unsurpassed expertise and a truly effective model for applied research and development.

Congratulations on the establishment of this unique and creative collaboration, and I wish the Fraunhofer Center for Energy Innovation the very best in all of its future endeavors.

Therefore, I, Dannel P. Malloy, Governor of the State of Connecticut, do hereby proclaim July 25, 2013 to be
Fraunhofer Day
in the State of Connecticut.

GOVERNOR

The partnership was sealed on July 25, 2013.
© *Fraunhofer*

Going global with surround sound

The new Nexus 7 tablet uses surround sound technology developed by the Fraunhofer Institute for Integrated Circuits IIS. Just recently the internet giant Google Inc. has licensed Cingo. At a Google press event the public was informed that Cingo is integrated in the new Nexus 7, for the Nexus 10 the new sound technology will be available through a software update.

"Owners of the Nexus 7 and Nexus 10 will be surprised that this improvement in quality was possible on handheld devices without compromises to the form factor and usability," said Harald Popp, head of the business department at the Audio and Multimedia division of the IIS. "When paired with HD video quality, Cingo transforms mobile devices into personal movie theaters that fit into a pocket."

The new software creates a realistic surround sound impression when listening to surround content over stereo speakers or headphones. Based on the latest developments in audio technology, Fraunhofer Cingo contains a complete set of tools to deliver an exceptional level of audio quality, unmatched on mobile devices.

The efficient delivery of surround sound to mobile devices is made possible by the High Efficiency AAC (HE-AAC) audio codec technology, which is for example used in Google Play for the delivery of movies with true 5.1 surround sound. HE-AAC was co-developed by Fraunhofer IIS and is today's most efficient high-quality surround and stereo audio codec. Android phones and tablets natively support HE-AAC Multichannel and in combination with Cingo, they become true entertainment centers while on the move or at home.

Research agreement with Dow AgroSciences

Dow AgroSciences LLC, a wholly owned subsidiary of The Dow Chemical Company, and the Fraunhofer Institute for Molecular Ecology IME have announced a multi-year research agreement that brings together the expertise and technologies from both institutions. The partners will collaborate on multiple projects to develop novel biotechnology approaches to improve and enhance crops.

"It is a privilege to be collaborating with Fraunhofer, a world-class research and development institution," says Daniel R. Kittle, global leader, Research & Development, Dow AgroSciences. "This significant agreement with Fraunhofer allows Dow AgroSciences' researchers to work with some of the best teams of scientists in the world to improve plant biotechnology and deliver improved products to our customers." Dow AgroSciences, based in Indianapolis, Indiana, USA, is a top-tier agricultural company providing innovative agrochemical and biotechnology solutions globally. The company, a wholly owned subsidiary of The Dow Chemical Company, has sales of $4.9 billion.

"It is a great honor for us to enter into this collaboration with Dow AgroSciences, one of the key players in modern agriculture," says Prof. Dr. Rainer Fischer, Senior Executive Director of the IME. "This collaboration will enable us to develop some of our most advanced technologies into innovative solutions for global needs and demands." The research will be carried out at Dow AgroSciences in Indianapolis and at the IME in Aachen and Giessen.

DOW® Dow AgroSciences

New environmentally friendly materials for the Indian market.
© *Fraunhofer WKI*

Infinite Solutions

India's economy is expanding and so are its cities. A lot of investment is now made in buildings and infrastructure. Demand for materials and construction as well as healthy and environmentally friendly design is high. This is what researchers from the Fraunhofer Institute of Wood Research WKI and their partners from the Eberswalde University for Sustainable Development found out when they took part in the collaborative celebration of 60 years Indo-German diplomatic relations themed "Infinite Solutions". Fraunhofer technology developed for urban construction was shown in an exhibition touring the great cities of India such as Mumbai, New Delhi, Bangalore, Pune, Chennai, Kolkata und Hyderabad.

Editorial notes

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