Fraunhofer magazine

1/11 special issue

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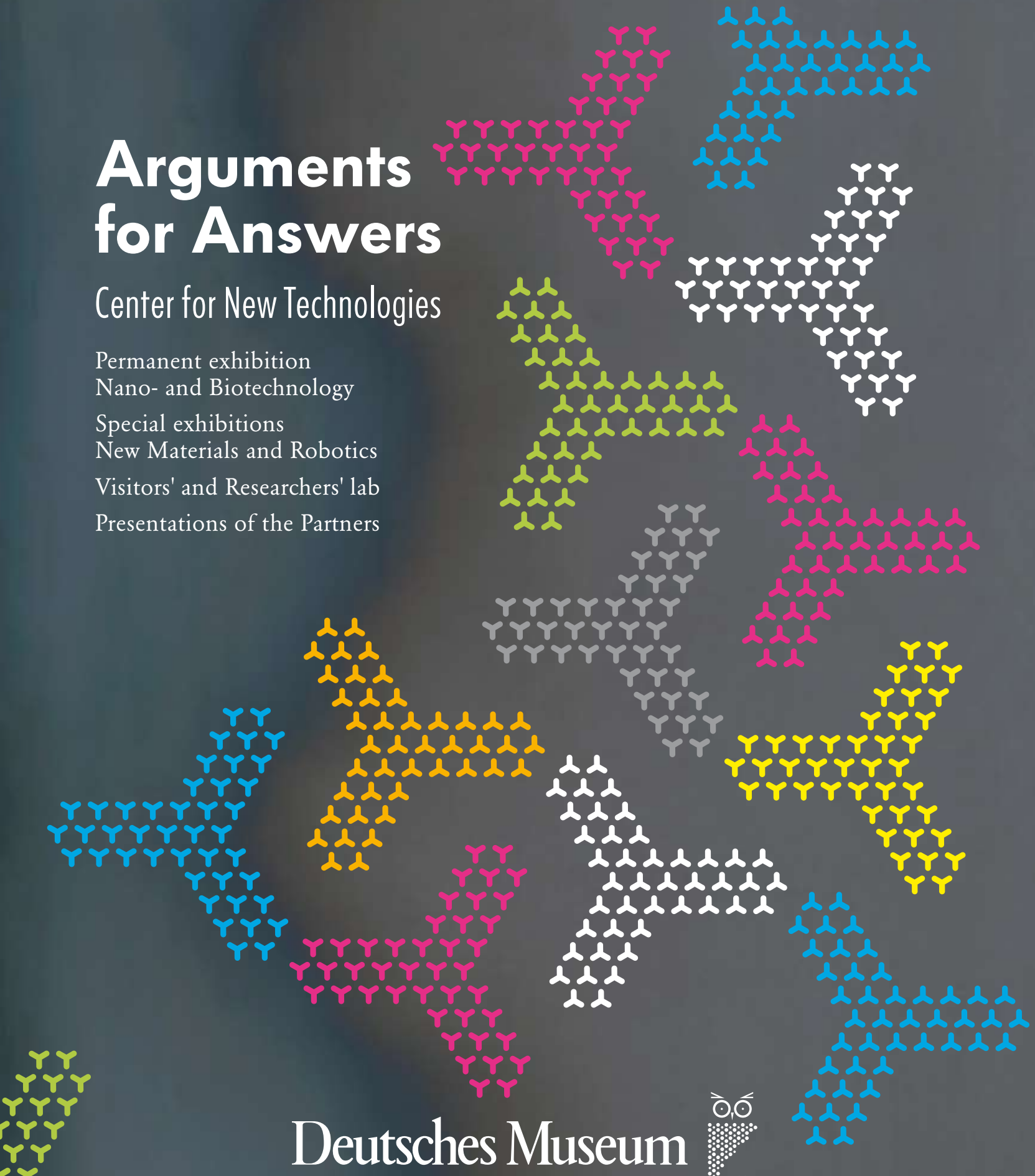

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Recovery needs new recruits

Prof. Dr. Hans-Jörg Bullinger. © *Bernhard Huber*

The latest economic data are better than they have been in a long time: quarter-on-quarter growth in gross domestic product was 2.2 percent in the second quarter of 2010. Business is welcoming the rise in new orders. Once again, exports are growing, as is domestic demand. Many companies are confident about the long-term outlook and expect employment to rise. There's no question about it: the prudent steps taken by business and government during the financial crisis are now paying off. In contrast to the 2001-02 recession, German companies this time have made an effort to retain their highly-qualified staff. They have enthusiastically taken up the option to reduce workers' hours in return for payroll assistance from the state, a policy known as Kurzarbeit, and have also benefited from targeted support in the Federal government's two stimulus programs.

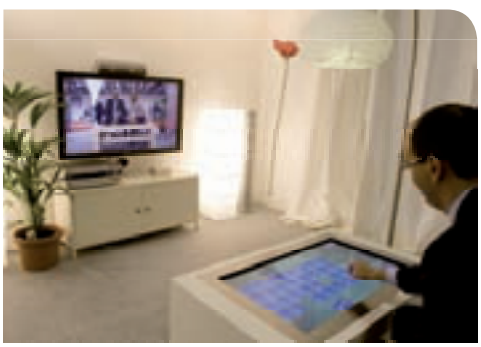
But to keep up with the recent level of new orders and to develop new products and services, business will need well-trained professionals in even greater numbers. Seven out of ten companies are already having trouble filling vacancies, warn the German chambers of industry and commerce (DIHK). A recent survey of around 1,600 companies found that roughly half are expecting a shortage of highly-qualified specialists in the coming five years. The effects of this on the German economy could be huge. Even at the height of the crisis in 2009, the national economy missed out on some EUR 3 billion of value creation because posts could not be filled.

There is a particular shortage of graduates in mathematics, information science, natural sciences and technology – MINT for short. In 2008 almost 86,000 students graduated from universities and technical colleges with a first degree in a MINT subject, accounting for roughly a third of all graduates. But in order to meet demand, at least 40 percent of all graduates would have to have studied a MINT subject. The greatest need is in the field of engineering sciences: studies by the Association of German Engineers (VDI) and the Institute for Economic Research (IW) show that there is already a shortage of almost 36,000 engineers.

The situation is set to worsen in the coming years: for every 1,000 engineers already in the workforce in 2007, there were only 35 new engineering graduates. For comparison, Spain had 90 graduates for every 1,000 engineers, Italy had 147, and Poland and the Czech Republic each had more than 200. It is ironic that the country best known for its engineers and technicians should be the one to run out of new talent. The coming decade might see a shortfall of 200,000 engineers. These are alarming figures, since no other European economy depends to such a degree on well-educated engineers as Germany.

Politicians, businessmen and the research community have been trying for years to encourage young people to study MINT subjects. For example, Fraunhofer's Talent School program offers schoolchildren who are interested in the sciences an insight into the careers open to researchers. And these efforts are beginning to bear fruit: the share of students graduating in MINT subjects has gone up by over two percent since 2004. But this increase is not nearly enough to meet the demand for specialists. What is needed is a concerted effort to help parts of the workforce that have been neglected up to now – such as immigrants – to retrain for new challenges , and to change the mindset that undervalues the contribution women can make.

Motivated and well-trained specialists are the key to renewed economic growth. Novel technologies as described in this volume of Fraunhofer Magazine are giving rise to innovations in many fields. But companies will only be able to realize this potential if they can attract and recruit employees with a thorough understanding of the latest technologies.



Content

Earthquake warning system

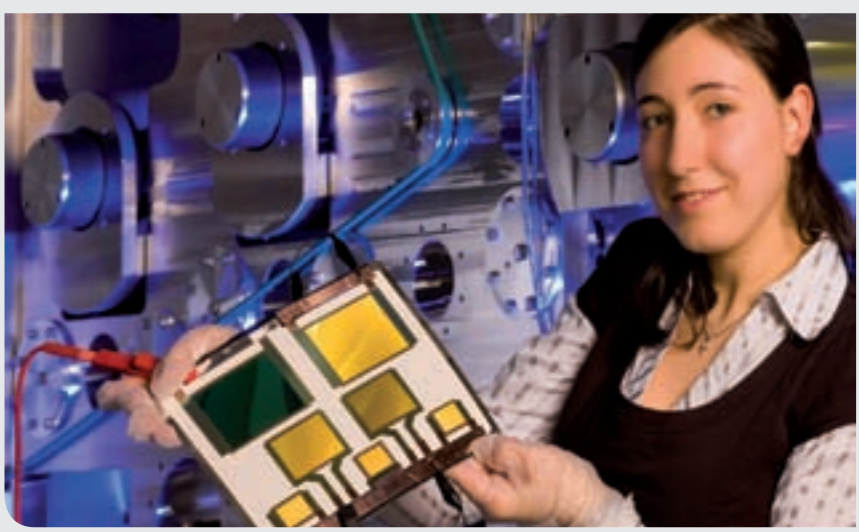
Railroad tracks move, bridges are in danger of collapsing – these kinds of events are a common occurrence during an earthquake. Researchers from the Fraunhofer Institute for Optronics, System Technologies and Image Exploitation IOSB in Karlsruhe and the Karlsruhe Institute of Technology KIT are working on an early-warning system.

The software calculates the propagation of the seismic waves shortly before the earthquake strikes and compares the calculated data with geographic and geological conditions in the region, thus providing a rapid analysis of the likely impact on transport and utility networks. Moving trains can therefore be warned and stopped in time. In the wake of a disaster this system provides the rescue services with valuable information on the damage caused.

Flexible lamps

Organic light emitting-diodes (OLED) are set to replace conventional incandescent lamps as tomorrow's light source. They lose only a minimal amount of energy while converting electricity into evenly distributed high-quality light. The OLEDs available on the market so far have only been mounted on rigid materials, such as glass, since the luminescent materials have to be sealed within a transparent barrier layer that keeps out humidity and oxygen, to ensure the lamp lasts. Scientists from the Fraunhofer Institute for Photonic Microsystems IPMS and the Fraunhofer Institute for Electron Beam and Plasma Technology FEP in Dresden have managed to develop highly efficient light-emitting diodes on flexible substrates. As part of the project funded by the German federal ministry of education and research (BMBF) the researchers are using a thin-film encapsulation process on a roll-to-roll coating plant. The OLED materials are applied on a low-cost aluminum foil and encapsulated using a layer system. The same process might be used in a few years to produce organic solar cells or storage systems.

Flexible organic light-emitting diode with new barrier layer system. © *Janek Wieczoreck*



Intelligent fabric

Electronics and microsystems can be integrated into even the most delicate clothing fabrics—and not only displays and light-emitting diodes, but also sensors and control electronics. The secret lies in stretchable circuit boards which are currently being developed by scientists at the Fraunhofer Institute for Reliability and Microintegration IZM in Berlin in collaboration with researchers at the Berlin University of Technology as part of the European research project "Place IT". The substrate material is a flexible thermoplastic polyurethane (TPU) foil. TPU is already widely used in the textile industry due to its excellent resistance to wear and tear. The conductor tracks are structured into the substrate in tiny meander patterns, allowing them to stretch.

There is a broad range of potential products. Intelligent fabrics can be used in any application that requires body data to be measured and monitored—examples include a shirt that monitors babies' breathing to prevent sudden cot death, and an "intelligent" bandage capable of detecting secretions or using pressure readings to ensure the bandage is not too tight. The researchers are also developing plasters that use electrical stimulation to accelerate wound healing.

The conductors are made of copper, just like on a normal circuit board. The copper film is attached to the polyurethane foil by means of lamination – a process roughly equivalent to pressing it on with a hot iron!
© *Fraunhofer IZM*

Sensitive robot skin

Robots are steadily making inroads into new fields of application in environments such as manufacturing, household and the healthcare sector. The safety features nessesary for the work with humans can be provided by a tactile sensor system, which can be applied directly as an artificial skin that completely covers a robot. Consisting of conductive foam and textiles, the robot skin contains integrated sensor cells that reliably detect any contact. A sensor controller processes the readings and transmits them to the robot, or alternatively to a computer, a machine or a production line. The sensors can also be incorporated in flooring to detect anyone entering a room.

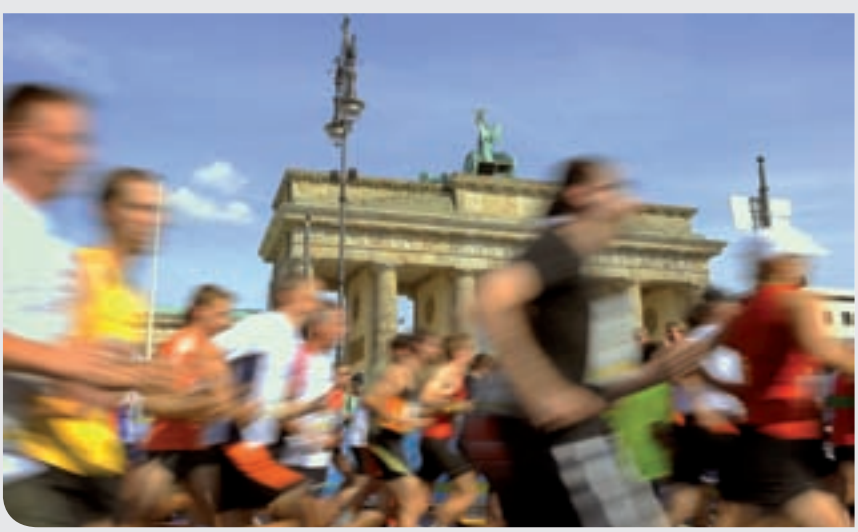
Researchers at the Fraunhofer Institute for Factory Operation and Automation IFF in Magdeburg designed and patented the sensor system in 2008 for their assistant robot LiSA. LiSA was conceived as a means of relieving lab staff from repetitive tasks, such as loading incubators and measuring equipment in biotech labs with sample trays.

Cell phone tracks heart rate

If you jog or cycle, you will know how difficult it can be to judge how fast you are going and how hard your body is working. One way of keeping track of your training session is to use a heart rate monitor, a device designed to take readings of athletes' heart rates and prevent them from pushing themselves too hard. Generally, this comes as a chest strap – the transmitter – and the heart rate monitor itself – the receiver – often in the form of a wristwatch.

Researchers at the Fraunhofer Institute for Open Communication Systems FOKUS in Berlin are currently working on a new system module for conventional chest straps that would enable athletes' cell phone to read their heart rate. The BlueHeart adapter transmits the signals directly to a smart phone. It is small, compact, and very lightweight, and designed to be attached to the chest strap. For endurance athletes who train in groups, it also offers the potential to compare and evaluate each team member's individual results.

Smart phones can help prevent athletes from pushing themselves too hard. © *dpa*



Early corrosion detection

Concrete bridges have to endure frost, vibration, exhaust emissions, UV radiation, road salt and a great deal more that causes corrosion damage. When cracks develop, and bits of concrete start to break off, the consequences can be fatal.

Experts from the Fraunhofer Institute for Microelectronic Circuits and Systems IMS in Duisburg have come up with a more effective, cheaper method for identifying corrosion at an early stage. A new sensor transponder permanently monitors the concrete. It was developed by the building materials testing facility in Braunschweig, where IMS researchers integrated it into a passive, wireless transponder system. Ultra-thin iron wires crisscross the sensors. If dissolved salts, for instance, reach the iron wires, these start to corrode and break. Based on the number of defective iron wires you can determine the extent of the corrosion and when the next round of repair work needs to be undertaken. The transponder transmits the measurement data to a reading device over a wireless connection. Since it is not powered by a battery, but by a magnetic field, the transponder can remain permanently embedded in the structure.

Sensor transponders constantly monitor the concrete. They report corrosion damage before cracks develop. © *ALIMDI.NET / Manfred Bail*

Light and yet safe, stable and reliable – these are the requirements that components have to meet, especially in aircraft construction. © *Bernd Müller*

Losing weight saves energy

Text: Birgit Niesing

Like fashion models who watch each and every gram, car makers and aircraft manufacturers are extremely vigilant when it comes to weight - because every pound less on the scales means a reduction in fuel consumption and carbon dioxide emissions. New materials, joining techniques and lightweight construction concepts all help airplanes and automobiles to shed weight. Composite materials, in particular, offer great potential for lightweight construction. Further research and development work is required, however, before we will see the use of lightweight composite materials in series production cars.

Automobiles are real heavyweights. A current mid-range car weighs between 1.2 and 1.5 metric tons. This is because modern equipment such as airbags, anti-lock braking systems, parking aids, electric windows, air conditioning and power-assisted steering not only enhance safety and comfort but also add considerably to weight. By comparison, a typical passenger car in the 1970s weighed between 700 and 900 kilograms. The heavier a car is, the more fuel it consumes and the more carbon dioxide it emits into the atmosphere, therefore a slimming course for automobiles would be beneficial to car drivers and the environment alike. Trimming 100 kilograms from the weight of a car reduces fuel consumption by between 0.3 and 0.6 liters per 100 kilometers depending on the type of vehicle and how it is driven, lowering carbon dioxide emissions by seven to twelve grams per kilometer. There are other advantages too: lighter cars accelerate better and offer better stability when cornering.

"In times of dwindling resources and increasing environmental awareness, lightweight construction is among the most important technologies for the future in aircraft manufacture, car making and mechanical engineering," emphasizes Prof. Dr.-Ing. Holger Hanselka, spokesman for the newly established Fraunhofer Lightweight Construction Alliance, in which 14 institutes are pooling their expertise (see box). "Lightweight construction means reducing the weight of a component while retaining adequate rigidity, dynamic stability and strength. This involves ensuring that the developed components and structures reliably perform their task over the entire required service life," Hanselka explains. Which in turn means using the right material in the right place by way of hybrid material design. "The object of the Alliance is therefore to cover the entire development chain – from material and product development through series production of components and systems to homologation and product deployment."

Optimal lightweight materials help in the efforts to reduce weight. In recent years, car makers have mainly focused on the lightweight properties of aluminum. Whereas in 2000 an automobile contained roughly 100 kilograms of this material, it now contains over 140 kilograms. Magnesium weighs even less than aluminum, but unfortunately it has a number of disadvantages. Although light, it can only withstand low loadings, and it also corrodes extremely quickly, which reduces its potential for use. Fiber composite plastics, FCPs, are particularly lightweight and also very stable. To produce them, fibers of glass, carbon or other materials are

embedded in a plastic matrix. Depending on the requirement, the fibers can be placed over each other in several layers with differing alignments, enabling the properties of the component to be optimally adjusted to the specific application.

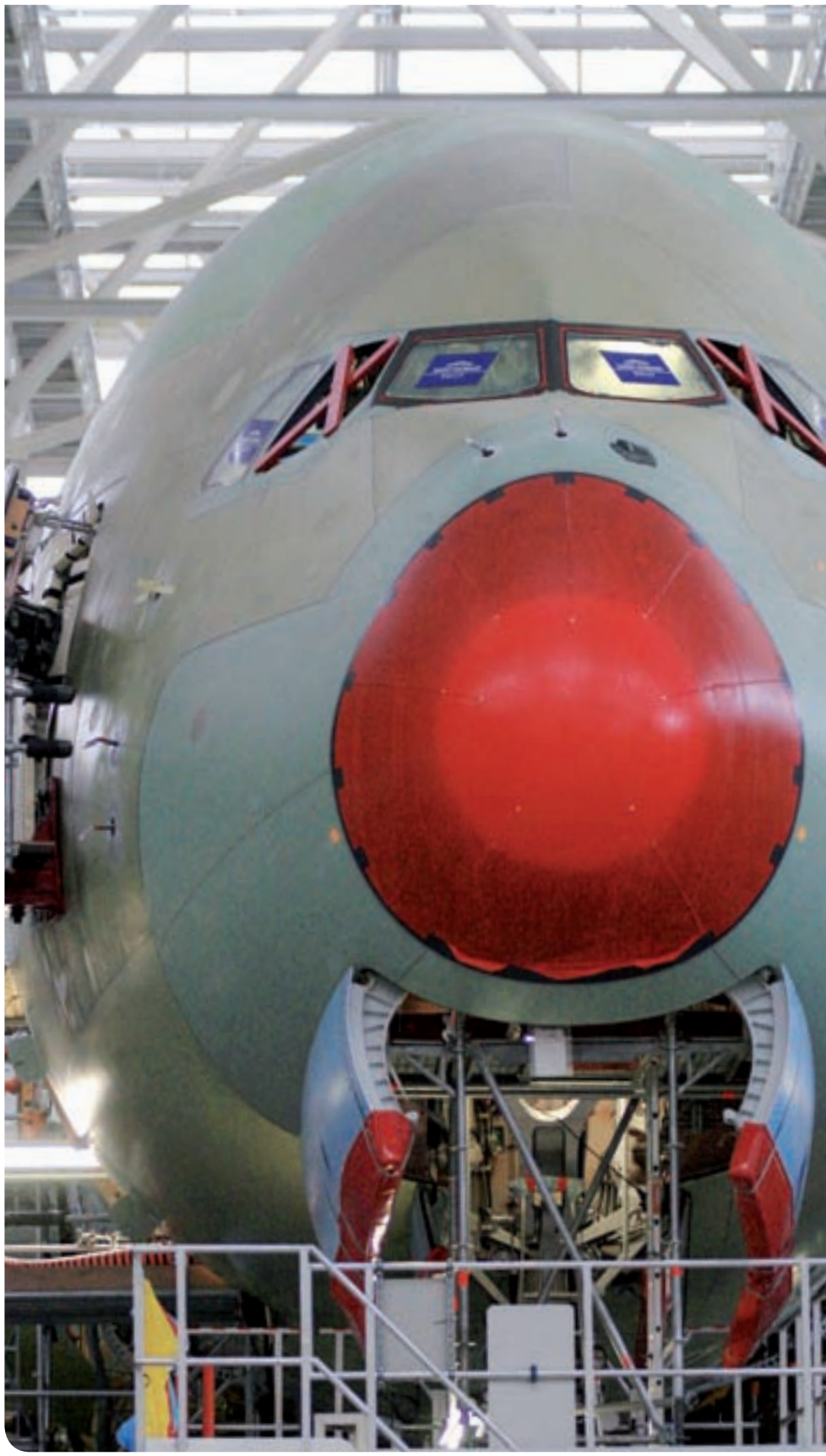
Carbon fiber reinforced plastics, or CFRPs, possess great potential for lightweight construction. They are 60 percent lighter than steel and about 30 percent lighter than aluminum. Further advantages are that they do not rust and can be used in crash-relevant structures. Fiber reinforced plastics are now firmly established in aircraft manufacture, including in the Airbus A380, where they account for 20 percent of the structure weight. Boeing is currently building the first wide-body aircraft with a fuselage consisting largely of fiber reinforced plastic. Thanks to lightweight construction, the 787 – also known as the 'Dreamliner' – will weigh about 20 percent less than comparable conventionally manufactured aircraft. The fuselage of the new Airbus A350 XWB will also be made largely of carbon fiber reinforced plastic.

Formula 1 has been using CFRPs for years. Apart from the engine, wheel carriers and transmission, the racing cars are made almost exclusively of carbon fiber. Altogether, up to 20 different types of carbon fiber fabric are used. The drivers' helmets are now also made of CFRP, and one saved the life of Felipe Massa last year when he was hit on the head by an 800-gram steel spring during qualifying for the Hungarian Grand Prix. The helmet weighing just 1.3 kilograms cushioned the impact enormously.

Carbon for series-produced cars

In future, CFRP will feature increasingly in series production cars. Mercedes-Benz has been using this lightweight material in its high-performance SLR McLaren sports car for a number of years already: apart from the front structure, which is made of aluminum, the complete body consists of this material. A short time ago, Daimler and Toray Industries, Inc. entered into an agreement on the joint development of lightweight automotive components made of carbon fiber reinforced plastic. And BMW is also turning to carbon. The Munich-based automobile manufacturer is building a new carbon plant in the USA in cooperation with carbon fiber specialist SGL, a company from Wiesbaden. The components produced there will be used in electric cars as well as in conventional vehicles. Lamborghini has been using CFRPs since the 1980s. In the Gallardo sports car, the rear spoiler, fenders and parts of the underbody are made of the lightweight material. Together with Boeing, the Italian sports car manufacturer supports university research into carbon structures by sponsoring a professorship. But not only car manufacturers and aircraft makers are turning increasingly to CFRPs. The innovative materials are also being deployed in the mechanical engineering industry. Trumpf, for example, uses carbon fiber in some of its machine tools, and Voith Paper produces high-quality rolls from CFRP.

The front-end assembly carrier made using tailored LFT technology is crash-safe. © *REA/laif*



However, there is still a great need for research and development because CFRPs are produced and processed completely differently from metals. The materials are woven, bonded and baked. This has the major advantage that even complex components can be produced in one piece. To harness the enormous lightweight construction potential of fiber composite materials, Fraunhofer research scientists are working on concepts which include design configurations suitable for fibers and textiles, innovative methods of construction, new structural and material concepts and production technologies that offer a high degree of automation for volume manufacture. "Series production of fiber composite components in the automotive and mechanical engineering industries will only be achieved if these high-tech materials can be produced more cheaply," emphasizes Prof. Dr. Frank Henning. The deputy director of the Fraunhofer Institute for Chemical Technology ICT runs the Karlsruhe-based Technologies for Hybrid Lightweight Construction innovation cluster and the Fraunhofer Function-Integrated Lightweight Construction project group in Augsburg.

The ICT is conducting work on production technologies to strengthen long fiber reinforced thermoplastic materials (LFTs) locally using endless fibers. The process makes it possible to produce function-integrated components at low cost. But will components made in this way be able to withstand the stresses and loadings that occur in a motor vehicle? The answer is a definite yes. In cooperation with partners from industry, research scientists at the ICT have produced a front-end assembly carrier using tailored LFT technology. The concealed component carries the headlights, enginehood locking system and fan cowl, and although completely metal-free, it meets the requirements of the specifications for a crash at 64 km/h.

The question as to whether fiber composite materials are suitable for extremely stressed and safety-relevant components such as car wheel rims was examined by Fraunhofer researchers in the internal Fraunhofer project WISA High Strength. They produced wheel rims made of sheet molding compound (SMC) material. SMCs are long fiber reinforced plastic structures which are processed by means of compression. The tests and calculations showed that fiber reinforced plastics are highly damage-tolerant and distinctly superior to car wheels made of aluminum.

Sandwiches for high stability

"Development and integration of the lightweights is no easy task – high-performance materials and innovative joining and production technologies have to be harmonized," states Professor Henning, highlighting the challenges. In the KITe hyLITE Technologies for Hybrid Lightweight Construction innovation cluster, three Fraunhofer institutes (ICT, IWM and LBF) are cooperating with industrial partners, the University of Karlsruhe and the Competence Center Vehicle Lightweight Construction to analyze new materials, determine the necessary material combinations and develop prototypes. They are working on suitable calculation techniques to predict the behavior of components and to optimize manufacturing processes. Building on experimental results, the researchers have created a numerical model and are developing ideally adapted testing concepts.

Sandwich materials offer the greatest lightweight construction potential for structures with a large surface area which are susceptible to buckling. They consist of extremely rigid and strong outside layers which are kept apart by a light sandwich core. As partners in a joint project, research scientists at the Fraunhofer IWM in Halle are developing high-performance sandwich structures made of CFRP outside layers with a supporting core of polymer foam for highly stressed and safety-relevant primary aircraft structures. The researchers are working on new testing concepts to verify their damage tolerance and are using special calculation methods to analyze the ability of the components to withstand the strong mechanical and thermal alternating loads encountered in aircraft.

For applications in space, each and every kilogram of structural weight saved is extremely precious. The materials used for the propulsion systems are exposed to temperatures in excess of 2000°C, and this is where the special properties of lightweight fiber composite materials with a ceramic matrix (ceramic matrix composites – CMCs) really come into their own. At these extreme temperatures they exhibit an even higher strength than at room temperature, and they are also corrosion-resistant and damage-tolerant. The research scientists at the IWM can test the properties of these materials at 2000 °C and exactly calculate the optimal arrangement of the reinforcing fibers and how they will perform in service. The microstructural defects in the material, which are a key factor in achieving a good level of damage tolerance, are also taken into account. The methods used additionally serve to improve other applications such as ceramic brake disks in automobiles.

Researchers at the Fraunhofer Institute for Structural Durability and System Reliability LBF test whether the lightweight construction materials will withstand alternating dynamic loadings in service and how they should be dimensioned. In addition, they develop adapted design concepts for new materials and structural health monitoring systems (e.g. for airplane wings) and examine how safe and operationally sound the materials are. "Only the correct design concepts will make it possible to produce a new class of lightweight structures offering, among other things, a higher degree of function integration, for example by using bionic design philosophies," explains Professor Andreas Büter, Head of the Competence Center Lightweight Structures at the LBF.

Lightweight, stable and corrosion-resistant – fiber reinforced plastics are an ideal material for airplanes, automobiles and wind turbines, but they have one disadvantage: they are complicated and costly to process and a large part of the work is still done by hand. Fraunhofer researchers are cur-

rently working on automating their production. Engineers at the Fraunhofer Institute for Production Technology IPT, for example, have developed a new process by which fiber reinforced plastics can be produced completely automatically. In this tape-laying technique the ingredients come off a roll. The plastic fibers are integrated in kilometer-long plastic tapes made of meltable thermoplastic material. The tapes are stacked on top of each other in several strip layers, are melted by laser shortly before being laid, and are then compressed to form a compact structure. This produces stable components.

Optimized but at the same time cost-efficient joining techniques are needed to join components made of fiber composite materials together such that they can withstand high loadings and meet the requirements of the specific application. Work on this is being conducted by the bonding technology experts of the Fraunhofer Institute for Manufacturing Engineering and Applied Materials Research IFAM. At present FCP materials are usually joined after the surface has been activated with film adhesives or hot-hardening adhesives. The joins are then hardened under pressure and heat in autoclaves. There is only one problem: the size of the autoclaves is limited – complete airplane wings do not fit in. Researchers at the IFAM are developing adhesives which harden at lower temperatures.

Aircraft in particular represent an extremely difficult challenge for bonding technology. In Stade, located between Hamburg and Bremen, the new CFRP North research center is being created within the CFRP Valley Stade competence network. Here, future-oriented methods of construction and automated production and assembly processes will be developed for the growth market of carbon fiber reinforced plastics. The IFAM is supporting the competence network with the newly established Fraunhofer Project Group Joining and Assembly FFM, and is working together with industry to develop assembly techniques for CFRP components on a scale of 1:1, including fuselage segments for wide-body aircraft. The work focuses in particular on rapid joining and cutting processes suitable for carbon fiber reinforced plastic.

Fiber composite components can be bonded together using lasers. At this year's JEC Composites Show in Paris, researchers from the Fraunhofer Institute for Laser Technology ILT presented this new joining technique for glass or carbon fiber reinforced plastics. A laser emitting infrared light melts the surface of the plastic parts. The components are then pressed together to form an extremely stable bond. It will be some time before fiber composite materials can be used on a large scale in car manufacture. Until then, automobile producers will deploy an intelligent mix of materials in order to save weight.

www.superlightcar.com

In the EU's SuperLightCar project, the research sector and industry developed a car body that is a third, or about 180 kilograms, lighter than conventional bodywork. The key to this was a specific approach – for each component the scientists selected the material which would achieve the biggest weight saving while withstanding the required loads. The result is a car body made of steel, aluminum, magnesium and fiber composite materials.

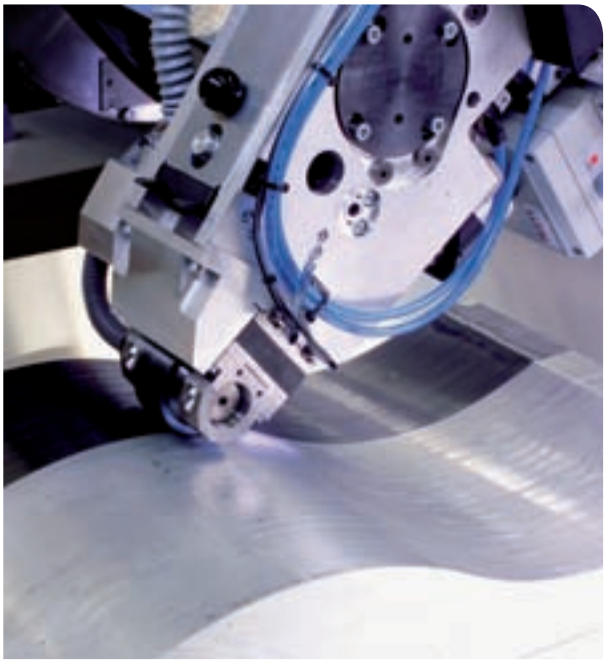
A mix of materials opens new markets

Lotus Engineering applies a similar strategy. This spring, the company presented a lightweight construction study. Using the example of the Toyota Venza, engineers showed how car weight can be reduced by up to 38 percent. The vehicle's bodywork is made of aluminum (37 %), magnesium (30 %), composite materials (21 %) and high-strength steel (7 %). The tailgate, doors and fenders are also made of various lightweight construction materials. These measures additionally reduce fuel consumption by 23 percent.

This mix of materials is only possible thanks to the intelligent use of modern bonding technology, as developed by the IFAM. It permits previously unrealizable material combinations, such as the joining of glass and steel, aluminum and magnesium, or fiber composite materials with metal. The bonding adhesive also enables additional functions to be integrated, e.g. vibration damping, electrical insulation and corrosion protection. The flexibly deployable joining technology can not only be excellently combined with mechanical joining techniques such as clinching, riveting, bolting and spot welding, but also increases the rigidity of vehicles. For example, the combination of spot welding and bonding reduces the residual deformation of the B-pillar of a car body by more than 25 percent in a side-on collision compared with spot-welded reference specimens. Nature is an excellent teacher on matters of lightweight construction. When designing components, many engineers are guided by the structure of bones. Metal foams, which are used to make light and stable components, have similar hollow structures to bones. The IFAM is a pioneer in the development of foamed metals. Many groups of researchers – including the Fraunhofer Institute for Machine Tools and Forming Technology IWU – are conducting work on these airy materials.

New materials, joining techniques, production processes and lightweight construction concepts will only be successful if they are safe and reliable. They have to be able to withstand loadings and stresses day in, day out over decades. At present, the condition of automobiles, airplanes and wind turbines is examined by means of periodic non-destructive testing. Fraunhofer researchers are now working on structural health monitoring methods that can be used to check the condition of components during operation. Car making, aircraft manufacture, mechanical engineering and plant construction are important branches of industry and employers in Germany. The use of new lightweight construction materials can help to strengthen the position of German companies internationally. ■

During the tape-laying process carbon fiber reinforced plastic tapes are welded by laser, producing stable fiber composite materials. © *Fraunhofer IPT*

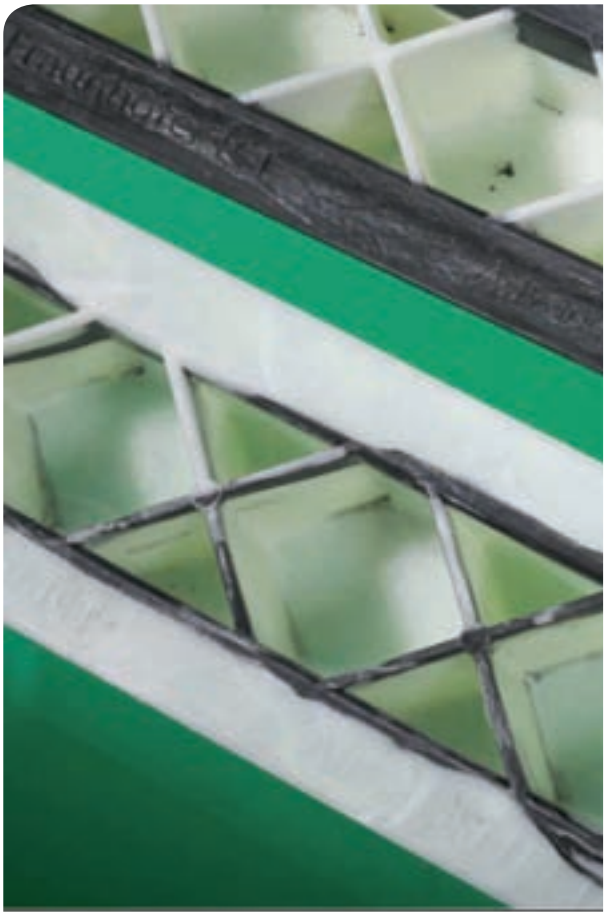


Fraunhofer Lightweight Construction Alliance

14 institutes have joined forces in the Fraunhofer Lightweight Construction Alliance. The researchers are conducting work on new materials and composites, production and joining technologies, function integration, design engineering and non-destructive and destructive testing methods for lightweight construction.

The members of the Alliance are the Fraunhofer Institutes for:
- High-Speed Dynamics, Ernst-Mach-Institut, EMI, Freiburg
- Chemical Technology ICT, Pfinztal
- Laser technology ILT, Aachen
- Manufacturing Engineering and Applied Materials Research IFAM, Bremen
- Silicate Research ISC, Würzburg
- Industrial Mathematics ITWM, Kaiserslautern
- Mechanics of Materials IWM, Freiburg, Halle
- Material and Beam Technology IWS, Dresden
- Machine Tools and Forming Technology IWU, Chemnitz
- Transportation and Infrastructure Systems IVI, Dresden
- Non-Destructive Testing IZFP, Saarbrücken
- Structural Durability LBF, Darmstadt
- Environmental, Safety and Energy Technology UMSICHT, Oberhausen
- Integrated Circuits IIS, Erlangen

www.allianz-leichtbau.fraunhofer.de



The ICT's assembly carrier prototype component made of LFT with unidirectional endless fiber or roving reinforcement.
© *Fraunhofer ICT*

Structural monitoring with integrated fiber composite PZT sensor/actuator.
© *Fraunhofer LBF*

The new sky

Less noise, less exhaust, less refuse - air travel of the future is expected to be quieter, cleaner and more environmentally friendly. In the EU project Clean Sky, Fraunhofer researchers want to make their contribution to solving this Herculean task.

Text: Monika Weiner

In the Flight Test Facility at the Fraunhofer Institute for Building Physics researchers can simulate the pressure, temperature and moisture conditions during a flight.
© Bernd Müller

The world of tomorrow is "green": low-emission, low-fuel, environmentally sound technologies are revolutionizing automotive and mechanical engineering as well as industrial design and urban planning. This change in paradigms is also extending its grasp to aeronautics: flying can become considerably more environmentally friendly – the aviation experts from the "Advisory Council for Aeronautics Research in Europe" ACARE are certain of this. In the guidelines that they compiled for the European aviation industry, the experts are calling for a 50 percent reduction in carbon dioxide and noise emissions by 2020; nitrogen oxides output should be reduced by 80 percent.

These goals may indeed be ambitious, Professor Holger Hanselka thinks – but definitely achievable. The head of the Fraunhofer Institute for Structural Durability and System Reliability LBF in Darmstadt worked assiduously on the topic of aviation over the last few years. Since 2008, he has been a member of the Governing Board – the decision-making body – of the EU's "Clean Sky" project, working together with decision makers from eleven other renowned aviation firms ranging from Airbus to Rolls Royce. „Through Clean Sky, the various technical aspects of aviation are put to the test, evaluated and developed further, within the framework of a 1.6 billion euro program. That is both a Herculean task as well as an opportunity," explains Hanselka. „Europe has never before seen such an all-encompassing research project of this nature."

A clean sky for 1.6 billion euro

The 7th Framework Programme for Research and Technological Development makes everything possible: The EU fosters cooperation between research institutions and business firms in the new Joint Technology Initiatives, or "JTIs" for short. These foster new room for maneuvering: In the "Clean Sky" project, for example, project participants can not only continue to develop individual technologies for specific applications, just like before – but they can also evaluate and advance the entire aviation system.

No single research group or company can solve a complex task of this type on its own. An Advisory Board had defined the most important technology fields – for example, engine technology, and wing and fuselage structures. These can now be handled separately from each other, however methodological expertise on design, processes and procedures is shared. Ultimately, everything is brought together into a greater whole.

The breadth of related subjects is immense: expert groups from dozens of businesses, research institutions and nations will jointly collaborate, test materials, simulate substance flows, hone calculation methodologies, conduct and analyze experiments. "At every company level, goals must be precisely defined, so that everyone knows exactly what he or she has to do," explains John Simpson, Fraunhofer program manager and member of the original Clean Sky Advisory Board. Example: Airplane. It can be divided up into wing, engine and fuselage construction. Each of these components can contribute to improving the ecological balance of the system as a whole. An optimized airflow profile on the wings cuts noise and saves energy; improved engine technology minimizes kerosene consumption; materials with long life spans save on raw materials; the application of recyclable materials prevents the accumulation of waste.

The puzzle pieces of future aeronautics

Hidden behind each sub-problem is a myriad of research tasks. In the past, for example, material lifecycles were rarely if ever given consideration in airplane construction – and consequently, aircraft that had completed their economic lifecycle were extremely difficult to dispose of. Other industries have evolved much further on this point: value creation chains were created that incorporate materials development, design, construction, manufacture and recycling.

Specialists at the Fraunhofer Institute for Chemical Technology ICT, for example, develop special plastics that not only possess the exact material characteristics desired by the manufacturer, but can also be disposed of at the end of their economic lives in an environmentally sound manner. In the "Clean Sky" project, the engineers will apply this expertise in order to work out new forms and materials for airplane structures. Other important parts of the value creation chain include production and automation. Here as well, the experiences from other industries can also be applied to aviation. "Airplane manufacturers who had hitherto built their craft primarily at manufacturing plants want to automate their production in the future. Fraunhofer institutes that specialize in production processes can bring their experiences into the equation," explains Hanselka.

The aviation industry places a particularly premium on safety – for good reason, because the lives of passengers and crew depend on the integrity of the materials used being able to withstand mercurial pressure and temperature conditions as well as the vibrations and shearing forces that occur over the course of each flight. „In the Clean Sky project, we want to engineer reliable materials, but we also need to develop systems for monitoring the finished components," explains Hanselka. Together with his colleagues at LBF, Hanselka wants to create a sensor system for the online monitoring of wings. Actuators that are integrated into the wings emit impulses. A network of sensors receives the signals and transmits them to an electronic data processing system. Fluctuations in the transfer pathway that indicate tears in the material can be immediately detected in this manner.

Right after safety comes health: the comprehensive concept for the aviation of the future that the "Clean Sky" project researchers have prepared also takes passenger well-being into account. So for example, testing should indicate if a newly developed material diminishes the air quality in the passenger cabin. In the Flight Test Facility at the Fraunhofer Institute for Building Physics IBP, researchers can simulate the pressure, temperature and moisture conditions during a flight.

The individual project groups have already started work. The developments, investigations and calculations that they make should – like pieces of a puzzle – ultimately result in an environmentally friendly design for the aviation of tomorrow. "The challenge of the next few years is to look deeply into the value creation chain. It must contain an optimized wing concept, an energy-saving turbine design, new fuselage constructions and monitoring concepts," says Hanselka. Prototypes are planned for the medium term and the results will be incorporated into demonstration models later. With the aid of these technologies, the European aviation industry should become „green" by 2020. ■

Carbon nanotubes are among the materials that will shape the 21st century. © *Martin McCarthy*

Multitalented microscopic tubes

New fuel cells and earthquake-proof buildings are just two of the potential applications for carbon nanotubes. Industry and science are conducting research into how the microscopic tubes can be produced and used.

Text: Klaus Jacob

20 years ago the Japanese scientist Sumio Iijima created an avalanche with an article he published in Nature magazine about carbon nanotubes. The microscopic structures referred to as CNTs stirred the imagination of many research scientists and led to a flood of publications and patents. CNTs have amazing potential, with a range of possible applications that extends from electronic components and new types of fuel cell to earthquake-proof buildings. This versatility stems from their unusual properties. CNTs are like tiny rolls of wire mesh, with atomic lattice walls. Their diameter varies between one and about one hundred nanometers, which means they are about 10,000 times thinner than a human hair. By comparison, they are extremely long, measuring from one to ten micrometers – they thus take the form of very fine threads. Their regular structure makes them extremely robust. In terms of strength they not only beat steel but are also stronger than indestructible carbon fibers. But that's not all. They conduct heat better than diamonds, which come top of the thermally conducting materials found in nature. This makes them interesting for electronic components, where heat is known to build up rapidly. What's more, they conduct electricity better than copper, and under certain circumstances can act as semiconductors.

Big market for CNTs

Despite their attractive potential, CNTs have so far not fulfilled their promise. Although experts reckon the market for CNT applications could be worth hundreds of billions, there are actually only a few CNT products available for purchase. These include high-tech tennis rackets, skis, surfboards, top-of-the-range golf clubs and ice hockey sticks. There are many technical obstacles to be overcome before the breakthrough to the mass market can be achieved. An initiative launched over a year ago with funding to the tune of about 70 million euros aims to get things going. More than 70 partners from science and industry have joined the Innovation Alliance CNT, or Inno.CNT for short. Five Fraunhofer institutes are participating in the alliance. The German research ministry BMBF is providing about half of the total budget for the project. The aim is to ensure that Germany maintains its leading role in this field.

The project was initiated by Bayer, a manufacturer of nanotubes. In the beginning of 2010 Bayer MaterialScience AG started up a pilot plant based on a new catalyst technology; it can produce 200 tons of CNT per year. "Through the Inno.CNT we want to advance the transfer of the exceptional material properties achieved on a laboratory scale into real products," states Inno-CNT cluster manager Holger Hoffschulz from Bayer Technology Services. The range of subject areas covered by the innovation alliance is as broad as its membership. 14 subprojects are focusing on the key future issues of mobility, lightweight construction, energy and environment. At the same time, four major overarching projects will concentrate on the production of nanotubes, their processing and evenly distributed integration in substrates such as plastic or metal. Safety is also a special subject area, because nanoparticles contain respirable substances which pose a risk to health.

www.inno-cnt.de/en/

In all applications the shape of the CNT plays a decisive role. This means not only its diameter and length, but also its defect density and wall structure. A distinction is made between single- and multi-walled nanotubes. The multi-walled types – as produced by Bayer – are available on the market at around 100 euros per kilogram. Single-walled tubes are higher grade, but their price is currently about the same as gold (30,000 euros per kilogram) because it has not yet proved possible to produce them in large volumes in a continuous process.

The Fraunhofer Institute for Material and Beam Technology IWS in Dresden is now experimenting with a new process and has achieved initial success. "We are already able to produce one kilogram of single-walled CNT per week," says working group manager Oliver Jost. He intends to increase the rate of production to one kilogram per day. The quality of the product too is promising. The tubes have a diameter of just one nanometer and a relatively defect-free structure. The Fraunhofer experts put the current cost at around 8,000 euros per kilogram – which beats the competition by a long way. "We could even get that down to 1,000 euros," Jost adds confidently.

For many applications the cheaper multi-walled CNTs fit the bill, especially as far as mechanical properties are concerned. In such cases nanotubes serve as reinforcing fibers in composite materials. Fiber-composite materials are playing an increasingly important role, in aircraft, automobiles and wind turbines, for example. Lightweight polymers are often seen as an alternative to heavy metal in the production of components. By increasing the strength of plastics, weight can be further reduced, thus saving fuel. The dimensions of the components can be made more compact while retaining the same loading capacity. The aim of CarboAir, a project being conducted within the Inno.CNT, is to achieve a weight saving of ten percent. Experts intend to build a small rotor blade for a wind turbine as a demonstrator; it is expected to last twice as long as a conventional blade. "We thought that this task would in fact be easier than it actually turned out," says Florian Sayer from the Fraunhofer Institute for Wind Energy and Energy System Technology IWES in Bremerhaven. The nanotubes resist being evenly distributed in the matrix, and tend to go lumpy. Nevertheless, Sayer believes that they are on the right track. In some cases, the strength of the workpieces has been substantially increased, even though CNTs only make up about half a percent of the total matrix components used.

Saving weight

Similar results were experienced by Thomas Hutsch from the Fraunhofer Institute for Manufacturing Engineering and Applied Materials Research IFAM in Bremen, who is working on CNT-reinforced metals in the CarboMetal project. "We have proved the reinforcement mechanism," he explains, but the optimum has not yet been reached because the selection of suitable carbon nanotubes and their integration are still causing problems. Fiber-reinforced metals are needed where low weight and high loading capacity are required at elevated temperatures, for instance in a hot engine.

The focus is also on weight reduction in the CarboProtekt project, in which foam materials, such as those used in motorcycle helmets and automobile bumpers, are reinforced with CNT. The aim is to attain a weight reduction of 20 percent, which seems feasible when as little as two percent CNT is used. Axel Kaufmann from the Fraunhofer Institute for Chemical Technology ICT in Pfinztal, who is dealing with the subject, believes that CNT research is generally making good progress: "We have reached a stage where CNT can be produced at a reasonable price. We now have to iron out the details for making volume production possible." ■

Solar cell know-how

The future belongs to solar electricity. More and more people are using environmentally-friendly solar power. Solar cell production is increasing globally, whereby modules made of silicon are still the most common. It is not easy, however, to produce these modules on a large scale, as the silicon wafers are very fragile and the robot arms used in mass production are often too 'clumsy'. Researchers from the Fraunhofer Institute for Manufacturing Engineering and Automation IPA in Stuttgart are currently developing new technical solutions in the HighSol project, funded by the EU's Sixth Framework Program. In a recently opened Demonstration Center, engineers and scientists can test various grip techniques and examine them with high-speed cameras. Initial results are now available. "Whereas the entire production has until now often been carried out using a single type of gripper," explains Christian Fischmann of the IPA ,"not all handling methods are equally well suited to every step of the process. Ultimately, we need to achieve the right balance between sensitivity, speed and operational costs."

Building boom

China's construction business is booming. According to UN estimates, 350 million Chinese will move from the countryside to towns and cities in the next 20 years. This migration presents the cities with enormous logistical and construction problems.

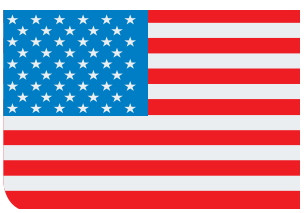
Fraunhofer researchers from the "Fraunhofer Building Innovation Alliance" BAU, an affiliation of 16 Fraunhofer institutes, are introducing solutions at the "Germany and China – Moving Together" event. The presentation is touring the most important centers in China, before making a final stop at the world exhibition in Shanghai in 2010.

At exhibitions, conferences and workshops researchers are showcasing new technologies that can help to build or renovate houses and residential estates in a way that is sustainable and compatible with healthy living. Presentations also demonstrate how flexible commuter transport systems can be integrated.

IT acoss borders

Europe is growing together, politically, economically and culturally. This has led to a growing tendency for public administrators in towns, municipalities, states and countries to work together across borders. The EU Services Directive, for example, in force since the end of 2009, stipulates that companies must provide a number of services throughout the EU – even in countries in which they do not maintain a branch office.

If information is to be exchanged across borders, IT solutions must be able to adapt to different administrative structures, languages and technologies. "The different linguistic and cultural backgrounds of the partners involved make it difficult to achieve this level of consistency. Misunderstandings are inevitable if terms, data structures and writing conventions are used in different ways, and meanings differ – regardless of what systems are used," explains Lutz Nentwig, manager of the eGovernment group at the Fraunhofer Institute for Software and Systems Engineering ISST. As part of the EU's "SEMIC.EU" (Semantic Interoperability Centre Europe) project, the ISST, together with]init[AG, GEFEG GmbH and France Telecom R&D, is developing software solutions for transnational eGovernment in Europe, operating across administrative, technical and linguistic borders.



Logistics for the USA

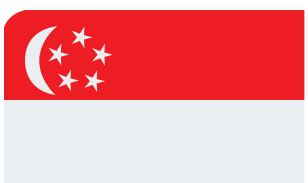
Researchers from the Fraunhofer Institute for Material Flow and Logistics IML in Dortmund intend to work even more closely with the Material Handling Institute of America MHIA in Atlanta, Georgia. The two institutes signed a Memorandum of Understanding during a trip by the former North Rhine Westphalian Minister of Science, Professor Andreas Pinkwart. TU Dortmund University also gained a new cooperation partner – the Georgia Institute of Technology.

"The agreements strengthen and reinforce the very successful cooperation that has developed between our scientific institutions in the area of logistics. They are both top global institutions and enjoy the highest international renown," concluded Prof. Michael ten Hompel. Prof. Uwe Clausen added, "We will continue to strengthen our existing cooperation on the optimization of transport logistics and air traffic management."

Energy performance

Johannesburg is the first city in South Africa to introduce energy performance certificates for their own building stock. This certification system was developed five years ago in Germany, and the calculation tools for it were devised by research scientists at the Fraunhofer Institute for Building Physics IBP in Stuttgart.

The technique has now been specially reworked for building certification in South Africa and adapted to the climatic conditions there. The aim of the EnerKey project is not only to increase the energy efficiency of public buildings, but also to improve access to energy resources and take environmental awareness of energy use into account. Alongside the IBP, the project members are TÜV Rheinland, the University of Johannesburg and the Council for Scientific and Industrial Research. The research scientists involved hope the EnerKey project will play a part in the sustainable development of Johannesburg.



Center in Singapore

Now that anyone can surf the web using just a tiny cell phone, interactive digital media are seen as a major growth market for the future. The Fraunhofer Institute for Computer Graphics Research IGD in Darmstadt and Nanyang Technological University in Singapore have established a joint project center, where research scientists will develop computer graphics, computer vision and virtual as well as augmented reality for internet-enabled cell phones.

"The leading scientists in Asia conduct research on interactive digital media at Nanyang Technological University," stated Dr. Wolfgang Müller-Wittig, head of the new project group, when the agreement was signed. "The Asian market is well known for its products in this sector. There is a wide field of activity for us here." German research minister Annette Schavan described the establishment of the project center in Singapore as a "success for the European research community".

New IR laser

Lasers are already firmly established in manufacturing, consumer electronics and medicine. They weld metal, send data through fiber-optic cables, read music CDs and harden dental fillings. But their technical potential is still far from being exhausted. The lasers of the future will be smaller, cheaper, more flexible and energy-saving.

The EU's VERTIGO project brings together research scientists to develop special laser modules that are not only compact, efficient and powerful but also emit in particularly long-wave infrared light. They are thus suitable for use in medical technology and in optical sensors – e.g. for detecting dangerous turbulence to the rear of aircraft as they take off.

Institutes and companies from the UK, France, Poland and Germany worked together, coordinated by the Fraunhofer Institute for Applied Solid State Physics IAF in Freiburg. The new products based on these IR laser systems are under development by the German company LISA Laser. It should soon be available commercially, built into sensors and medical devices.

Cancer drug on test

The Australian healthcare company Prima BioMed Ltd. and the Fraunhofer Institute for Cell Therapy and Immunology IZI in Leipzig will soon be working closely together. The autologous tumor vaccine CVacTM, developed by Prima BioMed, is to be produced in Leipzig next year for clinical trials as a test preparation. The therapeutic agent is based on dendritic cells and activates the body's own T cells. These activated T cells detect degenerated cells in the body and eliminate them, with almost no, or only very slight, side-effects expected. CVacTM is one of the new generation of immunotherapeutic pharmaceuticals. On completion of the clinical studies the Australian developers intend to market the drug internationally. The requisite clinical trials are to be conducted in various European hospitals, including tests centers in Leipzig.

A green future with laser light

Great leaps in technology rarely happen in isolation–the shift towards renewable energies will create markets not only for electric cars but also for new, environmentally friendly manufacturing techniques.

Text: Monika Weiner

The home of the American automotive industry: Detroit.
© David Rochkind/Rapport/laif

Not previously regarded as a pioneering force in climate protection, the USA currently seems to be turning expectations on their head. General Motors will launch its first electric car before the end of this year – and if the automotive giant's website is to be believed, the VOLT is set to change the world. One thing is for sure: US car makers, which were hit hard by the economic crisis, are currently pinning all their hopes on clean, emission-free mobility. They hope to dominate the world market with a new generation of electrically powered vehicles. The industry is being supported in this endeavor by the US government and the state of Michigan – home to the "Big Three" auto producers Ford, General Motors and Chrysler – as well as by several automotive component suppliers.

The American Recovery and Reinvestment Act saw the government set aside 2.4 billion dollars to support new technologies for hybrid and electric vehicles. The aim of the program is to rapidly ramp up production capacity for new battery technologies and to develop efficient electric motors. 1.4 billion dollars has already been channeled to battery developers and manufacturers in Michigan, who are also receiving state-level support in the form of tax breaks. That may seem like a lot of money, but the future of the American automotive industry, and its hundreds of thousands of jobs, is at stake.

America forges ahead, ploughs billions into e-mobility

Researchers in companies and at universities are working around the clock to develop technologies that will give cars a gas-free future. "The Americans are way ahead of the Europeans – more than 1.6 million hybrid vehicles have already been registered in the USA. The USA and Japan together make up 90 percent of the world market," says Stefan Heinemann, director of the Fraunhofer Center for Laser Technology CLT in Plymouth. In close collaboration with researchers at the University of Michigan in Ann Arbor, just 30 minutes' drive away, he is busy developing new manufacturing processes for the automotive sector. "Our goal is not just to develop and test economical and energy-saving method – we are also seeking ways of integrating those methods into the production process," he says. Laser technology plays a fundamentally important role, as Heinemann explains: "It provides us with a quick, clean, non-contact technique – and that saves time and money when you are manufacturing lithium-ion batteries". Cutting costs is a priority because batteries are expensive – in fact they are currently the costliest component of an electric car. The success of e-mobility depends to some extent on whether efforts to produce economical batteries bear fruit.

In theory, the manufacturing process is simple: a battery pack consists of several dozen small battery cells, each of which comprises a small cylinder containing an electrolyte solution and a stack of thin, electrically conductive layers – the electrodes. The cylinders are sealed with only the electrical contacts protruding from the top, and when connected together the cells create a powerful battery that can store enough energy to power an electric car over a distance of between 60 and 300 kilometers.

Of course, the devil is in the detail: producing the batteries is a relatively costly process precisely because the electrically conductive films from which the electrodes are fabricated are so thin, making it difficult to achieve smooth, clean-cut edges. To get good results, engineers currently have to make regular adjustments to their cutting and punching tools and constantly replace the blades, resulting in lengthy disruptions to production and high tool costs. But Stefan Heinemann's team at the CLT have now come up with an alternative. In their pilot plant the film is held in place by a vacuum and cut using laser light. The process is ten times faster than traditional cutting or punching tools – plus it produces less scrap and slashes the time spent on machine maintenance.

So if laser cutting is so simple, why is it not already the method of choice for battery production? "Engineers have always been concerned that the heating involved would alter the material properties of the thin metal films and impair the performance of the finished batteries," Heinemann explains. His team were careful to avoid this while developing their new process: "We always try to work with minimal energy levels. The technique that works best involves pulsed solid-state lasers with wavelengths between 0.6 and 0.1 micrometers which travel over the electrode film at speeds of up to three meters a second, guided by a scanner. There are two advantages to this method: the cutting time is short, and the laser radiation is exactly at the level at which electrode films have their absorption peak. So, we can cut the material faster and more efficiently, and hardly any energy is lost."

Lasers optimize the production of flat-type batteries

Researchers at the Fraunhofer Institute for Chemical Technology ICT in Pfinztal have found that the quality of the cut when producing electrode films using laser cutting is no worse than the cut of comparable films produced using traditional tools. Dr. Jens Tübke studied the samples from the USA under a scanning electron microscope to detect any possible changes to the material properties at the cut edges, and then he and his team fabricated test cells from the electrodes cut in the USA and subjected them to various tests. "We were able to check long-term stability by repeatedly charging and discharging the batteries. None of our tests detected any differences between traditional films and the films produced using laser cutting, and we also got the same results for the fully assembled flat-type batteries," Tübke reports.

But laser technology can be used for more than just cutting electrode films – it is also a useful tool for manufacturing and assembling the batteries themselves. Heinemann and his team use light to seal the cylinders containing the electrodes and electrolyte solution and then weld them together, saying "It is faster and more economical than traditional welding methods." Development of the process is now complete, and the Fraunhofer researchers are busy building their first prototypes for manufacture. Once the machine is approved for full-scale production, it will be able to produce tens of thousands of batteries a year for both the American and German automotive industries.

"Laser technology still has so much untapped potential," Heinemann sums up. "The need to save energy and the switch to renewable energy sources will throw up all sorts of new challenges, and we will need to come up with innovative solutions in fields such as lightweight component production, solar cell manufacture, and the development of new energy storage methods. Laser technology is faster, more versatile and more economical than traditional methods – we can only guess at the huge opportunities it could open up for us in the future." ■

Teleconferencing at home

New audio and video technologies could help people who live hundreds of miles apart to play a game of Scotland Yard together, exchange photos – or simply get together for a chat.

Text: Birgit Niesing

Friends who are miles apart can use their TV and hi-fi systems to sit around a virtual coffee table.
© Victor S. Brigola

"Mom, dad, where do you think Mr X is hiding? I think he's somewhere around King's Cross station", Lea says, excitedly pointing at the screen embedded in the coffee table, which is showing a map of London. "Let's try and trap him there so he can't escape – I'll take a taxi straight to the station!", she says, explaining her strategy to her fellow players. "Sorry little sister, you're on the wrong track. You'll have to wait till the next move to find out where I am!", laughs her brother Daniel from the big TV screen. Even though he left to study in Paris six months ago, he hasn't missed a single one of his family's weekly games of "Scotland Yard" in Wiesbaden – he just joins in over the Internet. That way he can always stay in touch with his parents and younger sister – and when he looks at the flatscreen display in his student accommodation and sees his family at home on the sofa, he almost feels like he is sitting at the table with them.

This kind of shared games evening could soon become a reality thanks to the Internet, new video and audio technologies and high-quality compression techniques designed to enable families to play games together even if they live hundreds of miles apart. Researchers working on the EU-funded project TA2 ("Together anywhere, together anytime") are striving to make group communication over the Internet better and easier. Thirteen partners from seven different countries are involved in the project.

www.ta2-project.eu

"People are so mobile nowadays, it is perfectly normal for family members or friends to head off to other cities or countries to study or work", explains Nikolaus Färber from the Fraunhofer Institute for Integrated Circuits IIS in Erlangen, which is one of the partners in the project. However much we stay in touch using e-mail, the Internet, mobile communications and video chats, those PC and cell phone solutions can generally only be used by one person at a time. They are therefore not suitable for group communication between families or friends.

"As part of the EU project, we're working on technologies that facilitate group communication", says Färber. The idea is that the new systems – which should be easy to install in a normal living room – will enable families or friends to see each other on their TVs, listen to each other through their stereo systems, exchange photos and videos, and play games together. The aim is to make it feel as natural as possible, as if far-away friends were actually sitting at the same table. That means high-quality images and natural surround sound are crucial, because the jerky images and distorted voices that characterize many of today's videoconference systems often make it a struggle to communicate. IIS researchers recently presented a delay-optimized version of the H.264 video codec at the consumer electronics trade fair IFA in Berlin. The codec – developed as part of the TA2 project – has been optimized for use in high-quality communication systems and offers crystal-clear images in high definition without noticeable delay. The codec has been designed to run on a normal home computer and uses a special capture card to further reduce delay. By minimizing the cost of special hardware, the researchers meet their ultimate goal of smoothly introducing the technology into people's living rooms. The optimized variant presented in Berlin is based on the H.264 standard, which was developed by a team that included researchers from the Fraunhofer Institute for Telecommunications, Heinrich-Hertz-Institut, HHI.

The high-quality audio solution is based on the "Audio Communication Engine" developed by Fraunhofer researchers. It integrates three distinct elements to significantly enhance the experience of today's phone- and videoconference solutions. At its core is the "Enhanced Low Delay AAC" MPEG audio codec, which guarantees hi-fi sound quality with low data rates and low delay.

CD-quality phone calls

Annoying echo is eliminated by the echo controller. " Echo control may be nothing new, but our technology is extraordinarily robust and user-friendly. You can place the microphones anywhere in your home and even move them around while you are talking. The echo control can also cope with people entering the room or noise building up from outside", says Färber, outlining the technology's benefits. " The implementation has been optimized to such a degree that the echo control will even run on basic processors, which makes the devices cheaper." The third element is powerful streaming technology which ensures good audio quality even in poor-quality networks.

This audio solution can also be applied to mobile communications. The "Audio Communication Engine for LTE-A (Long Term Evolution Advanced)" means that phone calls with CD-quality audio are now a reality in fourth-generation (4G) cell phone networks. Voices sound crystal clear – as natural as if you were in the same room – and the other big plus is that music and multimedia can be reproduced at top quality.

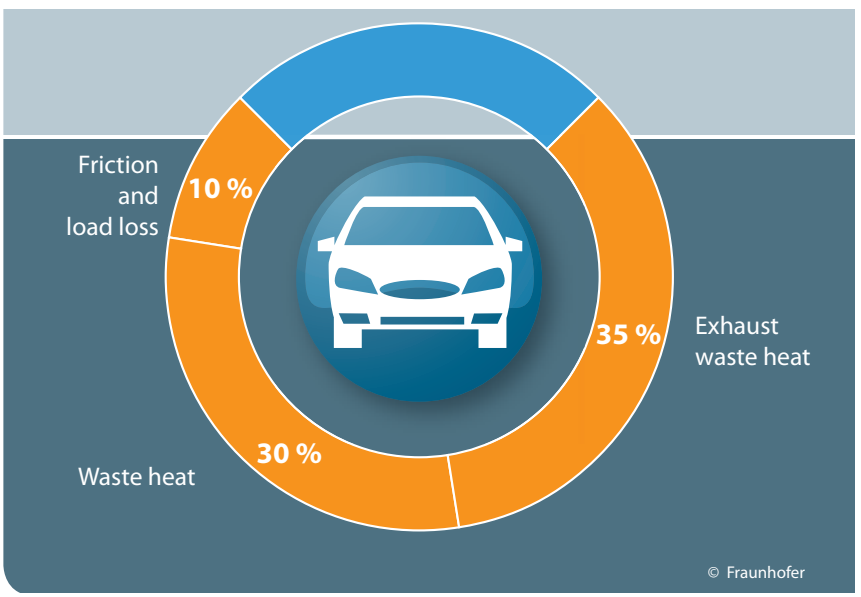
In summary, excellent sound quality is assured thanks to the "Enhanced Low Delay AAC" MPEG audio codec, echo control and the streaming system. "4G network operators can offer the kind of hugely improved voice quality that today's network technologies simply aren't up to: telephone conferences are less hassle and easier to follow, phone calls are clearer even in noisy settings, and streaming music sounds just like playing a CD", says Färber, summing up the benefit. ■

Atomic cherry cake

Machines generate heat. Rather than letting this heat go to waste, scientists are now harnessing it to produce electricity.

Text: Tim Schröder

Energy efficiency of an automobile
Energy input (fuel) 100 %
25 % actual output
75 % energy loss



Anyone who has burnt their fingers on a hot motorcycle exhaust will have learned the hard way that machines produce heat. This is true not only for internal combustion engines but also for computers, food mixers or factory robots. Wherever work is done, waste heat is produced. Up to now this energy has been lost into the atmosphere, which is a great waste. In view of depleting energy resources, research scientists throughout the world are now developing techniques for utilizing waste heat, including thermoelectric converters – 'thermoelectric batteries' – which convert thermal energy into electrical energy. This can then be used as electric power. The first thermoelectric batteries were developed more than 40 years ago for space flight, but they were heavy and expensive. Although thermoelectric batteries are now produced in high quantities, they are still relatively pricey, because rare and expensive elements are needed for their manufacture. Scientists are looking for ways to make this technology cheaper and more efficient so it can be used in mass markets. One approach is to use nanostructured materials – layered like a cherry cake but on an atomic scale.

The secret of a thermoelectric battery lies in thermoelectric materials with extraordinary properties: they must be able to withstand heat while delivering high voltages like a conventional battery, and they must be good electrical conductors but at the same time have very good thermal insulation properties, since they have to make use of temperature differences. A thermoelectric battery is particularly effective when the temperature difference between the hot side – for example on the exhaust – and the cold side – where the coolant cools the material – allows a high voltage to be generated. The electrons should be able to flow as freely as possible from the hot side to the cold side.

Combination of germanium and silicon

A European research team, including experts from the Fraunhofer Institute for Physical Measurement Techniques IPM in Freiburg, has now achieved a major advance. By combining germanium and silicon at the atomic scale they have created a new thermoelectric material with outstanding physical properties. The scientists published their initial results recently in the high impact journal "Nature Materials".

The new thermoelectric material was produced in a vacuum chamber at IPM. Using a microscopically fine laser tip the scientists vaporized silicon and germanium atoms and deposited them onto a silicon plate to grow an extremely thin crystal. Through precise control of the quantities of silicon and germanium, the temperature and other parameters, the germanium atoms arranged themselves in the silicon like cherries in a cake to form small islands, known as dots. "The tricky part is to grow the crystal in such a way that several clean layers of germanium dots and silicon form without any faults in the crystal," explains Armando Rastelli from the Leibniz Institute for Solid State and Materials Research, who heads the "Nanostructured insulators made of silicon" cooperation project. Normally, pure silicon is an excellent thermal conductor. This is essential for computer processors, because the components would get too hot if the heat could not dissipate. For thermoelectric elements,

The cooperation partners

- Institute for Integrative Nanosciences of the IFW, Dresden
- Max Planck Institute for Solid State Research, Stuttgart
- Fraunhofer IPM, Freiburg
- CEA Grenoble, Frankreich
- CNRS Bordeaux, Frankreich

however, the opposite is required. They need to exhibit as little thermal conductivity as possible. The presence of the germanium dots converts this material into an excellent thermal insulator. Physicists refer to heat oscillations being dispersed by the dots so that the oscillations cannot pass so easily through the silicon. The silicon-germanium crystal the scientists have grown retains heat about as well as glass. At present the new material is still an expensive prototype, but it is excellent quality – twice as good as similar materials from American research laboratories.

Measuring the physical properties is an art in itself. Alexendre Jacquot, a physicist at the IPM, succeeded in examining the new thermoelectric material using special equipment. A tiny metallic measuring strip, which heats up when an alternating electric current is applied, was fastened to the material's surface. If a component is a good thermal conductor, the surface will hardly heat up because the thermal energy is conducted away. A very good thermal insulator, however, will largely prevent the heat from dissipating and the surface temperature will rise. The equipment does not measure the heat directly but instead calculates it on the basis of the change in frequency of the alternating current generating the heat – a complex but precise approach. "The equipment enables us to assess the properties of the material samples very precisely," says project manager Rastelli, "and at the same time we have verified a high-precision measurement technique."

The new material could be put to use in a number of settings, but the present electron beam production method is too expensive for industrial use. This is why for some time now the Fraunhofer research scientists have been working on an alternative technique – using the sputter method to deposit the material in the vacuum chamber in larger quantities. Jacquot is certain that completely new ways of manufacturing thermoelectric components could be opened up if the efforts to produce silicon-germanium layers with excellent thermoelectric properties are successful. IPM scientists have already developed other unusual ideas in the field of thermoelectrics through to market maturity – for example, extremely efficient microcoolers and microthermogenerators, which are now manufactured by the company Micropelt. ■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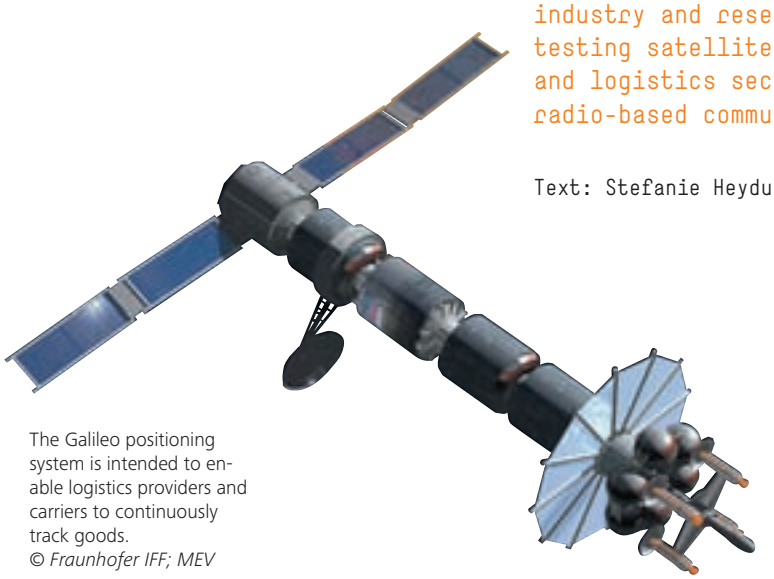
Galileo knows where your parcel is

The most advanced development lab for localization, navigation and communication in transportation and logistics is located in Magdeburg. At the Saxony-Anhalt Galileo Test Bed, industry and research partners are jointly developing and testing satellite-based applications for the transportation and logistics sector, public transportation, telematics and radio-based communication.

Text: Stefanie Heyduck



The Galileo positioning system is intended to enable logistics providers and carriers to continuously track goods.
© *Fraunhofer IFF; MEV*

Where's the package I've been waiting on for over a week? How long has the lettuce from Greece already been in transit on road and rail? The Galileo satellite navigation system will help provide answers to these questions in the future. At the Saxony-Anhalt Galileo Test Bed, industry and research partners are jointly developing and testing satellite-based applications for the transportation and logistics sector, public transportation, telematics and radio-based communication.

"The long-range goal is to interconnect different transportation, logistics and mobility technologies and develop new logistics services. For instance, by integrating dynamic traffic data for intelligent and green delivery logistics in the smart city, by developing new container concepts for perishable goods logistics or by incorporating new radio technologies for the intelligent port," explains Prof. Michael Schenk, Director of the Fraunhofer Institute for Factory Operation and Automation IFF. The Fraunhofer IFF is one of the regional partners operating the test bed. The Institut für Automation and Kommunikation ifak in Magdeburg, Hallesche Verkehrs-AG (HAVAG), the city of Magdeburg and Magdeburger Hafen GmbH are additionally involved. In the future, the lab will also be utilized for programs in applied transport research at Otto-von-Guericke University Magdeburg. Nearly three million euros are being invested in the Saxony-Anhalt Galileo Test Bed, which Otto-von-Guericke University Magdeburg is coordinating. It is being financed with funds from the state and the Economic Stimulus Package II.

Right down to the centimeter

The European Galileo satellite system is more precise than the American GPS and will make it possible to locate raw materials, goods, people or vehicles and global flows of commodities down to the exact centimeter. Combining the Galileo positioning system with other available localization, identification and communication technologies will facilitate the development of optimal continuous outdoor and indoor tracking solutions for every specific application. The Fraunhofer IFF is concentrating its research on the continuous tracking of goods among logistics providers and carriers. Since permanent storage facilities are being shifted to the road, both the number of shipments and the value of the goods are increasing. Security requirements are mounting, too. Logistics companies estimate that 80 percent of all irregularities occur during transfers. However, there can be difficulties in transit too. Studies document that theft of road freight causes economic damage of several billion euros a year and this trend is on the rise.

In the future, identification and localization solutions will guarantee that assets and goods are monitored without interruption. Fraunhofer researchers test such systems at the Galileo test bed. The test bed's infrastructure sprawls over the cities of Magdeburg and Halle (Saale). The lab's testing facility and outdoor grounds are located in Magdeburg's Port of Science.

Smart parcels

The test bed is also available for contract research and companies may use it directly. DHL, for instance, intends to employ a newly developed dynamic dispatching and routing system to make DHL Express's pick-up and delivery of urgent deliveries faster, more reliable and more environmentally compatible. Dr. Keith Ulrich, Head of DHL's Research & Innovation Division, says, "For us, this is essentially about flexibly managing flexible logistics networks. Satellite navigation opens entirely new opportunities for us. The development lab will enable us to devise new logistics concepts using current geodata to react to traffic jams or road construction."

The experts from the Fraunhofer IFF are testing such an application on the SmartTruck at DHL. The truck is equipped with RFID systems that fully scan the interior. Data on the current traffic situation are additionally referenced to calculate the optimal delivery route for shipments.

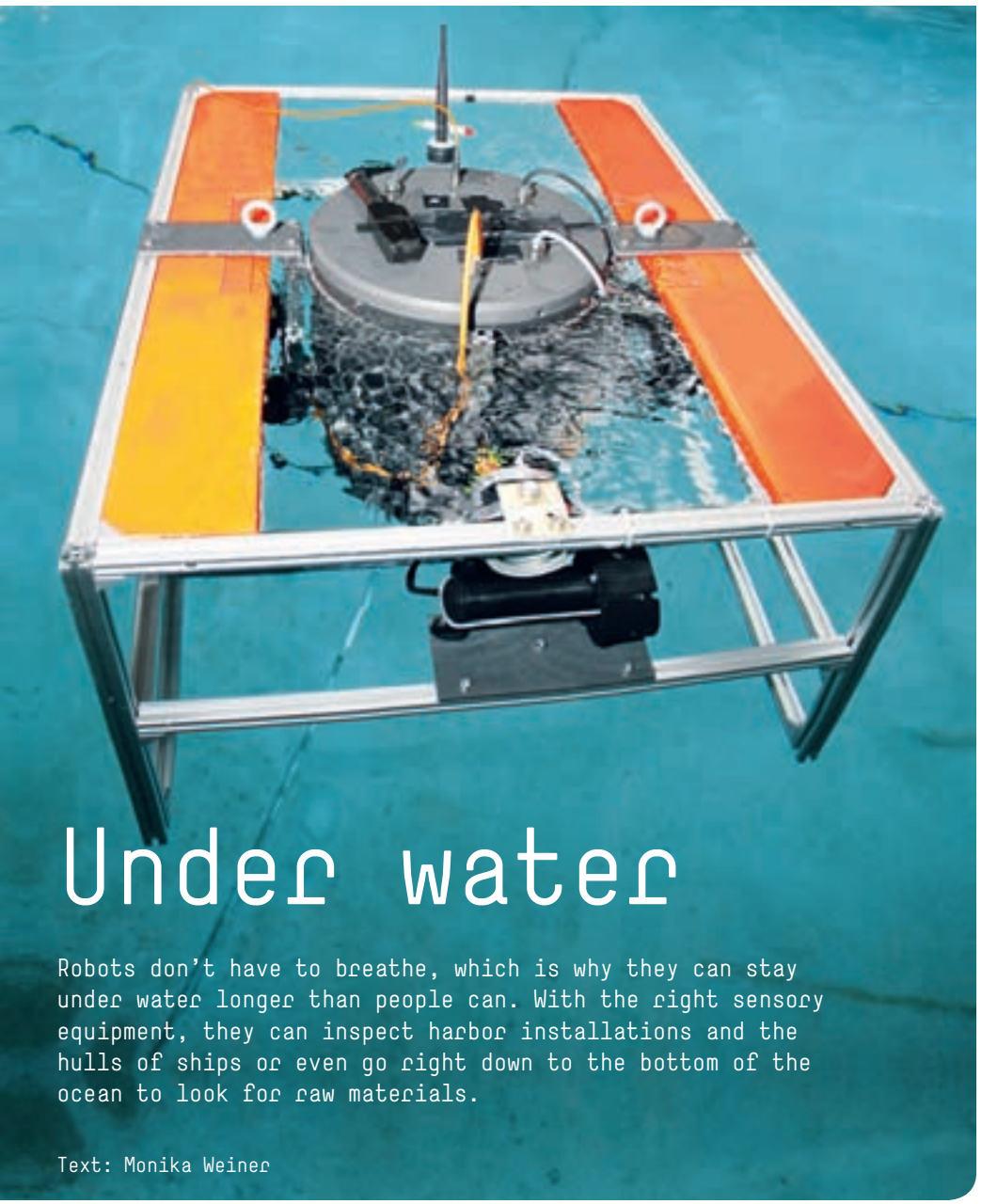
That not only cuts kilometers in transit. It can also significantly reduce CO_2 emissions. Moreover, monitoring the vehicle's interior assures that it is loaded and unloaded correctly. The SmartTruck also makes a delivery person's work easier: at a stop, the rack displays the position of the next item to be delivered.

Intelligent containers

The supply chain can be monitored even more precisely when swap bodies are equipped not only with RFID tags but also sensors that measure temperature or acceleration, for example. This makes it possible to track whether the cold chain has also been maintained.

One of the Magdeburg researchers' first industry partners intending to apply the swap body principle is the new logistics provider Fresh Parcel, a parcel service for fresh foods requiring temperatures between +2 to +7 degrees Celsius. The company wants to have its nighttime sorting performed solely at a single hub.

Shipments are packed in actively cooled interchangeable containers, which are self-cooling on both the truck and the trailer. The investors are collaborating with the Fraunhofer IFF's logistics experts at the Galileo test bed to make their "refrigerator on wheels" even more efficient and flexible. In the future, this will guarantee that vegetables, fruits and meats are fresh when they arrive at supermarkets. ■



Diving down – underwater robots are being tested in the recently built research tank.
© *Fraunhofer IOSB*

Under water

Robots don't have to breathe, which is why they can stay under water longer than people can. With the right sensory equipment, they can inspect harbor installations and the hulls of ships or even go right down to the bottom of the ocean to look for raw materials.

Text: Monika Weiner

Under water, people come up against their limits very quickly because they can only survive for a couple of minutes without breathing. Scuba divers equipped with compressed air tanks and automatic diving regulators are able to go deeper, but they still can only stay there a limited period of time. The reason is the fact that the deeper divers go, the greater is the exterior pressure and therefore also the air consumption. Beyond this, the solubility of oxygen in the blood also changes which can cause physiological problems at greater depths.

People can use submarines to submerge longer and deeper. Inside air pressure is built up that equals that on the surface. Passengers do not notice the enormous water pressure at a couple of hundred or even thousand meters down. Unfortunately, this luxury has a price because manned submarines are so expensive that only large-scale research institutions and the military can afford them. This is also why unmanned underwater vehicles are less expensive if they are connected by cables to central control equipment that might be on the banks of the river, a drilling platform or a research ship. Equipped with cameras, sensors and grapplers, remote-controlled diving robots are used these days for research, inspection and service work. The trouble is that the usefulness of this equipment is limited by the length of the cable and the navigator's skill because steering an underwater vehicle in 3-dimensional space is a real art.

No wonder that engineers all over the world are looking for easier and more flexible solutions. Researchers have been working for years to develop autonomous underwater robots that can find their way under water and can work without human intervention. There are AUVs (short for autonomous underwater vehicles) that can gather data or take samples all by themselves before they return to the point of origin. Dr. Thomas Rauschenbach, the director of the Application Center System Technology at the Fraunhofer Institute for Optronics, System Technologies and Image Exploitation IOSB in Ilmenau, Germany, explains: "This technology is enormously versatile, although to date it has been limited to niche markets. It is still too expensive for routine jobs such as inspecting sheet piling, masonry dams or ships' hulls."

The new generation of autonomous underwater robots

That might change soon. Together with researchers at four Fraunhofer institutes, Rauschenbach's team is presently working on a generation of autonomous underwater robots that will be smaller, more robust and cheaper than the previous models. These new AUVs should be able to find their way in clear artificial mountain lakes just as well as in muddy or moving harbor water. That means that they should be equipped for working on the ground of a deep lake just as well as for inspecting flat concrete pedestals that offshore wind power plants are mounted on. Rauschenbach adds "The presently available market studies postulate an increasing need for AUVs. Service work is becoming increasingly automated, and interest is burgeoning in the deposits of raw materials at the bottom of the ocean. The energy stored in the form of methane hydrates at the bottom of the ocean, for instance, exceeds the presently known deposits of petroleum and natural gas." If we believe the forecasts of the technological visionaries, in the future these raw materials will be processed right on site, i.e. at the bottom of the ocean - and that is something else underwater robots are needed for.

The expected demand is spurring research, which is why scientists and engineers all over the world are working on new AUVs. As far as Rauschenbach is concerned, "what's different

about us is the fact that we are interdisciplinary. The Fraunhofer institutes involved in this project have decades of experience in coming up with sensors, image-analysis processes, batteries and control equipment."

Seeing under water – cameras are the robots' eyes

The engineers at the Fraunhofer Institute for Optronics, System Technologies and Image Exploitation IOSB in Karlsruhe, Germany, are building "eyes" for the underwater robot. Optical perception is based upon a special illumination and analysis technology that makes it possible for them to orient themselves even in muddy water. The first step is ascertaining the distance to the object. Then the camera transmits a laser impulse that is reflected by the object (such as a wall). The camera screen opens some milliseconds before the reflected flash of light arrives which means that the sensitive sensors can collect the incident pulses of light. The camera equipment makes sure that incorrect information caused by reflections on suspended particles in the water are not even registered, which means that meaningful images can be made even in the dirtiest harbor water. Rauschenbach's team has developed the robot's "brain" in the Ilmenau-based part of the Fraunhofer IOSB, System Technologies and Image Exploitation. This is a control program that keeps the AUV on course even when there is a current – for instance, at a particular distance to the wall that is supposed to be studied. They will be testing this software with the three existing under-water vehicles in Ilmenau until the robot has been completely built.

Finally, the new robot's "ears" come from the Fraunhofer Institute for Biomedical Engineering IBMT in St. Ingbert, Germany. Ultrasound sensors help it stay oriented so that it can study objects. In contrast to the previous and relatively long-wave sonar technology, these researchers are using high-frequency sound waves that are reflected from walls or obstacles and then registered by the sensor. High-frequency waves even make it possible to track down fine cracks. The experts at Fraunhofer have come up with their own technology to make the sensor fit for underwater use. The electronic components are poured into silicone under a vacuum, which is how they stand up to pressures of 600 bar (corresponding to the pressure 6,000 meters deep) without needing a heavy and expensive housing. The high-performance and simultaneously lightweight lithium batteries of the Fraunhofer Institute for Silicon Technology ISIT in Itzehoe that supply the underwater robots with energy are also covered with silicone. A special form of energy management that researchers at the Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT in Oberhausen, Germany, have come up with saves current and ensures that the data are secured in an emergency before the robot's energy is exhausted and it has to surface.

The eyes, ears, brain, motor and batteries are now built into a carrying frame similar to a torpedo. The prototype is approximately two meters long and 200 kilos heavy. It has just taken its maiden voyage in the new immersion tank on the grounds of the Fraunhofer Institute for Optronics, System Technologies and Image Exploitation in Ilmenau, Germany. This tank is only three meters deep, but, as Rauschenbach says, "that's enough to test the key functions. Moving fast and far is easy. The real challenge is maneuvering slowly in closer quarters, stopping and gathering data. Our immersion tank is ideal for that." The autonomous diving robots made by Fraunhofer will put to sea for the first time in fall of 2011 when the engineers will put their robot in the water from the POSEIDON research ship together with the scientists from the IFM-Geomar research center in the German city of Kiel. They are also planning several dives as deep as 5,000 meters.

As soon as tests are completed, the researchers want to continue to develop these prototypes to be ready for series production. Rauschenbach adds: "We can offer industrial customers either individual components or an overall system that can be modified depending upon the area of application. For instance, the underwater robots could be given a grappler for making independent repairs. We are targeting an AUV that can be used anywhere, works completely autonomously and simultaneously gathers the data that allow subsequent quality control." That would mean that the researchers would not only surpass human limitations, but also those of the previous equipment. ■

Robbie, please take over!

Carrying heavy crates, serving drinks and reliably documenting the work done – service robots can lighten the load for personnel in nursing homes. An initial practical test of mobile service robots shows that both care staff and residents accept the support provided by robots.

Text: Birgit Niesing

Care-O-bot® 3 fetches fresh drinks from the water dispenser and offers them to the residents of the nursing home. © *Fraunhofer IPA*

Maintenance robots which can see and feel

They are there when you need them: The service robots for maintenance support developed in the ImRoNet project can handle complex tasks in masterly fashion, they can control and monitor technical systems and they can instruct plant personnel. What's more, they are simple to operate and can already perform some movement sequences independently. An essential prerequisite to user support is that sensors scan the environment in detail, enabling the robots to "see" and "feel". This means the maintenance assistants can not only avoid obstacles but also carry out simple tasks on their own – for instance gripping an adjusting wheel precisely and opening or closing it with exactly the right amount of force. These systems were developed by researchers at the Fraunhofer Institute for Manufacturing Engineering and Automation IPA in Stuttgart, the Karlsruhe Institute for Technology and the industrial partners Beckhoff GmbH, metaio GmbH, GPS GmbH and Schunk GmbH & Co. KG.

For more than twelve years Nadine Petrova has been on the care staff of a nursing home. She washes the elderly people, feeds them, changes dressings and provides emergency treatment. She has to regularly record the tasks she has performed. Although the work is physically very demanding, she cannot imagine doing any other job. Her work also includes simple routine tasks which are not directly connected with caring for the home's residents, e.g. fetching and carrying. Last month a robot started to help her out with her care duties. It took over tiresome carrying tasks such as delivering mail, laundry and drinks, using its navigation system to move reliably from ward to ward. This new robot assistant is easy to operate either using a built-in touchscreen or via Ms Petrova's smart phone.

Another robot helps the care staff to serve drinks to the elderly people. In the day rooms it regularly takes drinks of water to residents who have not had enough fluids. But how does it know which of the residents have not drunk enough? Using an encrypted radio connection, the robot retrieves the information it needs to identify individual residents and their fluid intake from a database which both the automatic assistants and the care personnel use to record the quantities of liquid issued so far.

www.wimi-care.de/eng

This is broadly how mobile service robots could be deployed to assist care staff in future. Research scientists in the "WiMi-Care" project carried out a needs analysis in the elderly care sector to work out what tasks could be handled by robots. From this they derived two example scenarios – carrying drinks and serving them – and studied them in an initial practical test in the Parkheim Berg nursing home in Stuttgart. The WiMi-Care project, funded by the German federal ministry of education and research, brings together the University of Duisburg-Essen, User Interface Design GmbH, MLR System GmbH and the Fraunhofer Institute for Manufacturing Engineering and Automation IPA. The three-year research project was launched in November 2008. "The main goal of the initial test phase was to verify the technical feasibility of the selected scenarios and to obtain initial feedback about user acceptance. This we have accomplished," states Dr. Birgit Graf, Head of the Domestic Service Robotics/Personal Robotics Group at the Fraunhofer IPA.

The carrying function was tested in the initial phase using the CASERO® driverless transport system produced by MLR System GmbH, Ludwigsburg. CASERO® distributed mail and delivered laundry as well as drinks to the wards. Meanwhile, the Care-O-bot® 3 robot assistant, developed by research engineers at the Fraunhofer IPA, supplied the residents of the nursing home with fresh water. "The robot has a mobile base, an arm and a gripper, enabling it to carry out complex handling tasks, such as operating a water dispenser," explains Graf. A new version of Care-O-bot® 3, developed in the EU project BRICS, was used for the tests.

A simplified scenario was implemented for the Care-O-bot® 3's initial test phase in which "Robbie" filled a beaker in the water dispenser by pressing a button, placed the beaker on a tray and moved through a corridor into the day room, offering the water to the elderly people there. "The residents reacted very positively to the robot and quickly understood that they should take the beaker from the tray," explains Graf. The only negative point was that they then only rarely took a drink. One of the goals for the next project phase is "to give the robot a more convincing manner, so that it's not seen just as a novelty but so people take its promptings to have a drink seriously."

www.care-o-bot.de/english

The next tests are scheduled for the start of 2011. In addition to improved interaction with the users, the intention is to further elaborate and optimize the scenario by then so that the robot can perform several interaction cycles on its own, without the need for control and monitoring by the IPA staff. The research scientists also want to develop an additional scenario for the entertainment and animation of the residents in which, for example, parlor games or memory training programs can be started on the touchscreen, music played or poems read out. ■

3D – without the topping

Films in 3D are in fashion. Now, on the heels of such success in movie theaters, this form of presentation is moving forward to conquer living rooms, too. At the consumer electronics fair IFA in Berlin Fraunhofer researchers showed how 3D television is possible without special glasses.

Text: Beate Koch

3D movies are a hit in movie theaters, but they're also on the advance in home living rooms, too. Whether on the silver screen or the home theater, viewers need to wear shutter or polarized glasses if they want to be able get the three-dimensional – or, in experts' jargon the stereoscopic – viewing experience. That changes, though, once the developments of the Fraunhofer Institute for Telecommunications, Heinrich-Hertz-Institut, HHI in Berlin are considered. Developers there have been working for several years to make a vision come true: 3D without the glasses. The mark of their success is a display they call »Free2C_digital.«

"A 3D display is always based on the same principle," explains René de la Barré of HHI. "Two images are made visible, one for the left eye and one for the right." A sophisticated selected barrier sees to it that each eye views only the image content intended for it. To make this work, the viewer must hold his head absolutely still while viewing." That's no fun for anyone. Therefore we have linked the 3D display with an additional technology: electronic head-tracking. A camera sees the head and identifies the precise position of the eyes. This information is used to update the image content. Each movement of the head or eyes is registered, and the display is adjusted accordingly. The viewer always sees the perfect 3D image without having to put on an extra pair of glasses. "A process like ours that can do without glasses is referred to in the field as 'autostereoscopic,'" de la Barré explains.

At the trade fair in Berlin, he and his team exhibited another new development as well: a multimodal display. It allows viewers to toggle back and forth between different display formats. There is a multiview mode in which multiple views of a scene are projected. This enables multiple persons to see an image in 3D. This can be switched to single-user mode,

A special multiview mode projects multiple views of a scene. This enables multiple persons to see an image in 3D.
© *Ansgar Pudenz/alphadog*

either automatically or at the touch of a button. Single-user mode requires just two picture views and delivers a more intense experience of depth. "Our display technology is designed so that the 3D televisions now being introduced can be watched without wearing glasses," de la Barré describes. "That also solves a current problem. Because at the moment a 3D television picture cannot be displayed on a multiview display."

A perfect 3D-image for singles and groups

The reason: 3D television signals lack the needed additional information about depth. The current method for making 3D television recordings does not register depth information yet. The solution developed by HHI-researchers circumvents this lack of information. It uses just the two views broadcast – one picture each, left and right – and dynamically adjusts to the eye position of one or more viewers. "We have come up with a process that will enable us to provide these two views for even two or three viewers – instead of a single camera, we work with multiple cameras integrated into the display. We use them to track the eyes, tailoring the images perfectly for the different viewers," de la Barré observed.
The challenge with this autostereoscopic solution is to link multiview displays with eye-tracking and to deliver individually tailored picture content to each viewer in real time and free of distortion. One method patented by HHI adjusts picture content electronically on the display in keeping with the X-Y-Z positions of viewers' eyes. This occurs with virtually no delay. This way, a 3D display can be continuously adjusted in all directions in line with the viewer's position. The method also permits toggling back and forth between outputs of two or more views in response to the current number of viewers in the room. ■

The city that thinks with you

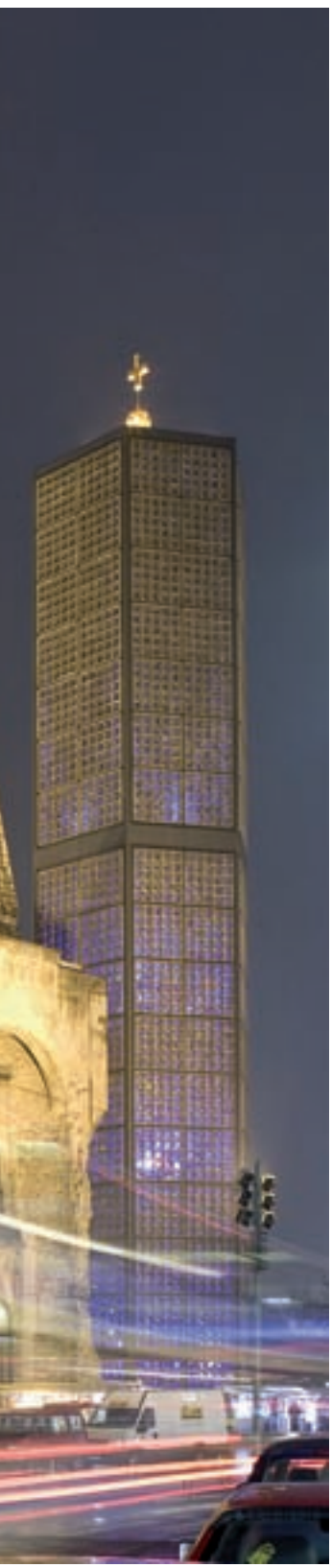
State-of-the-art information technologies have the purpose of improving transportation, environmental protection and governmental administration while driving down costs. Many people want to return to the cities. This is the reason why researchers at Fraunhofer are working on the city of the future together with policymakers and the private economy.

Text: Stefanie Heyduck

Only a high-performance broadband network makes a city a smart city.
© H. & D. Zielske / LOOK-foto

Smart City Projects from Fraunhofer

Scientists at a number of Fraunhofer institutes are researching the cities of the future to make sure that people can live securely, healthily and unbureaucratically in an energy-efficient fashion even when they are mobile. The model city of energy efficiency is emerging in the area of Abu Dhabi, the capital of the United Arab Emirates, which by the way is the most environmentally friendly city in the world. Masdar City runs exclusively on regenerative energies. Researchers from all over the world (including the Fraunhofer Institute for Solar Energy Systems ISE, the Fraunhofer Institute for Building Physics IBP and Fraunhofer Institute for Industrial Engineering IAO are involved in this project.



People who live in the city have long since gotten used to traffic jams, traffic noise and fine dust in the air, not to mention long waits at governmental offices and downtown crowding. Unfortunately, these problems will be increasing in a couple of years. These days, more than half of all people in the world live in cities, and the United Nations forecast that 70 percent of the global population will be living in cities by 2050. The crowded conditions in the core of the city cause apartment high-rises on the outskirts of the city to disappear and subsequently deteriorate, thus tearing holes into the cityscape. We have to rebuild this district to boost people's quality of life and increase its operating efficiency for business and trade.

But that's not all. Another challenge is the fact that more and more people are driving instead of walking again. One of the reasons is the fact that public transport is not keeping pace with the population explosion. If we want the environmental zones to function and keep cars with an excessive CO_2 footprint out of residential areas, we will have to come up with new drive and traffic management systems. How can we stay mobile? How can we manage traffic? How can we supply cities with environment-friendly energy? These are the hot-button issues that scientists and urban planners are grappling with by working on information and communication technologies that make intelligent cities out of megalopolises.

How a city gets smart

Professor Dr. Ina Schieferdecker from the Fraunhofer Institute for Open Communication Systems FOKUS in Berlin, Germany, was at a Smart Cities Conference when she answered the question as to what makes a city smart – or even intelligent. She opined that "a municipality becomes a smart city when it uses an above-average number of new applications which causes the general level of networking to rise." She assigns a key role to information and communication technologies with the basic prerequisite of being a high-performance broadband network. Then Schieferdecker added even more details: "The idea is devising new technologies and linking them in an intelligent fashion to guide flows of information, traffic issues, energy efficiency or administrative matters." A city is only smart if it can be guided with a new infrastructure, can absorb knowledge about its own situation and can use trend analyses to identify parameters.

In other words, we're talking about networks, sensory systems, mobile communication and machine-to-machine communication. Experts talk about building up a reliable urban data source – a city cloud infrastructure that brings electronic services to people and makes them available to the private sector. Franz-Reinhard Habbel, the spokesman of the German Municipal and Community Association, is positive that "cities will be transforming themselves into service providers." Equipping cities to become intelligent amalgamation areas is an urgently needed investment because cities not only have to stay attractive for the people living there, but also for the companies located there.

The intelligent capital

Berlin, Germany, is a young and multicultural city under major financial pressure. It needs investments and new ideas to stay attractive for the people living there and for the private economy. The trouble is there is no money for that. Professor Dr. Schieferdecker chimes in again by saying "if we want to use urban resources and infrastructures more efficiently in the future, we will have to increasingly automate and streamline them." This is the reason why business partners from private industry, policymakers and the scientific community should help build models and stake out new markets.

As the capital of Germany and the amalgamation area of policymakers, the private economy and urban life, Berlin is an excellent locus for research and development. The issues of the future alternate between mobility, security, energy efficiency, climate protection and quality of life, and the first step to be taken towards an intelligent Berlin is expanding its range of information. A case in point would be the thousands of tourists who could be guided through the city by mobile electronic tour guides or orient themselves at nodes in freely accessible digital information boxes.

Professor Dr. Schieferdecker once again: "Even uncomplicated administrative IT-based processes boost efficiency if they are geared towards people's needs." They could be electronic web-based scheduling systems or services jointly provided and used by the urban government, policymakers, city inhabitants and the private economy. This also boosts transparency and the level of acceptance for these services. People and machines should be able to securely access data wherever they are in an energy-efficient fashion, whether they are mobile or on broadband. The networked Berlin of tomorrow is still just a vision, but soon it will be possible to intelligently control the city to support inhabitants, guide the flows of tourists, make administrative duties simpler, regulate traffic and keep resource utilization to a minimum. ■

Learn to play by playing

Recorder, guitar, piano or violin - many children and young people learn to play these popular instruments. It requires a lot of practice to read note after note from the sheet music and then strike the right key or pluck the correct string. Songs2See software makes learning easier.

Text: Beate Koch

Songs2See software makes learning easier and more entertaining.
© Fraunhofer

In the digital age, often children no longer learn about the world of melodies and rhythms via an instrument, but via the computer – using games like Singstar, Guitar Hero or Rock Band running on Wii or XBox. Instead of a real instrument, the players hold a game controller in their hands, which sometimes even looks a bit like a guitar but has buttons instead of strings that the player must hit. "It is our goal to offer people who want to learn an instrument even more fun and variety, using elements that they perhaps already know from computer games. This motivates them, and it trains not only musical knowledge, but motor skills as well," says Christian Dittmar of the Fraunhofer Institute for Digital Media Technology IDMT in Ilmenau, Germany.

The attraction of Songs2See is that it takes only a few mouse clicks to turn one's favorite songs into practice pieces that can be compiled as an individual practice folder. Christian Dittmar explains how it works, "First, the user selects a song from his CD or MP3 collection and imports it into the software. Legally that is not a problem, since he purchased the song and is only using it for private purposes. In this case he does not simply listen to the music, but he also uses it to make music." The player can select which instrument s/he wants to play by clicking on it. Currently, the choices are the recorder, the glockenspiel and the melodica. The piano, guitar, trumpet, saxophone or drums will also be supported in the future. With the next click, the software presents the song in three different ways. The first one is that it is displayed as a music sheet. The second one shows the player where the fingers have to be placed on the instrument and in which sequence. Finally, there is the intuitive rendition – similar to music computer games, which show the duration and height of the respective tones with the aid of bars.

Now everything is ready to the point that the learner can take his instrument and practice the song. A microphone (most computers have an integrated microphone) records what was played. The software shows the player the position in the music sheet where he currently is. Songs2See also evaluates if the notes are struck properly and if the rhythm is being maintained. This way the practicing does not become too difficult, and pitch and tempo can be changed as desired and with it the individually adjusted degree of difficulty, key or style of music. As Dittmar explains, "What we are doing is called automatic music transcription. In order to run the note recognition in the background, we had to teach the software to accurately recognize the tones of the varied instruments and not be confused by accompanying music."

Learning software is also a helpful tool for schools

The software is of particular interest to retailers of music learning software, but also for music publishing houses, who can prepare their sheet music material with it interactively. The software can of course be useful for teaching music at schools. Partners in Norway are already testing it.

The Songs2See project is supported by Thuringia's Ministry of Economy, Employment and Technology via the European Fund for Regional Development. In this way, the Free State of Thuringia and the European Union are supporting the international cooperation between the Thuringian partners Fraunhofer IDMT, KIDS Interactive GmbH, Sweets for Brains GmbH and European partners such as Stord/Haugesund University College, Grieg Music Education AS and Tampere University of Technology. ■

Scenting out cracks

Contact: Dr.-Ing. Christof Koplin, christof.koplin@iwm.fraunhofer.de

Damaged helmets release a warning smell. © *Fraunhofer IWM*

Damage to cycle helmets will soon cause a real stink – literally! Crash helmets can only do their job properly in an emergency if they are in perfect shape, which is why experts recommend replacing your head protection gear every once in a while. A new technique developed by the Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT in Oberhausen and the Fraunhofer Institute for Mechanics of Materials IWM in Freiburg releases scented oils from the helmet's plastic materials if they get damaged or badly bent. The scented oils that cause the smell are first enclosed in microcapsules. These capsules are then added to a polypropylene mass which is injection-molded to form the final component. The scientists establish the best combination of materials for each specific application with the aid of volunteers and calculate the required number of scented capsules in each case by means of numerical computer simulation.

This process is not only suited to products which are difficult to test for defects, such as cycle, motorbike and construction helmets. It can also be used to check pressure hoses – in washing machines for example – which are difficult to access. Smell sensors could also monitor plastic water and gas supply pipes to detect critical defects, because the escaping aroma can be reliably detected even over long distances.

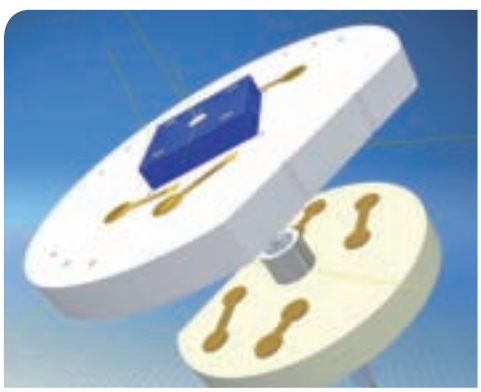
Brilliant protection

Contact: Dr. rer. nat. Andreas Holländer, andreas.hollaender@iap.fraunhofer.de

Product piracy does not just affect consumer goods, such as watches and brand-name clothing. Manufacturing industry also has to combat bogus and inferior-quality materials. Specialized security features, like watermarks, barcodes, RFID tags and holograms, protect against counterfeiting, theft and manipulation. A team of researchers from four Fraunhofer institutes recently engineered a brand new process that is particularly forgery-proof: they add various fluorescing dyes to the entire material, thereby creating a unique marking.

It is virtually impossible to decode the type and quantity of the dye additives because the quantities used are so small: a concentration of just a few ppb (parts per billion) of dye is enough to mark the material. Another advantage: the anti-counterfeit protection cannot be removed since the dye permeates the entire material.

The process is also suitable for quality assurance, e.g. of coatings: with the aid of various dyes, manufacturers can monitor the chemical composition, the degree of dryness and the thickness of the coating during the production process. The new technology has already passed initial practical tests.



The transmitting fiber conducts the laser light to the microscanner mirror. Both are fitted in the endoscope tip. © *Fraunhofer IPMS*

Detecting tumors fast

Contact: Dr.-Ing Michael Scholles, michael.scholles@ipms.fraunhofer.de

To diagnose cancer reliably, doctors usually conduct a biopsy including tissue analysis. A microscopic image sensor, fitted in an endoscope, is being developed for in vivo cancer diagnosis, to speed up the detection of tumors.

A newly developed microscope head with a diameter of just eight millimeters makes this possible. It can optically resolve and display tissue cells measuring just 10 to 20 micrometers. The scientists at the Fraunhofer Institute for Photonic Microsystems IPMS in Dresden envision that the MEMS (micro-electro-mechanical system) microscope head will eliminate the need for biopsies.

The researchers have combined the sensor with a microscanner mirror. The aim is to produce the microscope head in large quantities in an automated process for subsequent installation in endoscopes. It could also be used in technical endoscopy, for instance to examine cavities in buildings or to inspect the insides of engines and turbines.

Storing green electricity as natural gas

Scientists have devised a new way of storing energy. They convert electricity generated from the sun and wind into gas and store the energy in existing pipes and gas holders.

Text: Marion Horn

The usual approach is to convert natural gas into electricity. Research scientists are now taking the opposite route. They convert electricity into a natural gas substitute which can be stored like conventional natural gas.
© Heinz Wohner / LOOK-foto

Wind and sun are sources of clean energy. But the wind cannot always be relied on to blow, nor does the sun always shine. Energy stores are needed because when it's blowing a gale, wind power plants deliver more electricity than the power grid can handle. High-capacity storage systems – such as redox-flow batteries and pumped-storage power plants – can then supply energy during windless periods.

A partnership between business and research has found a new way of keeping energy on tap by storing surplus electricity generated by wind turbines and photovoltaic systems as climate-neutral methane – a natural gas substitute. Natural gas has traditionally been converted into electricity, but now the cooperation partners are taking the opposite route. Using a new process, the research scientists are converting electricity into a synthetic natural gas.

The process was developed by the Center for Solar Energy and Hydrogen Research Baden-Württemberg (ZSW) in cooperation with the Fraunhofer Institute for Wind Energy and Energy System Technology IWES. The Stuttgart-based partner company Solar Fuel GmbH is currently preparing its industrial implementation. "With the rapid expansion of renewable energy, the demand for new storage techniques is increasing sharply. We see a very big market here, because the long-time storage of renewable energy is the key to the expansion of wind and solar power," explains Managing Director, Dipl.-Ing. Gregor Waldstein. A demonstration system built for Solar Fuel in Stuttgart is already running successfully. Construction of a much larger facility, in the double-digit megawatt range, is scheduled to commence in 2012.

Well-known technologies newly combined: hydrogen electrolysis and methanization

So how does the process work? Dr. Michael Specht from the ZSW explains: "Our demonstration system in Stuttgart uses electrolysis to split water from surplus renewable electric-

The cooperation partners

The ZSW is one of the most prominent research institutes in photovoltaics, energy system analysis, renewable fuels, battery technology and fuel cells. About 170 scientists, engineers and technicians currently work at its three locations in Stuttgart, Ulm and Widderstall. Together, they generate revenue of more than 22 million euros.

www.zsw-bw.de

Solar Fuel GmbH develops technologies and systems to balance out the fluctuating supply of renewable electricity to the power grid, including the process for converting electricity into carbon-neutral, renewable natural gas for a wide range of uses. Solar Fuel was established in November 2007 by Managing Director Dipl.-Ing. ETH, MBA Gregor Waldstein.

www.solar-fuel.com

ity, producing hydrogen and oxygen. A chemical reaction of the hydrogen with carbon dioxide causes methane to form – which is the same as natural gas, only synthetically produced." For the first time, the technologies of hydrogen electrolysis and methanization are being combined. The gas can not only be stored, but can also be used as fuel or for heating and refrigeration. Liquid fuels such as gasoline and kerosene can also be produced from it.

At the IWES, research work is being conducted on the system-technical aspects of the process. "With the new technology we can keep green electricity available on tap as natural gas. One of our aims is to enable the energy supply from wind farms to be planned and controlled. The new concept is a key building block for the integration of renewables in a sustainable energy system," says IWES research scientist Dr. Michael Sterner. The process opens up new ways of using wind and solar power for mobility. "We are also producing carbon-neutral fuels with a high energy density," Sterner adds. The efficiency achieved in converting electricity into natural gas exceeds 60 per cent. "In our view that's better than a total loss," emphasizes Michael Specht. Such a loss occurs when, for example, wind power cannot be used. The most prevalent current form of storage – the pumped-storage power plant – has only limited potential for expansion in Germany. In developing the new technology, the ZSW has been guided by the key question of which storage systems offer adequate capacity for the varying volumes of renewable energy generated depending on the wind and weather.

The natural gas network benefits from an extensive storage reservoir. Its capacity exceeds 200 terawatt-hours, which equates to several months' consumption. By comparison, the electricity grid only has 0.04 terawatt-hours. And integration into the infrastructure is easy. The natural gas substitute can be fed into the supply networks, pipelines and storage facilities like conventional natural gas and can then be used to power natural gas cars or fire natural gas heating systems. ■

Driving on electricity

Battery systems, wheel hub motors, charging stations - what will the key components for tomorrow's electric cars look like and how will they be integrated in the existing electricity network? Fraunhofer System Research can provide the answers.

Text: Marion Horn and Birgit Niesing

In just ten years' time there should be a million electric automobiles on German roads. That is the goal of the German government. But a lot of research and development work is required if electric cars are soon to be running around in Berlin, Hamburg, Cologne, Frankfurt and Munich. The switchover to these vehicles will mean lots of changes: The car industry will stop producing certain automotive components, and they will be replaced by others, while energy companies will have to come up with new business models and tariff structures to supply electricity for vehicles.

"We are doing a great deal of work on the subject of electromobility, including concepts, system integration, energy generation and distribution, storage technologies and many other issues. We pool the expertise and capabilities of 33 institutes in our Fraunhofer System Research for Electromobility consortium," says Professor Ulrich Buller, Senior Vice President for Research Planning. The aim is to develop prototypes for hybrid and electric vehicles to support the German auto industry as it makes the crossover to electromobility. The German ministry of education and research BMBF is funding this project with a total of 44 million euros from the government's economic stimulus programs.

"Fraunhofer's electromobility system research supports the transition to a sustainable 'all-electric economy'. We aim to generate knowledge and technologies along the entire value chain – especially at the interfaces – and make them available to industry," emphasizes Professor Holger Hanselka, chief coordinator of electromobility system research. The researchers are not only developing individual parts but also the entire system. The various components are being integrated in the Frecc0 concept vehicle, the Fraunhofer e-concept car type 0, which will serve as a scientific test platform. This demonstrator is based on an existing vehicle from the company Artega Automobil GmbH: the new Artega GT will enable researchers to test e.g. how wheel hub motors or crash-proof battery systems perform in the total system. As from next year car manufacturers and automotive suppliers will be able to use the Frecc0 to try out new components.

Making a technological crossover

Wheel hub motors enjoy good prospects of becoming the accepted drive concept for electric vehicles. Fraunhofer research engineers are developing these motors, which are integrated in the car's wheels. Because they do away with the need for a gearbox and differential, the usual losses and wear suffered by mechanical transmission components no longer occur. What's more, the direct drive on each individual wheel can improve motoring dynamics and safety.

"We are working on a wheel hub motor in which all the main electrical and electronic components, in particular the power and control electronics, are integrated in the engine space," explains Professor Matthias Busse, Director of the Fraunhofer Institute for Manufacturing Technology and Applied Materials Research IFAM in Bremen. The researchers are also developing an innovative safety and redundancy concept to ensure that vehicle safety is guaranteed even if the system fails. This work is being conducted by engineers at the IFAM as well as at the Fraunhofer Institutes for Integrated Systems and Device Technology IISB in Erlangen, for Mechanics of Materials IWM and for Structural Durability and System Reliability LBF in Darmstadt.

The battery is a key component

Everything depends on the battery. Electric cars will only gain ground if they are provided with a powerful, reliable, long-lasting and cost-effective energy storage unit. Experts from eleven Fraunhofer institutes are conducting research on such battery systems. The engineers are focusing their work on the lithium-ion battery system, which consists of several hundred cells. This presents a problem, since the cells do not always discharge at the same rate. If individual cells fail, or do not deliver the performance expected, this could effect the entire battery. Researchers aim to work round the problem by developing sophisticated cross-networked battery management systems and an overarching energy management system. Such systems already exist for stationary batteries. "In just fractions of a second the electronic system measures the line-to-line current, the individual cell voltage and the temperature of each cell, and from this information determines their charge and ageing condition. That makes it possible to judge the risk of overcharging, excessive discharging, overheating or premature ageing for each individual cell," says project manager Dr.

In the electromobility system research project, Fraunhofer experts are working on new vehicle concepts, energy generation and distribution, storage technology and technical system integration.
© *Fraunhofer*

Matthias Vetter from the Fraunhofer Institute for Solar Energy Systems ISE in Freiburg, explaining the basic principle.

The complex car battery system is divided into two lines, each comprising eight modules of twelve cells. A total of 16 interlinked battery management systems are used to control everything. They communicate with an energy management system integrated in the battery pack via a databus widely used throughout the auto industry – a CAN (Controller Area Network). The system balances out differences in the charge condition of individual cells, for example, and thus provides maximum capacity and energy. At the same time it communicates with the vehicle and provides forecasts about distances and limit values. In addition it monitors whether the required outputs exceed critical current and voltage limits. On the instrument panel the driver can read how far the car can still travel before the battery needs to be charged. The system also takes preventive action in the event of an accident, using circuit breakers to switch the battery off totally or line by line.

Using the braking energy

Unlike conventional vehicles, electric cars can recapture the energy that comes from braking and feed it back into the battery. The experts refer to this as recuperation, and are working on ways of maximizing this energy recapture in future.

Electromobility is only worthwhile if cars can tank up on renewable electricity, but energy from the sun and wind is subject to great fluctuations. Thinking around this problem research scientists have come up with the idea of using electric cars as mobile energy stores for electricity from renewable sources. As the average car is parked for at least 20 out of 24 hours, its battery could be conveniently charged when the wind is blowing or the sun is shining. If the power grid operators are short of electricity they could draw on the stored energy available.

The right time for recharging

A power supply system geared exclusively to consumption, such as is the case today, would be of little use. “We need an intelligent network, a smart grid, in which both electricity and information flow,” explains Dominik Noeren from the ISE. Tariffs should be dependent on the situation in the electricity grid, which means that electricity would be expensive at times of peak demand. Prices would fall, on the other hand, when there is a surplus of renewable energy available.

Fraunhofer researchers have developed an intelligent charging station, where electric cars can tank up on electricity when the grid load is low and the input of renewables is high. This would enable load peaks to be avoided and the contributions from solar and wind power to be fully utilized.

Wheel hub motors, battery systems and charging stations are just some of the building blocks of an electromobile future. Fraunhofer researchers intend to develop further components in the months ahead. ■

Making solar cells more efficient

Solar energy will play a crucial role in the energy mix of tomorrow as solar energy is available in unlimited quantities. With the aid of concentrator solar cells and systems, record efficiencies can be achieved for the conversion of sunlight into electricity. The Fraunhofer researchers who developed the new technology now get the EARTO award 2010.

Text: Beate Koch

Climate change and ever scarcer fossil resources will determine the energy mix of the future. Solar energy will play an integral role in this regard. Dr. Andreas Bett and Dr. Frank Dimroth together with their research group at the Fraunhofer Institute for Solar Energy Systems ISE in Freiburg developed a metamorphic triple-junction solar cell consisting of III-V compound semiconductors: gallium indium phosphide, gallium indium arsenide and germanium. This special structure makes it possible to optimize the use of almost the entire solar spectrum for energy production. The result: efficiency levels that nearly double the efficiency of conventional silicon-based solar cells. This way a record degree of efficiency of 41.1 percent was achieved. However, to use these solar cells in a cost-effective manner on earth, the sunlight must be concentrated for example with a Fresnel lens. This requires a special module technology which has also been developed by the Fraunhofer researchers.

The high degree of efficiency is made possible by stacking multiple top-quality solar cells on top of each other. "Our triple solar cell consists of more than 20 individual layers, all of which we have optimized," says Dr. Frank Dimroth. A multi-junction solar cell is created with the aid of processes similar to those used in the semiconductor industry. "Our work involves a modern epitaxial process known as metal organic vapour phase epitaxy," Dr. Dimroth explains. The process involves successively depositing solar sub-cells on top of each other on a substrate of germanium. The result is a wafer-thin solar cell structure just a few µm thick, with a well-hidden complex inner structure of up to 50 monocrystalline layers. With the development of metamorphic crystal growth, Andreas Bett, Frank Dimroth and his colleagues have made it possible to use a larger range of III-V compound semiconductors to grow multi-junction solar cells. This makes the solar cells better adapted to the spectrum of wavelengths found in sunlight. "We have improved both the structure of the semiconductor as well as the material quality, the metal contacts and the antireflection coatings, in order to arrive at this result", stresses the researcher.

From the lab to industry

Originally, these compound solar cells were engineered for use in space. The combination of highly efficient cells with a lens amplifier ensures that – in comparison to conventional solar modules – only one five-hundredth of the semiconductor surface is needed. The cells within their own specially designed concentrator modules measure only three square millimeters in size. A Fresnel lens is situated over these mini solar cells, at a distance of approximately ten centimeters. This configuration concentrates the sunlight by a factor of 400 to 500. To prevent the cells from overheating, they are attached to a copper support that distributes the heat sufficiently well. Thus, passive cooling of the solar cells suffices. This technology was modified for the use on earth: "Thanks to this construction, we were able to produce modules with a degree of efficiency in excess of 29 percent," says Dr. Andreas Bett. Modules for terrestrial use are on the market since 2007. A spin-off of ISE – Concentrix Solar GmbH – produces them under the brand name FLATCON®. They are being used in a solar park in Spain, for example.

To facilitate the swift transfer of technology from the laboratory to industry, a demonstration laboratory was constructed at the institute, with the same machines that would be used in industry. Here, researchers are developing and testing production processes for the construction and connection technology, module integration and quality control. For the development of the new metamorphic triple-junction solar cells, the team has been closely collaborating for years with AZUR Space Solar Power in Heilbronn, the leading European manufacturer of solar cells for space. This partner is aiming to bring the new highly efficient solar cells to the market by 2011. Concentrix is preparing itself to produce the modules containing the cells and the concentrator technology.

Prof. Eicke R. Weber, Director of Fraunhofer ISE, is convinced: "We expect that high-efficiency concentrator technology – in addition to photovoltaics using crystalline silicon and the classic thin-layer technology – will become established as a third technology for cost-efficient generation of solar electricity in the sunny regions of the world."

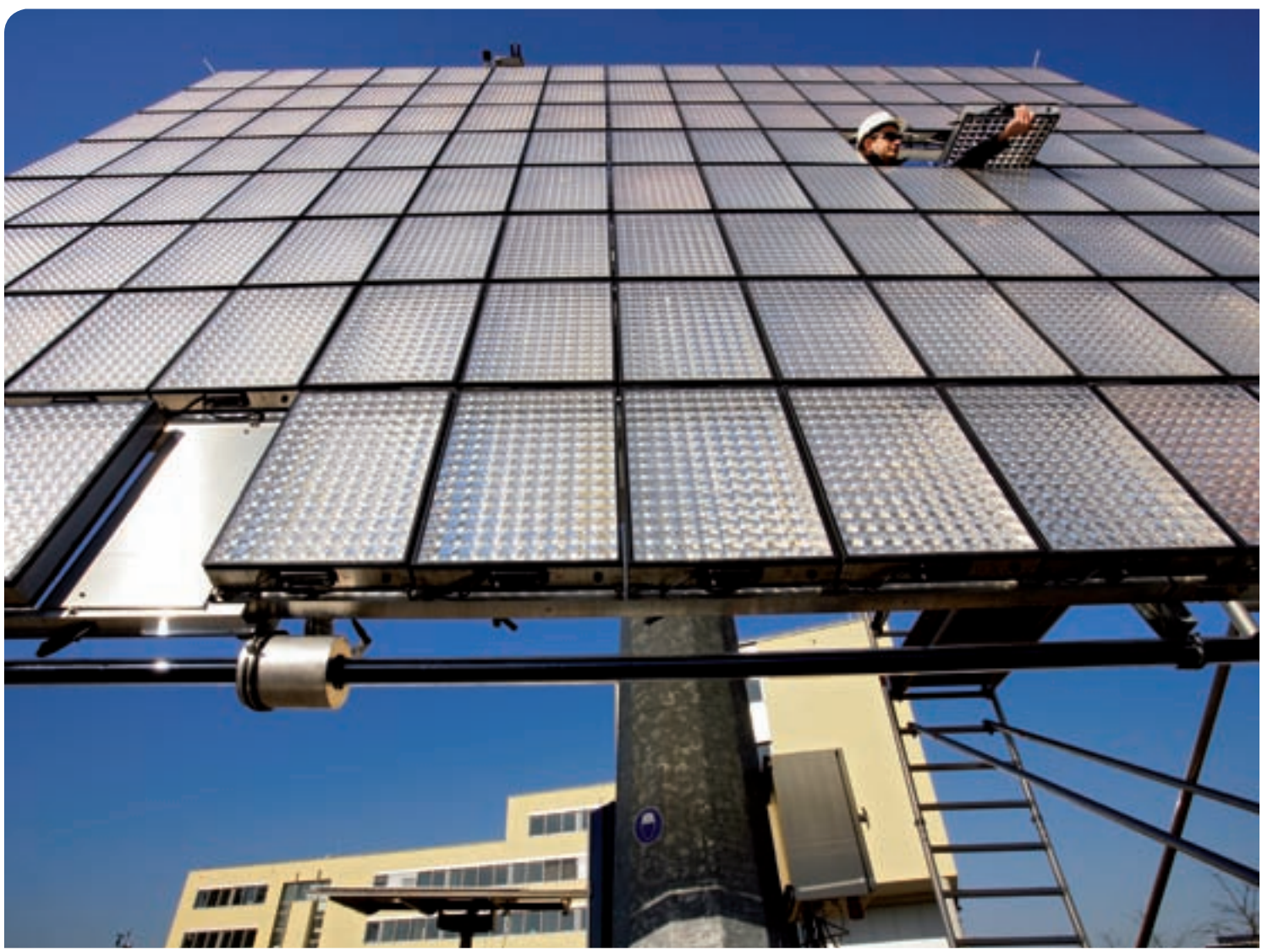
In recognition of their work, Dr. Bett and Dr. Dimroth in May 2010 received the Joseph von Fraunhofer Prize. In 2009 Andreas Bett was awarded the prestigious Bequerel Prize of the Euopean Commission and Frank Dimroth in June 2010 earned the "Fondation Louis D" award, the highest-endowed award presented in France for achievements in science. In October 2010 Bett and Dimroth were rewarded with the award of EARTO, the European Association of Reasearch and Technology Organizations.

"The EARTO Innovation Prize is awarded to RTOs, Research and Technology Organizations, in recognition of their contribution to an innovation of significant economic and social impact. This year's edition was no different. Once more, the level of the competition was high and submitted projects were excellent examples of what RTOs do best: relevant and targeted innovations creating growth and addressing the Grand Challenges of our time", concludes President of EARTO, Prof. Erkki KM Leppävuori. ■

The European network

EARTO is the trade association of Europe's specialised research and technology organizations. Its members make a major contribution to strengthening economic competitiveness and social development in Europe by supporting product, process and service innovation in all branches of industry and services, public and private. EARTO is an international non-profit organization and represents RTOs with a total staff of some 150,000 scientists, engineers and technicians and an annual turnover of €15 billion. Their equipment and facilities total several billion euros and their services benefit more than 100,000 customers annually.

Dr. Frank Dimroth received the French science prize from the Fondation Louis D. *© Dirk Mahler*



High concentration photovoltaic systems convert more sunlight into electricity than other solar technologies. *© Concentrix*

Energy-efficient power grids

By the time electricity comes out of your wall socket, it has already traveled from some faraway place such as a North Sea wind farm or made its way from a regional wind, solar or biogas power plant. Yet as things stand, a considerable amount of this energy is lost before it even reaches the end user.

Text: Marion Horn

Picture for a moment the cars, trucks and motorbikes that race along highways, branch off into cities, pause at traffic lights and crawl along side streets. Now apply that image to electrical energy as it makes its way along transmission lines from power plants to substations. The flow is regulated by a system akin to traffic lights. Then the electricity is carried along cables to factories and downtown areas and on through secondary cables. Numerous relay stations reduce the voltage—an essential part of ensuring your appliances have ready access to a low-voltage mains supply. It is thanks to this highly complex infrastructure and sophisticated technology that consumers can simply flick a switch to power up their coffee machine.

"Our society is becoming increasingly electric", says Professor Lothar Frey, director of the Fraunhofer Institute for Integrated Systems and Device Technology IISB in Erlangen. "We hardly notice how much the role of electronics is spreading through our everyday lives. All our appliances need a reliable mains supply—and that's precisely where we are going to be seeing some major changes. Transport networks and power grids will grow closer together as a result of e-mobility, because whenever an electric vehicle is being topped up with electricity its battery can act as a form of storage for the power grid. There will be more and more sources of renewable energy—even individual households will supply power to the grid." Supply and demand will be increasingly prone to fluctuation,

Undersea cables generally carry direct current. This is then converted to alternating current for distribution to consumers. © *Stefan Strand/ddp*

since the energy generated by the wind and sun varies according to the prevailing weather conditions, while consumption varies according to the time of day. Plans are already underway for major projects such as Desertec, which aims to build solar thermal power plants in the sunniest regions of North Africa and the Middle East to produce electricity for Europe, with high voltage power lines or undersea cables carrying the power to consumers.

The task now is to adapt existing cables, systems and components to the future energy mix to ensure that electricity reaches consumers reliably and with minimal losses. Power electronics experts are seeking new solutions, for example by developing enhanced components for converting electrical energy, and making it safe and reliable.

Robust components for the power grid of the future

There are two types of electricity: direct current and alternating current. Germany uses alternating current, which oscillates back and forth like a wave, with the electrons changing direction 100 times a second. Using transformers, alternating current can easily be converted to very high and very low voltages, though this requires large amounts of iron and copper. The challenge is that alternating current loses up to 40 percent of its energy over long distances, while direct current loses no more than seven percent. That's why direct current with its constant voltage is the preferred choice for undersea cables and energy transmission over distances greater than 500 kilometers, though additional converter stations are then required to convert the high-voltage direct-current power back into alternating current — still used by most of the appliances in private households and companies.

"One project we are working on with Siemens Energy is high-voltage circuit breakers. These are needed to transmit direct current through the electricity grid and they are one of the key elements of large-scale projects such as Desertec. We need to make the circuit breakers more reliable, more scalable and more versatile than current solutions if we want to meet the challenges posed by future power grids", says Dipl.-Ing. Markus Billmann from the IISB. To achieve this, the researchers are experimenting with more economical semiconductor cells that could not be used for high-voltage direct-current (HVDC) transmission with previous circuit technologies.

"At each end of an HVDC transmission system you have a converter station", Billmann explains. "Thyristors have traditionally been used as converters, but we are now starting to see more IGBTs. Unlike thyristors, these devices can be turned off and operated at higher switching frequencies— that makes it possible to build far smaller systems that offer improved dynamic control."

One of the biggest challenges is protecting the cells against critical failure. With some 5000 modules connected in series in a converter station, the system can cope if just a few of them fail, but only if this failure leaves the adjacent modules completely unscathed, because otherwise the entire system could be destroyed in a chain reaction. "We have finally found a way of tackling that problem, and we have all kinds of other ideas that we are looking forward to investigating with our cooperation partners in the Electronics for Sustainable Energy Use innovation cluster", Billmann enthuses. "For example, we are working on bespoke materials, customized components and intelligent systems that could slash the energy consumption of the devices and installations and make them much more compact."

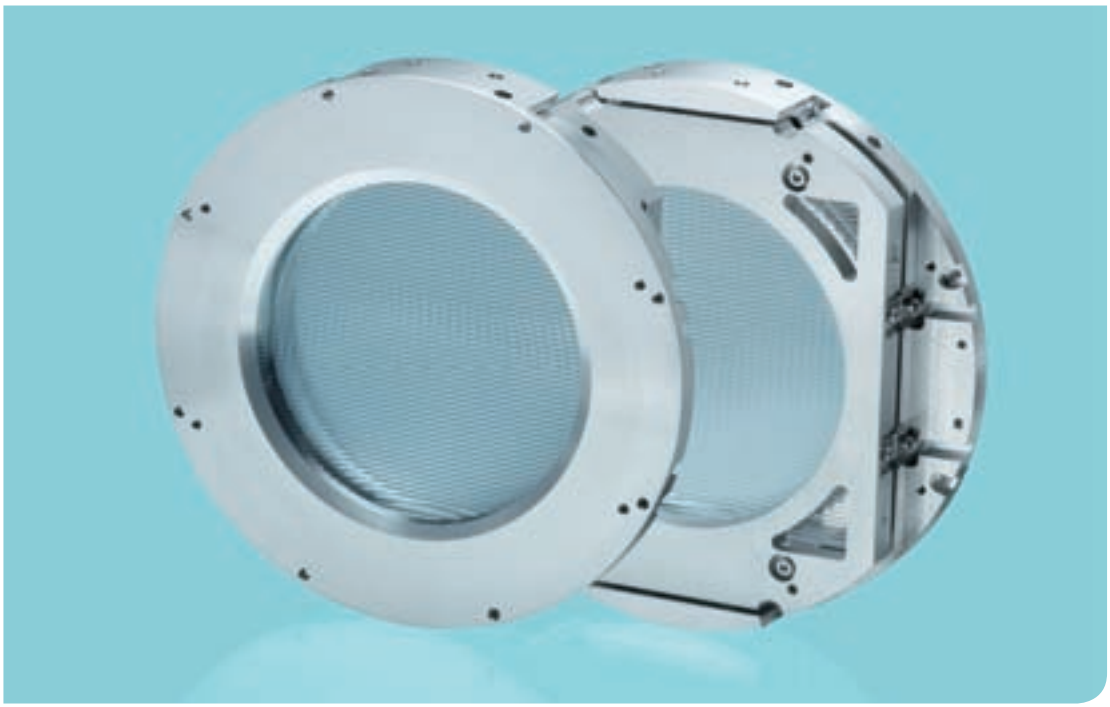
The innovation cluster, coordinated by the IISB, allows companies and research institutes to pool their expertise. They are developing components for the power grid of the future—their contribution towards maintaining the power supply we have come to rely on. ■

Fraunhofer innovation cluster: Electronics for Sustainable Energy Use

In the Nuremberg metropolitan region, commercial companies and research institutes are stepping up their collaboration in the fields of power electronics and energy technology. Together they are working on economical, compact and reliable components and systems for numerous different applications, from household appliances to electric cars and mains power supply. They are also investigating the possibility of connecting homes and offices with a low-voltage direct-current grid.

The research partners include the Fraunhofer Institute for Integrated Systems and Device Technology IISB (coordinator), the Fraunhofer Institute for Integrated Circuits IIS, the University of Erlangen-Nürnberg, the University of Applied Sciences Nürnberg, and the Bavarian Laser Centre. The cluster receives funding from the state of Bavaria, industry and the Fraunhofer-Gesellschaft as part of the German federal government's Pact for Research and Innovation.

www.iisb.fraunhofer.de



Optics wafers are ideal for applications with high outputs. © *Limo*

Spherical is so passé

Cameras, DVD players, laser printers, telescopes - they all work only thanks to state-of-the-art precision optics. Today you need sophisticated systems made up of numerous finely tuned mirrors and lenses. But in future, a single component should suffice: an all-rounder by the name of free-form optics.

Text: Monika Offenberger

The beam transformation system forms an almost round profile from the pronouncedly non-symmetrical far-field distribution of the emitter light. © *Limo*

If you need to wear glasses in the movie theater yet also have difficulty making out the letters clearly when reading the newspaper, then you need varifocal glasses. They provide sharp images at any distance while correcting individual eye defects. "Varifocals seamlessly combine several lenses with different focal lengths into a single lens, and often still with a single cylindrical lens. They are a simple example of an optical free-form surface," says Dr. Andreas Bräuer from the Fraunhofer Institute for Applied Optics and Precision Engineering IOF in Jena, where he heads up the Microoptical Systems department. His team is also working on designing more complex free-form surfaces for every conceivable application.

There is certainly no shortage of potential applications, not least because free-form surfaces could make it easier to produce most optical systems – CD players, scanners, high-power lasers, microscopes and telescopes. The advantages are obvious: "The lens on a high-resolution cell phone camera currently consists of up to seven lenses, each just a few millimeters in diameter. Every one of these tiny components has to be assembled precisely so they work together to generate a sharp image. Less work would be involved if, instead, you could use a single optical element which fulfills all the functions of the individual lenses. That would also free up space and reduce weight," explains Dr. Ramona Eberhardt, head of the Precision Engineering Departement at the IOF. Even laser light has to be fed through a finely tuned system made up of various lenses before it boasts the required properties; the lenses align the initially fan-shaped light beam to create parallel beams and focus it on its target.

Free forms are hardly used in the optics industry

These are just two examples from many. Optical systems are used in disparate industries – in industrial systems and the automotive industry, medicine and materials processing, aircraft construction and consumer electronics, information technology and life sciences. In all these areas you could save time and space, weight and resources by reducing optical components.

Yet despite the widespread need, free forms have hitherto hardly been used in the optics industry, not least because their design and manufacture have posed major challenges for mathematicians and engineers.

The lack of symmetry of free-form surfaces presents problems. They can – put in layman's terms – be bent and twisted like a potato chip. By contrast, spherical lenses are highly symmetrical and can be clearly characterized by their radius and the centre of curvature; they refract a light beam according to known rules and concentrate it at a defined focal point. You can also define rotation-symmetric lenses without a spherical surface – aspheres – with just a few variables, despite their limited symmetry. By contrast, free-form surfaces are anything but symmetrical. They have, as the mathematicians say, any number of degrees of freedom. To describe them, Bräuer's team is developing suitable calculation rules, or design algorithms. And to ensure that production machinery can read these algorithms, they are being translated into the relevant computer programs.

"What we need are interrelated, finely tuned process chains – from design through production to testing of free-form optics systems. Yet hitherto we have only mastered individual process steps, and then with limited precision on the whole," explains Dr. Klaus-Friedrich Beckstette, Senior Director of the CARL ZEISS Technology Center in Jena and Oberkochen. To plug this gap, the IOF has teamed up with ZEISS and three other industry partners to set up the FREE research consortium. The aim: "We intend to develop the scientific and technological principles for complete process chains and demonstrate them by means of various sample applications – line scanners, camera lens and data glasses incorporating a head-mounted display," says Beckstette.

Optics design forms the starting point for each project. There are basically two approaches to this task. One can either calculate how a given free-form surface affects the light incident upon it. This top-down approach is a fairly simple way of obtaining suitable results. Alternatively you want a certain light distribution and are looking for a suitable optical free form. In this case things start getting difficult, because you have no idea beforehand what it will ultimately look like. This bottom-up method entails hundreds of parameters and an equally large number of options for calculating the required free form. "You can end up totally lost in the woods," says physicist Andreas Bräuer, "and then you fire a shotgun and maybe hit some animal or a mushroom picker. To enable us, so to speak, to shoot more accurately where the deer are standing, we try to limit the parameters and establish certain rules. To do this, we adapt existing mathematical algorithms for our purposes," explains the Fraunhofer researcher.

"We already have a few usable approaches and specific designs," says Beckstette, "but there are still a few areas we cannot yet tackle using current design methods. There is still a lot of research to do." This view is shared by the German federal ministry of education and research BMBF. This year the ministry will embark upon a three-year funding program for the FREE project and ten other research projects relating to free-form optics. It is also shared by the KOMPASS research project, in which the Fraunhofer IOF is likewise involved. Dr. Lutz Aschke, managing director of the microoptics company LIMO, summarizes the project's aim: "We want to investigate how optical free forms can be series-produced efficiently out of glass with high precision."

New approaches to large-scale manufacture

Not only do suitable design algorithms have to be developed, so too do new technological approaches to large-scale production. Negative molds are required, into which – depending on requirements – glass, metal or plastics can be introduced like cake mix into a cake pan. To ensure these injection molds are of the necessary quality, various manufacturing techniques – ultraprecise turning and milling, grinding and polishing as well as hot stamping – need to be combined. "For each application, we have to consider very carefully how the element can be developed most effectively. Then it is manufactured and measured to ascertain whether the quality requirements have been met," says IOF researcher Eberhardt. The fruits of these efforts are eagerly awaited since the market for precision optics is huge. "The need for tools that can be used in series production is correspondingly large," continues Eberhardt. "And German optics manufacturers have already got the development process up and running." ■

Conductor paths in a new light

Fraunhofer researchers are optimizing tomorrow's lighting systems.

Text: Frank Grotelüschen

Press the light switch – and the entire ceiling is illuminated in an even, pleasant hue. This "luminous sky" is not on sale yet, but researchers around the globe are devoting much of their energies to making it a reality. The underlying technology is based on organic light-emitting diodes, or OLEDs, which emit light once a current is applied to certain types of molecules. While the first OLED lamps recently went on sale, they are small and expensive. Experts from the Fraunhofer Institute for Laser Technology ILT in Aachen are collaborating with Philips to come up with a process that should enable much larger and cheaper lamps to be produced, making them suitable for the mass market.

OLEDs provide the foundation for a new generation of lamps – wide-area light sources that can be molded into any shape and integrated easily into interior designs. Experts are not only looking at ways to clad entire walls and ceilings with luminescent layers but also the possibility of coating windows. During the day these windows would be transparent as usual. At nighttime they produce light as if it were still daylight outside – a pleasant, almost natural form of lighting. OLEDs also hold great potential for display technology: they can be used to produce ultra-thin screens, which could one day even be rolled up when mounted on a flexible base.

Success depends on the price

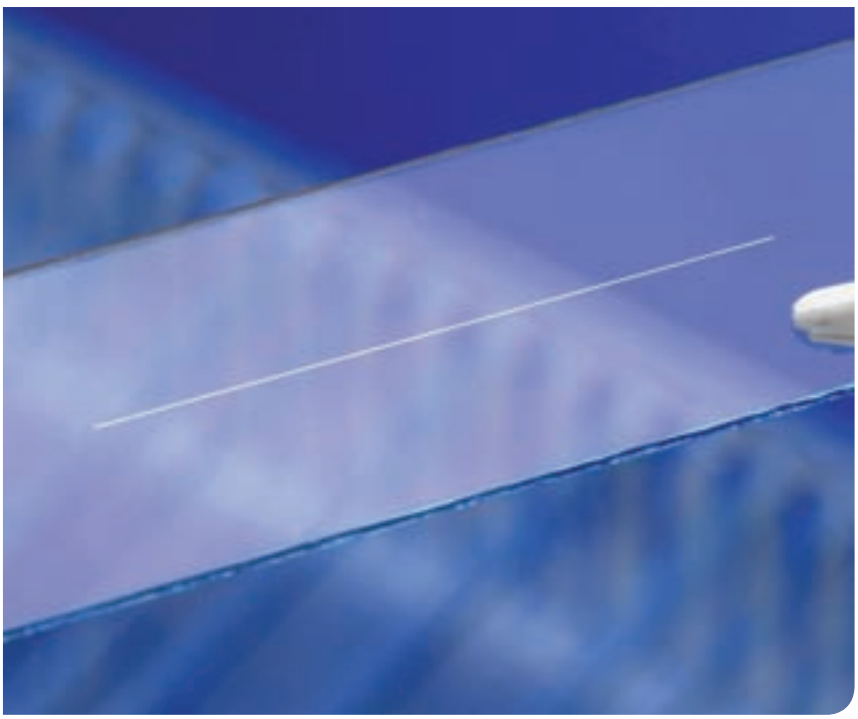
Poor durability has been a long-standing issue. Yet OLEDs have more recently achieved levels of 5,000 hours continuous operation – adequate for many standard applications. The "luminous glass" is currently around twice as efficient as an incandescent lamp. Long-term the experts hope to be able to match the efficiency of a low-energy lightbulb. However, the main drawback has been the price. An OLED lamp, which went on sale earlier this year, a flat disc barely eight centimeters in diameter, costs around 250 euros – way too much for the mass market.

The innovative lamps are still very expensive because the manufacturing process is very complex. An OLED lamp takes the form of sandwich-like layers: on the bottom sits a flat electrode, with various intermediate layers above, as well as the actual electroluminescent layer made up of organic molecules. The sandwich is topped by a second electrode made out of indium tin oxide (ITO), a special transparent material.

Additional conductor paths

Together with the electrode on the bottom, the ITO layer applies a current to the OLED molecules, causing them to emit light. Unfortunately, the ITO electrode alone is not conductive enough to distribute the current evenly across a larger area, despite the very good compromise between high transparency and low electrical resistance. Consequently, the brightness in the centre of the panel lamp fades noticeably instead of emitting a homogenous light pattern. "To remedy this, you need to integrate additional conductor paths into the ITO layer", says Christian Vedder, scientific researcher at the Fraunhofer ILT. "These conductor paths are made out of metal and distribute the current evenly across the surface so that the lamp lights up homogenously." The paths need to be as thin as possible, since they otherwise impair brightness and produce undesired lighting patterns.

Normally the conductor paths are applied using an energy-intensive vapor-deposition process. The ITO electrode is coated with a wafer-thin metallic layer in a vacuum chamber. A special photoresist is then applied to map put what will subsequently be the conductor paths. The remaining metal is thereafter etched away chemically, leaving behind just the conductor paths. Yet this conventional method has certain drawbacks: "The process is very expensive. At the very most, only ten percent of the applied metal is used. Most of the materials, including the chemical etching agents, require time-consuming, costly disposal", says Christian Vedder.



Conductor paths on glass. © *Fraunhofer ILT*

Homogenous luminosity for OLEDs thanks to micro-scale conductor paths. © *Philips*

The new process, now developed by ILT researchers in collaboration with Philips, is different: instead of vapor-depositing a great deal of material, most of which has to be subsequently removed, the scientists in principle only apply the amount of metal that is actually required. A mask foil, in which micrometer-sized slits have been cut out to form the negative of the required conductor path pattern, is placed on the surface of the ITO electrode. A thin metallic foil made of aluminum, copper or silver – depending on which metal is used for the conductor paths – is laid over the mask. A laser then traces the conductor path pattern at a speed of several meters per second. The metal melts and vaporizes; the existing vapor pressure presses the melt drops through the fine slits in the mask onto the ITO electrode. This produces extremely fine conductor paths that precisely follow the envisaged pattern.

Successful tests in the lab

A clear advantage of this process is that it does not have to be conducted in a vacuum chamber. Working at normal atmospheric pressure, the laser also only melts and vaporizes the metallic foil where conductor paths are to be laid on the OLED surface, which means very little material is wasted, too. And finally, the new process can produce very narrow conductor paths down to 40 micrometers. This is much finer than the 100-micrometer width using conventional techniques.

"We have already managed to demonstrate in the lab that our method works", explains project manager Christian Vedder. "The next step is to implement the process on an industrial platform, together with our partner Philips, and to develop the plant and equipment that will allow us to apply the conductor paths on a large scale at low cost." In two to three years' time the new laser technique could be ready to roll out – an important step on the way to realizing the vision of luminous wallpaper for walls and ceilings.

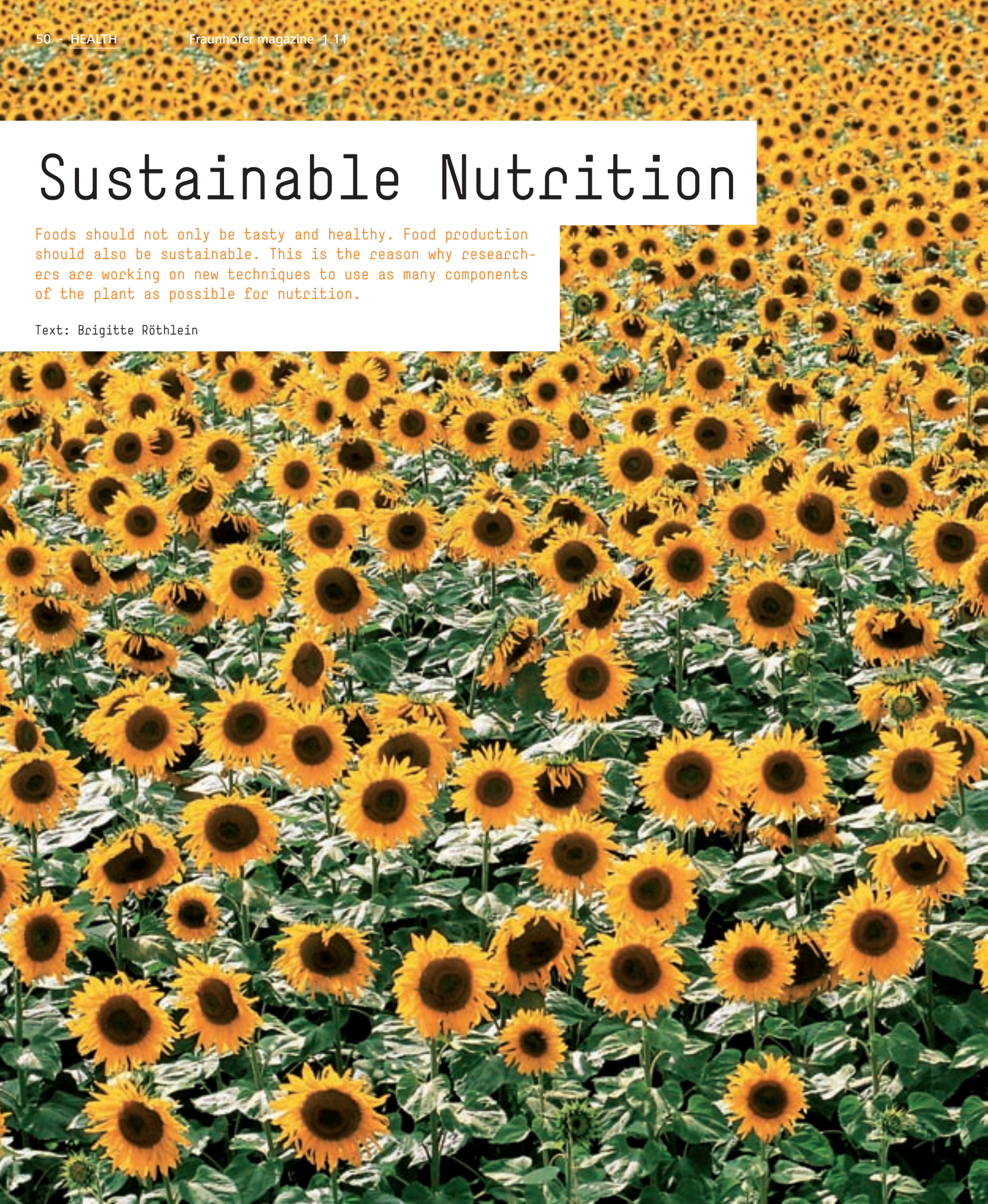
A chance to make solar cells cheaper

The method may also be suitable for other applications. "The market for solar cells is one such possibility", says Christian Vedder. „With solar cells you need thin conductor paths to collect the current generated by the cell." Using the ILT technique, manufacturing costs for solar cells could be reduced further, while making them more efficient at the same time. The finer you can manufacture the conductor paths, the less active surface you shade – making solar cells more efficient. ■

Sustainable Nutrition

Foods should not only be tasty and healthy. Food production should also be sustainable. This is the reason why researchers are working on new techniques to use as many components of the plant as possible for nutrition.

Text: Brigitte Röthlein



You can earn 950 euros from one hectare of sunflowers, although it would be 1,770 euros if you would not only process the oil, but also the other basic materials. © *Michel RENAUDEAU/HOA-QUI/laif*

Meat consumption is dramatically increasing in rising-star countries such as China or Brazil, and indeed the global consumption of red meat has quadrupled since 1961. Poultry consumption has increased as much as tenfold. This is not to say that there are not substantial regional differences because a European, for instance, eats twenty times as much meat as an Indian. FAO, the Food and Agricultural Organization of the United Nations, expects that global meat production will double by 2050 due to soaring prosperity.

There is too much farming just for animal breeding

Will our world be able to cover everyone's future needs with its limited farmland resources? Dr. Peter Eisner from the Fraunhofer Institute for Process Engineering and Packaging IVV in Freising, Germany, revealed some potential solutions to the impending dilemma at the annual academic conference of his institute. First of all, we have to recognize that producing meat requires a great deal of land. Eisner cites "the Worldwatch Institute that has calculated that producing one kilogram calls for 16 kilograms of grain or soy beans as animal feed. This has meant that in the United States 80 percent of the grains is fed to farm animals. If growth continues unabated into the future, all of the farmland available in the world will be used just for producing feed in 2022."

This situation is exacerbated by competition with energy plants. The more expensive petroleum becomes, the more the focus shifts to plants from which bioethanol can be produced. This also reduces the farmland available for producing food. People took to the streets in Mexico in 2007 to protest the dramatic rise in the price of cornmeal for tortillas because the United States was importing large portions of the Mexican corn harvest to produce bioethanol.

Cultivating plants as a foodstuff is substantially less land-intensive that producing meat. Producing one kilogram of meat takes 40 square meters while you could produce 120 kilograms of carrots or 80 kilograms of apples instead on the same land. But even today, one-fourth of all global farmland is used as grazing land, and animal feed is cultivated on one third. In contrast, only a small portion of farmland is used for cultivating plant foods – this is just seven percent in the United States. They would be able to feed one billion people with the grain they would save if they only produced one fourth less meat.

Almost no one listens when starry-eyed idealists say Eat Less Meat! This is why we need intelligent solutions, especially better plant utilization. Peter Eisner drives home the message that "you cannot only produce high-quality foods from plants. You can also produce technical raw materials and energy carriers," which he demonstrates using the example of sunflower seeds. Previously, sunflower seeds were pressed to extract oil while the residues were used as lower-quality animal feed. That is how you can earn 950 euros per hectare of farmland. However, if we could go beyond extracting oil to do what Eisner proposes – namely processing all of its components to create high-quality basic materials for the foodstuffs, cosmetic and fuel industries – we could get 1,770 euros out of one hectare of farmland. Eisner thinks "that would make ecological and economic sense, and it would spell out an increase in agricultural proceeds with the same yield per hectare."

Plant food additives as a substitute for raw materials of animal origin

Using plant food additives as a substitute for raw materials of animal origin is particularly important, which is why Eisner showcased a "milk substitute" made of lupine proteins that can be used for example in ice cream or cheese. It does not contain any lactose, has a neutral taste, is free of cholesterol and is rich in polyunsaturated fatty acids.

Lupine seeds are also the basic material for a new plant protein isolate with properties similar to fats that Daniela Sußmann, a researcher at the Fraunhofer Institute for Process Engineering and Packaging, has come up with. A special production technique can be used to extract protein suspension from the lupine seeds as a highly viscous compound that has a very creamy texture. Sußmann remarks that "its manufacture is based on a precipitation technique that is presently in the stage of refinement and will be later placed on an industrial scale. The microscopic structure of this product is similar to fat particles in fried sausages, which is why it can be used for creating low-fat sausages that taste just as good as the original. Previous reductions in fat frequently also reduced the sensory impression." She conducted sensory tests

to determine whether adding the lupine proteins can even improve the juicy and creamy impression of the low-fat sausage recipe – and they were successful. "We found that you can achieve a substantial improvement in the impression of low-fat liverwurst that is similar to fat by adding ten percent of protein isolate."

To the consumer's, farmer's and environment's advantage

That would be a step in the right direction as far as nutrition in Germany is concerned because sausages there are among the foods with the highest level of fat. Each German eats an average of 31 kilograms every year, which causes overweight and cardio-vascular diseases. Christian Zacherl, a researcher at the Fraunhofer Institute for Process Engineering and Packaging who has analyzed trends for the future of sausages insists that reducing the high level of fat content and adding less salt are big issues. He goes on record saying that "this is important for the projected nutrient profiles that the European Commission is outlining at present with upper limits for salt, fat and sugar in foods with health statements in their advertising." The food industry has to toe the line there while still satisfying consumers' needs for foods that are ready to eat, quick to prepare, that are edible for a long time and stay tasty. And let's not forget healthy. Everybody would be well-served if a certain portion of the fat could be replaced with proteins from plants. Consumers would be satisfied because they would eat less fat, farmers would be satisfied because they would get higher yields, and the environment would be satisfied because producing plants is more sustainable than producing meat. ■

Clockwise: Lupine, sunflower, soy, linseed, broad beans and rapeseed.
© *Fraunhofer IVV*

Research in Chile

The Fraunhofer-Gesellschaft is setting up its first research center in South America. On October 22, 2010, the Fraunhofer-Gesellschaft and the Chilean Ministry of Economic Affairs signed a bilateral agreement giving the go-ahead for an extensive cooperation. Professor Alfred Gossner signed the bilateral agreement with Juan Andrés Fontaine, the Chilean minister for commercial affairs, in the presence of the Chilean President Dr. Sebastián Piñera and Chancellor Dr. Angela Merkel in Berlin.

The new Fraunhofer Center for Systems Biotechnology will be established in Santiago de Chile. It is funded by INNOVAChile, which was created by the governmental economic promotional society CORFO to attract world-class international research institutes to Chile for joint research and development partnerships. Several organizations have been evaluated, but Fraunhofer-Gesellschaft is the first and so far the only one to receive a funding commitment from the Chilean government. Partners on the Chilean side are: the two iconic universities Pontificia Universidad Católica de Valparaíso (PUCV) and Universidad de Talca, and the private non-profit organization Fundación Chile. The German partner is the Fraunhofer Institute for Molecular Biology and Applied Ecology IME, headed by Professor Rainer Fischer. The foundation of the Center was actively supported by the German-Chilean Chamber of Industry and Commerce.

The Fraunhofer Center for Systems Biotechnology is the first research center to be launched by the Fraunhofer Chile Research Foundation established on October 4, 2010, and it will work closely with Chilean research organizations and private enterprises. The research carried out at the new Center will benefit from and make a long-lasting contribution to Chile's pioneering spirit and economic strength, reflecting the country's faith in a traditional economy based upon raw materials, agriculture, aquaculture and the sustainable use of natural resources. Systems biotechnology is an emerging field in life sciences that aims to develop an understanding of the complex and dynamic processes in cells, organisms and even ecosystems at the systems level. This is achieved by creating computer models and mathematical simulations, which are then applied to problems in biotechnology using a combination of large-scale laboratory experiments and computational biology.

German and Chilean researchers will combine their strengths to develop and optimize a wide range of technologies that will be used to develop rapid tests for fish diseases and more effective fish vaccines (partnership with Fundación Chile), to develop new nanotechnology solutions to remove pesticide residues from beverages and purify waste water (partnership with Universidad de Talca) and to improve the performance of enzymes and increase the efficiency of biomass utilization in the energy industry (partnership with PUCV).

Dr. Gossner (right in front) signed the bilateral agreement with Juan Andrés Fontaine (left in front), the Chilean minister for commercial affairs, in the presence of the Chilean President Dr. Sebastián Piñera and Chancellor Dr. Angela Merkel.
© *Bundespresseamt*

New test facility in the US

Albuquerque, New Mexico, will be the home of a new test facility for solar models .
© *Debernardi*

A unique testing laboratory for solar modules is located in Albuquerque, New Mexico. The Photovoltaic certification test company CFV is jointly owned by CSA Group, the Fraunhofer Institute for Solar Energy Systems ISE, the Fraunhofer USA Center for Sustainable Energy Systems CSE, and VDE Testing and Certification Institute.

The facility, that now starts operations, is located within the Mesa del Sol development of Albuquerque close to the airport, Sandia National Labs, the University of New Mexico, and other major players in the PV supply chain. "The decision to place this new solar testing facility in New Mexico puts us in the epicenter of the PV installation market in the U.S." said Randall W. Luecke, President of CSA International.

In addition to the CFV Solar Test Laboratory, Fraunhofer CSE and Fraunhofer ISE will operate a R&D facility at Mesa del Sol, focusing on long-term reliability, decreased cost and increased performance of PV modules. The new location was chosen by CFV Solar Test Laboratory after a thorough evaluation process. "The top officials of the State of New Mexico, Bernalillo County, and the City of Albuquerque are very committed to developing the solar industry in their region, and have given us the necessary support to make this project possible," says Nolan Browne, Managing Director of Fraunhofer CSE. "I also want to recognize the invaluable assistance we received from U.S. Senator Jeff Bingaman and Albuquerque Economic Development, whose interest and support for the project have helped us make this decision."

Award-winning efficiency

The production plant of BMW Motoren GmbH in Steyr is the winner of the competition "Fabrik 2010 ".
© *BMW*

Researchers at Fraunhofer Austria GmbH found themselves pondering an interesting question—which is the most efficient factory in Austria? To find out, they set up a competition entitled "Fabrik 2010". A total of thirty factories took part, each of which was analyzed in a three-stage process of scientific evaluation. The researchers then paid a visit to the twelve most promising candidates to inspect and assess their processes on site.

The 180 day marathon of evaluation and assessment produced a clear winner – BMW Motoren GmbH in Steyr, a company that has managed to increase productivity by 40 percent over the last five years. "That's exactly the kind of success story we need to safeguard jobs in a high-wage country like Austria," says Prof. Wilfried Sihn, who headed up the jury. Trailing by just one point, Robert Bosch AG took second place. "We effectively had two winners with virtually the same score", says Sihn , "but in the end we had to choose one of them!" Third place went to Infineon Technologies Austria.

But the aim of the competition was not only to create a ranking of production sites and companies. The researchers were also keen to find out exactly what criteria make successful companies stand out – and the Fraunhofer experts' findings here were unequivocal: Virtually all the top-ranked companies have impressive quality management systems. They also place a strong focus on their employees by actively involving them in problem-solving processes and through flexitime arrangements.

Research that makes the difference

What impact does applied research have at the European level? A study, conducted by the Technopolis Group, answers this question: The annual economic impact of the European Research Organizations RTOs - is approximately 50 billion euros. The report shows how countries profit from their RTOs: They have a track record of increasing the rate of innovation in industry by enabling companies to go beyond the limits of their internal technological capabilities. They significantly contribute to economic growth through more effective exploitation of research and adaptation of existing and new technologies for specific applications.

And yet, RTOs are largely undocumented and their specific role is poorly understood. The study provides a clear definition of the mission and activities of RTOs and identifies an urgent need for proper official statistics about the sector in Europe, so that their key contribution to the economy and society is fully visible. The report also makes recommendations to unleash the potential of RTOs: By making greater use of their innovation in the public and private sectors. And by encouraging RTOs to internationalise so as to make them stronger through competition and cooperation. Professor Erkki KM Leppävuori, president of the European Association of Research and Technology Organizations comments: "The study demonstrates that RTOs are essential actors in the European innovation system and give real value for money."

Brazil

In 2010 Germany celebrated the National Science Year focusing on "The future of Energy". At the same time the German Ministry of Education and Research BMBF together with the Brazilian Ministry of Science and Technology inaugurated a bilateral year of science on sustainable and innovative technologies. In the fall a delegation of Brazilian scientists came to Germany in order to meet researchers at different Institutes. With the experts at Fraunhofer they discussed cooperation in different fields such as sustainable economic development or renewable energies.

Brazil is booming – economically and technologically. São Paulo has become main cultural, financial and traffic junction. © *gettyimages*

Fraunhofer strengthens European innovation networks

Europe is growing closer together – and that includes the research and development sector. Within the European Union, there are numerous companies and scientific organizations that are developing new and high-level technologies. But competition is fierce on the world market, and if Europe is to prove successful in this global contest, it is essential that two things happen: the EU must combine its forces, and more research findings must be transformed into viable and sustainable products and services.

The European Commission launched the European Institute for Innovation and Technology (EIT) as a means of stimulating innovation within the unified European Research Area. EU funding to the tune of 308.7 million euros has been earmarked for the first phase of the initiative, which runs until 2013. The aim of the EIT is to drive forward European innovation policy by creating regional and international networks. To this end, teams of research institutions, universities, technology centers and commercial enterprises are now pooling their resources and undertaking thematic work within "Knowledge and Innovation Communities" (KICs). The first three KICs were designated just a short while ago: sustainable energy, climate change and future information and communication society. Fraunhofer Institutes are involved in all three networks.

Editorial notes

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