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2/13 special issue

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Striking out in a new direction

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

Currently, planet Earth is home to more than 7 billion people – and counting. One of the greatest challenges of the 21st century will be to provide them all with the basic necessities of life and ensure universal access to medical care, modern communications technology, and mobility. It will take no less than a paradigm shift to meet this challenge.

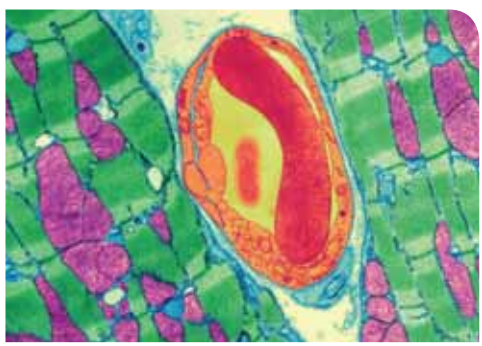
Up to now, growth has always gone hand in hand with an increased demand for natural resources – cereals and water, petroleum and natural gas, minerals, ores, and rare earth metals. It is already 40 years since the Club of Rome rang the alarm bell with its report "Limits to Growth". Current predictions by scientists, economists, and futurologists are even grimmer: The new report "2052 – A Global Forecast for the Next Forty Years" points to growing environmental destruction and the collapse of our ecosystem. And it is indeed true that all resources are becoming scarce, and global warming is leading to more frequent extreme weather events and rising sea levels.

In the light of this situation, economic growth models of the kind we have pursued in the past, with their dependence on ever-increasing consumption of resources, can hardly be considered a fitting solution to the needs of the world's growing population. It is high time to find new, more sustainable approaches that enable us to optimize the way we use natural resources, drastically reduce pollutant emissions, and develop renewable sources of energy.

It is likely to be an uphill battle, as anyone who has tried to challenge the status quo can confirm. Efforts to change established processes and introduce new, sustainable practices are almost sure to encounter opposition. To overcome these obstacles we need time, and above all the specialized knowledge and perspicacity of far-sighted individuals who also understand the importance of accommodating the requirements of industry. The Fraunhofer-Gesellschaft, with its 80 institutions in Germany, amply fulfills these requirements. Not only do our researchers work in close collaboration with leading academic scientists at the best universities, they are also in daily contact with a wide range of industrial customers. This three-way communication results in innovative materials and design concepts, and novel methods of production and recycling.

In the supplement to the current issue of Fraunhofer's weiter.vorn magazine, we describe how that may look in practice. Here we showcase current Fraunhofer projects aimed at finding ways of producing more goods using significantly fewer resources. We also illustrate how information technology, mobility and buildings can all be designed to be more efficient. In the future, systematic recycling will also become more important. The cover story features new recycling strategies and methods that Fraunhofer researchers are currently developing to provide future generations with an introduction to closed-loop recycling management.

As the new President of the Fraunhofer-Gesellschaft, I am a fervent supporter of such new approaches, because they are the foundation on which we can build a better future. They represent the first step on the road to a more responsible and sustainable economy that generates growth without overexploiting our planet's limited resources.



Content

Planning tool for harbors

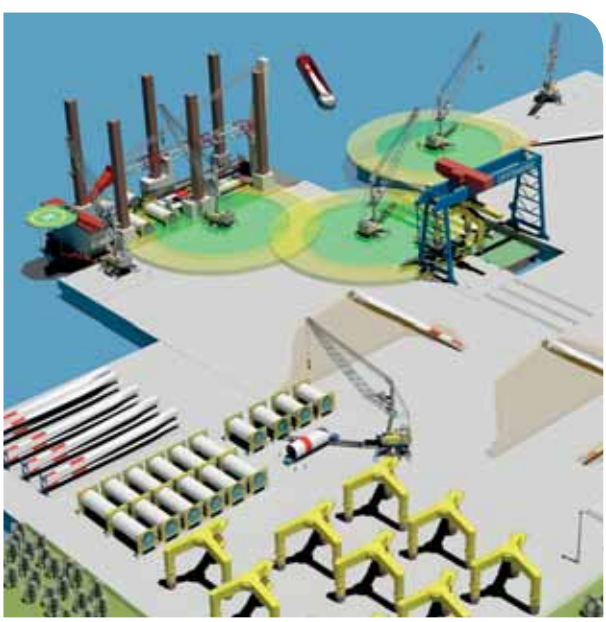
There are currently more than seven billion people living on planet Earth, and these numbers are growing. Providing this population with life's essentials, ensuring they have medical care, mobility and access to modern communications technologies is one of the greatest challenges of the 21st century – and it will take nothing less than a paradigm shift to overcome that challenge.

Global trade is increasing, placing growing demands on existing seaports and those that are yet to be planned and built. Scientists at the Hamburg-based Fraunhofer Center for Maritime Logistics and Services CML have developed the software system ToolbaR PlannEr, or the Toolbased Rapid Planning Environment, to improve seaport planning.

The system can also be used to plan terminals, logistics sites and inland transshipment hubs. It is very versatile: a multitouch planning table allows users to create 2D plans that can be evaluated quickly and visualized in 3D in real time. A maritime block library enables logistics experts at the CML to test out new designs by "shifting" the modules. An interface to simulation software tests and checks data that has already been used. A ship simulator, which adjusts navigation requirements to suit local conditions, is another important component of the software system.

CML research scientists are also developing a concept for a "green" container terminal, featuring innovative technologies for saving energy and lowering emissions.

Representation of a virtual offshore terminal.
© Fraunhofer CML



Keeping ice off the wings

Low temperatures and high wind speeds can quickly cause ice crusts to form on the wings of aircraft when they fly through clouds. The ice crust can increase the aircraft's air drag by up to 40 percent and make the aircraft heavier; while lift is reduced by up to 30 percent and fuel consumption rises.

Researchers at the Fraunhofer Institute for Structural Durability and System Reliability LBF have now developed a new way of heating the wings. They incorporate nanomaterials into the wing material that create an electrically conductive layer which allows the wing to be heated. This conductive layer is built into the material itself, so it is protected by layers above. And since the wing also remains free of metal parts, it is better protected against lightning, too. Just how effective this heating could be is demonstrated at ground level, where the wings can be made to reach temperatures of up to 120 degrees Celsius.

Nanomaterials in the wings create an electrically conductive layer that makes it possible to heat the wing. © *dpa*

Supermarkets save energy

With their mammoth refrigerators and elaborate lighting systems, supermarkets consume a huge amount of energy. In fact, supermarkets use up to ten times more energy than the average household. Now, supermarket operators are looking to take advantage of a new concept developed by the Fraunhofer Institute for Solar Energy Systems ISE in Freiburg to slash their energy consumption by up to 30 percent. With help from building contractors, the planning team and manufacturers, researchers have come up with a holistic concept. When implemented by Aldi Süd in their new buildings, the scientists were successful in cutting energy consumption by 20 percent in the very first year of operation, and by 25 percent the year after.

At some 40 to 50 percent, refrigeration accounts for the lion's share of supermarkets' electricity bills. If the individual refrigerator units are controlled centrally rather than separately, however, operators can save energy. The heat produced is no longer dissipated into the surrounding air but instead channeled into a three-stage recooling system. During the winter, the system recovers the heat from the refrigerator units via a heat exchanger and uses it to heat the store. This eliminates the need for gas and oil-fired boilers, while ventilation systems are no longer required for heating but can focus entirely on ventilating the shop space.

The experts are using carbon dioxide in place of conventional chemical refrigerants, since the global warming potential of a carbon dioxide-based cooling system is 3000 to 4000 times lower. To illuminate supermarkets' large spaces, the scientists are chiefly relying on natural light.

Skylights in the roof cut down on energy consumption for lighting. © *Ralph Kensmann, StartDesign GmbH*

Lasers used for polishing implants

The surface quality of an implant is decisive for the success of a patient's recovery after surgery. Bone implants require a porous structure that encourages cells to incorporate themselves into the new surface. Other implants, on the other hand, call for surfaces to be as smooth as possible, to stop bacteria colonizing the structure and to prevent damage to surrounding tissue. Companies and researchers working together as part of the MediSurf project have reduced the time needed to process dental and blood-carrying implants (such as heart pumps), and improved their acceptance.

Experts at the Fraunhofer Institute for Laser Technology ILT in Aachen have developed a flexible and cost-efficient plant for automated implant polishing, and have built a prototype that is already in operation. Results prove that the machined implants are just as readily accepted as those polished by hand. Laser polishing is 30-40 times faster, yet also guarantees that the desired surface structure is achieved, and machine processing also scores higher as the cleaner and more environmentally friendly method of choice. And without the need for the polishing agents and abrasives used in manual polishing, laser polishing leaves no chemical residues on the implant, either.

Untreated and laser-polished components of the ventricular assist system INCOR made out of titanium. © Fraunhofer ILT

Recycling 2.0 – perfectly separated

Electronic devices contain a lot of useful materials. One of the challenges of the future is to recycle them.
© *Sean Gallup/Getty Images*

Around 60 billion metric tons of raw materials are used worldwide every year. While demand is predicted to rise to 140 billion metric tons by the year 2050, these resources are finite. Systematic recycling is one way to ensure that there will be enough raw materials available for new products in future. Researchers are working on the next generation of closed loop recycling management as part of the Beyond Tomorrow project "Molecular Sorting".

Text: Birgit Niesing

We have over 100 million unspent euros stashed away in our cupboards. According to estimates by the Umweltbundesamt (the German Federal Environment Agency), there are circa 72 million old and disused cell phones lying around our homes: a veritable goldmine. Each phone contains approximately 250 milligrams of silver, 24 milligrams of gold, nine milligrams of palladium and nine grams of copper. This may not sound like much to begin with, but when multiplied up the total value of these precious raw materials comes to over 100 million euros.

We are also wasteful in the way we deal with our old electronic appliances and the useful materials they contain. The European Union has ascertained that our broken toasters, mixers, waffle irons or hair dryers usually end up in our domestic refuse, a practice which means we Europeans are effectively destroying two billion euros worth of electronic waste every year. This is likely to change in the years ahead. Recognizing that resource shortages may soon pose a real threat to economic growth in Western Europe, the EU has launched an initiative aimed at tackling the scarcity of resources. And improved recycling of electronic waste is a keystone in these efforts.

A study carried out by the EU Commission makes it clear why we have to act quickly. The availability of 14 of the raw materials most heavily required by industry is already deemed to be at a critical level. These include cobalt, used in lithium-

ion batteries, germanium, for the manufacture of fiber optic cables and infrared sensors, and tantalum, found in cell phones. Estimates predict a threefold rise in demand for these raw materials by 2030, and this cannot be met unless we implement systematic recycling strategies.

The United Nations also streses that industrialized countries will have to radically change the way they handle resources if a worldwide crisis is to be avoided. "One man's garbage is another man's raw material. The waste and recycling sector will play a decisive role in the Green Economy of the 21st century," says Achim Steiner, executive director of the United Nations Environment Program (UNEP). He encourages developers to think ahead and consider the recyclability of the devices they are designing, as "it is two to ten times more efficient to recycle metal than to extract it from the ground." There is as much gold in 41 cell phones as there is in a metric ton of gold ore.

As a country with limited natural resources, Germany is particularly affected by the increasing shortage of raw materials. The Fraunhofer-Gesellschaft is therefore not only working intensively to develop new processes that will improve the efficiency with which energy and resources are used today (see supplement), but also on the next generation of closed-loop recycling. As such, "Green Electronics" has for some time already been an important research topic at the Fraunhofer Institute for Reliability and Microintegration IZM in Berlin, and it is one of the few institutes in the world that is studying the sustainability of electronic systems within their immediate technological context. The Fraunhofer Project Group for Materials Recycling and Resource Strategies IWKS in Alzenau and Hanau is tasked with finding solutions that will secure the supply of resources for industry in the long term. Researchers have begun by collating and analyzing verified data on global materials cycles in order to then develop resource strategies. Alongside these activities, they are developing new, ecological and commercially viable processes for recycling critical materials.

Materials separation at molecular level

The Beyond Tomorrow project "Molecular Sorting for Resource Efficiency" is one of the primary ways in which Fraunhofer experts are seeking to drive forward the concept of systematic recycling and production in closed-cycle flows (also see box). Their aim is to develop a production system requiring no input of new raw materials, by making repeated use of secondary raw materials and returning them to production in a cascading process.

This is easier said than done, however. Scientists must first overcome the significant challenge posed by the fact that most modern products consist of a colorful mix of materials. Copper, silver, gold, nickel, zinc, palladium, cobalt – a cell phone alone contains as many as 60 different raw materials, in the tiniest amounts. "The fine distribution of these materials demands that we come up with new techniques for separating and sorting them," says project coordinator Professor Jörg Woidasky of the Fraunhofer Institute for Chemical Technology ICT in Pfinztal, near Karlsruhe. In contrast to present recycling methods, scientists want to process the rare and valuable raw materials in just a few steps. "For the first time ever we intend to base the separation processes on the smallest scale of sorting we can use, which means going all the way down to the molecular or even atomic level," says Woidasky in describing molecular sorting. Scientists working on the research project are developing new recycling concepts for metals as well as for mineral, biogenic, organic and silicate raw materials.

Precious metals and rare earths in particular, are generally only found in especially small and finely dispersed amounts. Minute amounts of such metals are contained not only in cell phones, but also in RFID tags or nanosilver shower gels. Recovering the rarest and most expensive of these precious metals and rare earths is likely to become a necessity in the years ahead. Researchers at the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB in Stuttgart are working on new recycling technologies and on process integration. Recycling takes place in three stages. Researchers have placed their hopes on bioleaching, whereby microorganisms are used to extract metals from ores, incineration slag or mature timbers saturated with metallic salts by turning the insoluble metallic elements they contain into water-soluble salts. Special polymers or sustainable raw materials such as keratin or lignin are then used to selectively bond the dissolved metals or rare earths. The valuable raw materials can then be separated out via electrophoresis.

"Although methods already exist to enrich specifically-targeted, individual metals in solution, these tend to be expensive and not universally applicable," reports Dr. Thomas Schiestel of the IGB. "In order to close product cycles, new technologies need to be developed that are easily integrated and can be flexibly employed for different metal groups."

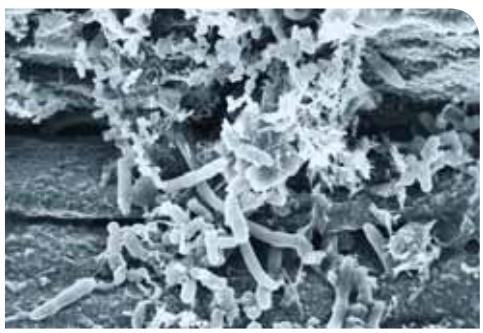
The research work being carried out is already proving successful. Scientists have conducted bench-scale testing which demonstrates that microorganisms separate and solubilize ions out of metal swarf. This enrichment was carried out by synthesizing functional polymers with phosphonate, iminodiacetate and mercaptan groups, which all have a particularly high affinity to silver, copper, neodymium and lead, a heavy metal. The team was also able to modify keratin in such a way that it selectively bonds gold at high capacity. The metal ions are separated using free-flow electrophoresis. "Previous experiments confirm that fractionation is possible," says Schiestel. The scientists now hope to apply the processes they have developed to other metals, primarily other rare earths and precious metals.

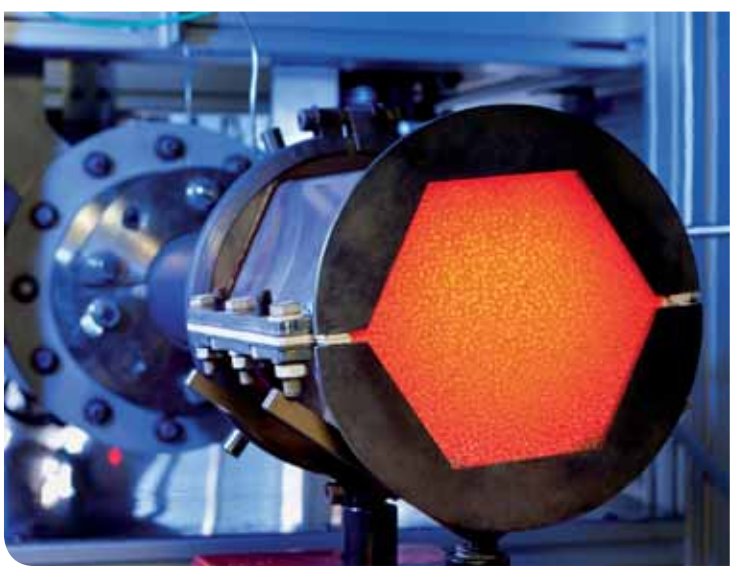
Ultra-clear glass made from scrap flat glass

What separating materials at molecular level would look like is demonstrated by experts at the Fraunhofer Institute for Silicate Research ISC in Würzburg and the project group

Producing highly-transparent glass (pictured in the background, white) requires extremely pure raw materials, or a new method for recycling conventional flat glass (pictured in the foreground, green). © *Fraunhofer ISC*

Metal ions are solubilized from swarf by microorganisms. © *Fraunhofer IGB*





Porous ceramic filters will enable raw materials to be recovered from hot gas processes. © *Fraunhofer IKTS*

"Molecular Sorting"

The Markets Beyond Tomorrow program started in 2011 sees Fraunhofer researchers working on solutions for the current challenges posed by scarce resources, the need for sustainable energy and affordable healthcare. One of the seven funded Beyond Tomorrow projects is "Molecular Sorting for Resource Efficiency". Scientists are developing new techniques for separating and sorting in order to enable systematic recycling. Over the course of the project they intend to put together a complete methods construction kit for recovering and recycling materials to address the needs of a wide range of industries, including automobile manufacture, mechanical engineering and plant construction.

The following institutes are involved:

- Fraunhofer Institute for Chemical Technology ICT (coordination)
- Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB
- Fraunhofer Institute for Silicate Research ISC
- Fraunhofer Institute for Ceramic Technologies and Systems IKTS
- Fraunhofer Institute for Building Physics IBP
- Fraunhofer Institute for Wood Research, Wilhelm-Klauditz-Institut, WKI
- Fraunhofer Institute for Systems and Innovation Research ISI

molecular-sorting.fraunhofer.de/

A rotor blade with foam filling (left), and the result of comminution using an impact reactor (right). © *Fraunhofer ICT*

IWKS, using high-grade glass that is free of coloring agents. This ultra-clear glass enables maximum light permeability, which is why it is used in photovoltaics, fiber optic cables or display screens, for example. The material has to be as pure as possible, as even the slightest contaminations can impair quality. Even the tiniest traces of iron (0.1 percent) are enough to considerably reduce transparency. "The dynamic rate of growth within the field of photovoltaics in particular is so great, that the predicted demand in coming years for highly-transparent flat glass will outstrip the natural iron-free raw materials available, even when the amount of highly-transparent glass provided by "disused" photovoltaic modules is included," reports Dr. Jürgen Meinhardt from the ISC. An alternative source of raw material could be conventional flat glass, which until now has been "downcycled" into cheap container glass or mineral wool. However, the iron content poses a problem, as it is simply too high. The research team now wants to separate iron from glass at the molecular level, converting any tiny residual amounts of iron in such a way that the transmission of light is no longer affected. To do so, they melt the glass at temperatures of around 1500 °C. In describing the process, Meinhardt explains that "effectively what we do is fish out the iron atoms inside the glass furnace."

Smart wood recycling

The demand for sustainable resources is also on the increase. Taking wood as an example, not only is the demand for high quality timber on the part of furniture companies growing, but the demand for fuel is also rising. "There is no way that the sustainable wood resources available in Germany will be able to completely meet the predicted levels of demand for wood as a material and a source of energy in future," says physicist Peter Meinlschmidt from the Fraunhofer Institute for Wood Research, Wilhelm-Klauditz-Institut WKI in Braunschweig. "That's why it is becoming increasingly important for the European wood products industry and paper industry to recycle industrial scrap wood, such as residues from timber factories and plywood mills, and wood from old palettes, packaging, furniture, or demolition wood."

To date, however, only around 33 percent of the approximately eight million metric tons of scrap wood generated every year in Germany are reused. In Italy, by comparison, 89 percent is reused. One of the reasons for Germany's low recycling quota is the Waste Wood Ordinance, which prohibits or severely limits the use of wood which has been coated with halogenated organic compounds or treated with wood preservatives. New separation techniques at molecular level should help tackle the problem without endangering the precautionary thinking behind the Ordinance. In order to be able to recycle more old wood, the first step must be to identify any harmful substances it may contain. "We therefore intend to detect these substances by scanning the surface of the wood using various techniques, including near infrared spectroscopy, laser-induced spectroscopy and mass spectroscopy, after which it can be sorted," explains Peter Meinlschmidt, describing the approach being taken by the WKI experts. The wood is then cleaned. "Wood treated with organic wood preservatives can be cleaned using supercritical fluids. We then plan to use wet-chemical, combustion and pyrolysis processes to remove or concentrate heavy metals," he continues.

Organic plastics, cellulose, basic chemicals and other new products can also be obtained from the cleaned wood. The aim is to develop a demonstrator sorting unit for scrap wood which will use a cascading process to reuse a large part of the wood that is wasted today, until it is finally used for heating purposes at the end of the cascading chain. Scientists have already laid the first important foundations for this project by developing techniques for removing the top coats of painted surfaces and film-coated chip- and fiberboard. This is where most of the contamination is concentrated.

Another type of waste that is usually dumped in landfill sites or used as mining backfill material, which pulls it out of the materials cycle, is bottom ash from municipal solid waste incineration (MSWI). Scientists at the Fraunhofer Institute for Building Physics IBP want to change this. "It is our primary aim to separate out all the metal, glass and ceramic com-

Untreated MSWI bottom ash (left) contains fragments of glass and ceramic (right). © *Fraunhofer ICT / Fraunhofer IBP*

ponents from the MSWI bottom ash, in order to reduce the overall volume," explains Dr. Volker Thome. Researchers are focusing on the use of electrodynamic fragmentation, in which ultrashort lightning bolts are shot through the bottom ash, breaking it down into its individual components. Metals, glass and ceramics can be separated out in this way. At a later stage, the researchers also hope to use the leftover material to develop a cement substitute or cement aggregate, since MSWI bottom ash reacts in a remarkably similar way to cement when it is combined with water.

Specialized processes are also called for to separate and sort the hybrid materials finding more widespread use in the automotive industry and in the construction of wind power plants. Experts at the ICT are working out guidelines for sustainable materials and product design so that, wherever possible, all constituents of these mixed components can be recycled.

Ecological and economic viability

Not only solid waste can be broken down to provide resources. Emissions also contain raw materials. Waste incineration plants, for instance, burn very heterogeneous materials. During this process, the metals that are contained in the waste, such as germanium, zinc, and increasingly scarce phosphor, are deposited in the ash that is then disposed of. Recovering these resources is the aim of scientists at the Fraunhofer Institute for Ceramic Technologies and Systems IKTS in Dresden. They are developing special ceramic filters that first selectively precipitate specific substances at temperatures of over 850 °C, so that they can then be recovered at the highest possible degree of purity following a further recycling stage. Metals generated in this way, such as germanium, can be used in the semiconductor industry, for example. And recycled phosphor can be used by the fertilizer industry.

But does this recycling effort really pay dividends to the environment? In order to answer this question, Fraunhofer experts create a Life Cycle Assessment model for each molecular sorting method by channeling the information they have gathered back to the development team via several iterative loops. This ultimately results in processes that can not only be "certified" as being ecologically balanced, but that also make ecological analysis an integral part of development. "Recovering material resources from waste is fundamentally desirable in light of the drive to conserve natural resources," emphasizes coordinator Jörg Woidasky. "That being said, the effort must be sensible in relation to the use that is gained from it, not just from an economic but also from an ecological point of view."

But are the methods that have been developed really economically viable for the "markets beyond tomorrow"? Scientists at the Fraunhofer Institute for Systems and Innovation Research ISI in Karlsruhe set out to address this question via a "foresight process". They established three model scenarios: first the "new green world"; then its opposite, "après nous le deluge"; and then a variant that lies somewhere between the two, "business as usual". Results indicate that immediate demand for new technologies will generally prevail in numerous scenarios.

New, efficient recycling methods are one possible way to become less dependent upon imports of expensive and scarce raw materials. Substitution, or replacement with alternative materials, is yet another avenue. Numerous Fraunhofer institutes are busy here, too, exemplified by work on sustainable raw materials that can be used instead of crude oil to produce plastics and chemicals. Just how this can be done is demonstrated by the Fraunhofer Center for Chemical-Biotechnological Processes CBP in Leuna.

"Aiming to recycle raw materials to the greatest possible extent, to substitute scarce resources and to make use of renewable energies, opens up new business opportunities," emphasizes Professor Reimund Neugebauer, president of the Fraunhofer-Gesellschaft. "This helps strengthen the position of countries like Germany as top industrial locations." ■

Virtual power plant

The consolidation of many of the smaller energy producers can amount to far more than the sum of its individual plants. The Fraunhofer Institute for Wind Energy and Energy System Technology IWES in Kassel has successfully proved this point by establishing a virtual power plant that raises energy availability, turns a profit and provides a more secure supply.

Text: Brigitte Röthlein

The centerpiece of the Regenerative Model Region Harz is the virtual combined power plant. It connects together various renewable energy producers, regulable consumption devices and energy storage units in the region.
© RegeneratvKraftwerke Harz GmbH

The Harz region in central Germany is known for its natural beauty, tree-covered hills and blue lakes. As an area made up of many discrete parts and without any large urban centers, it is an ideal setting for an energy infrastructure based on renewable energy. It is home to many small and medium-sized energy producers: wind parks, photovoltaic facilities, agricultural operations with biogas plants, as well as a pump storage station.

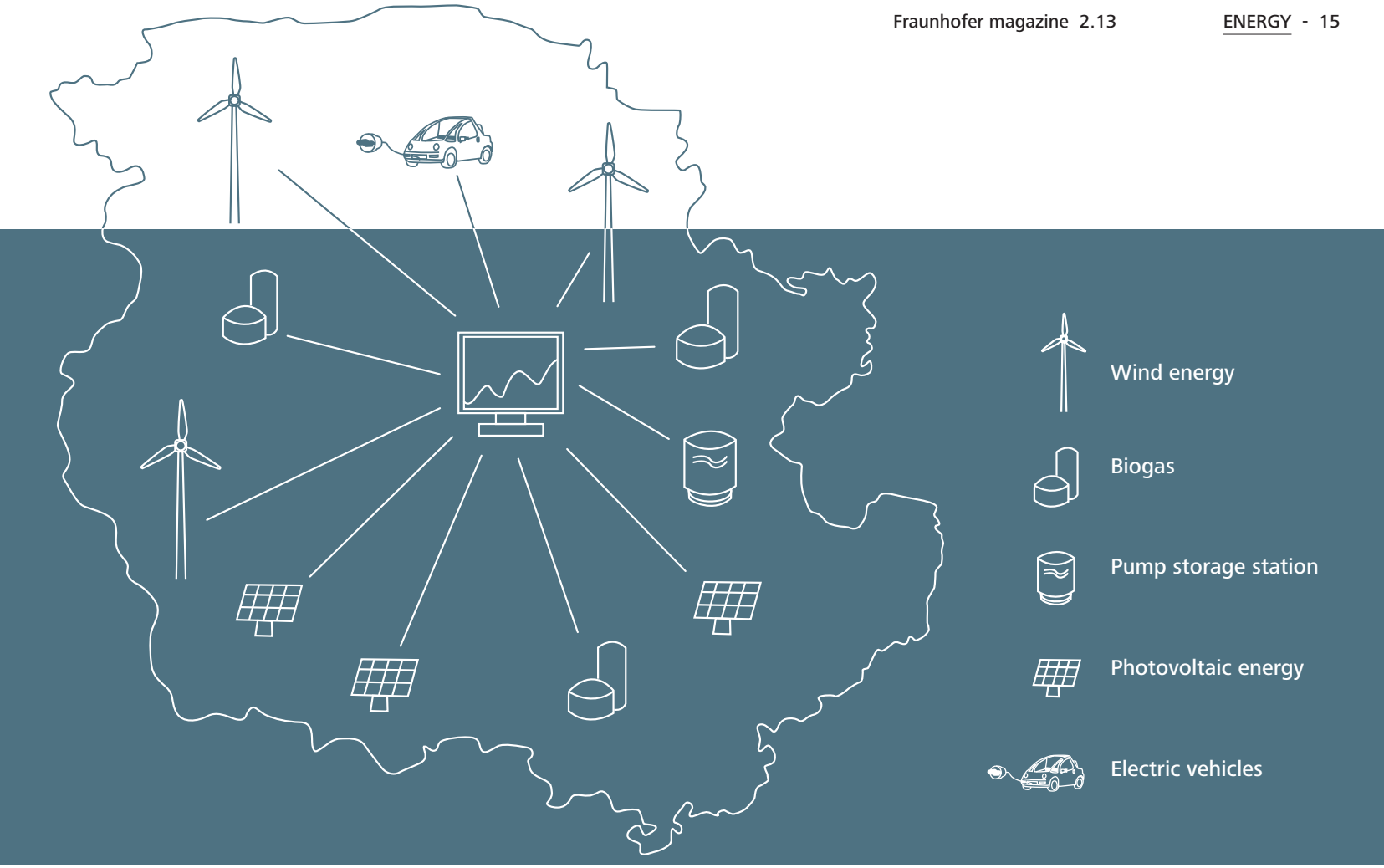
Each individual producer can feed the electricity they produce into the grid, but alone cannot be counted as a major player. But thanks to a software platform developed at the IWES together with Siemens AG as part of the German federal government's E-Energy initiative, many of the smaller producers have been able to pool their strengths within a virtual power plant.

25 plants with a combined output of 120 megawatts

Since January 2011, researchers have been putting just such a power plant through its paces in the Regenerative Model Region of Harz (RegModHarz), with excellent results. A total of 25 plants with a combined rated output of 120 megawatts, as well as a pump storage plant and electric vehicles that act as virtual storage, have been interconnected over the internet. Central control helped mitigate the drawbacks associated with renewable energy, most commonly that the sun is not always shining just as the wind is not always blowing. But when many of the smaller producers work together, it becomes possible to counter-balance regional differences or to activate biogas plants as soon as electricity demand increases. At the same time, surplus electricity can be stored or converted and used as heating. This has resulted in a powerful network which is served by a decentralized organization, able to present itself as a larger unified force in the energy trading markets. "Every source of energy – be it wind, solar or biogas – has its own strengths and weaknesses. If we succeed in cleverly combining the different characters of the various forms of renewable energy, we will be able ensure that Germany has a reliable supply of electricity," predicts Dr. Kurt Rohrig, deputy director of the IWES. Since April last year, the RegModHarz virtual power plant has generated and billed 46 gigawatt hours of electricity.

Supply and demand largely determines the price paid for electricity. Producers can submit an offer on each of the large electricity trading markets for the following day. In order to estimate how much electricity will be produced as accurately as possible, reseachers make forecasts based on weather data supplied by the DWD (German weather service) to calculate their expected electricity yield. And to determine the electricity demand of the individual regions, they equipped 43 households in the Harz region with smart meters and integrated these into the trial. Dr. Reinhard Mackensen, head of the Energy Informatics and Information Systems department at IWES: "It is also conceivable that a large energy consumer, let's say a paper plant, could adjust its electricity consumption based on the amount of electricity being produced. Alternatively, we could introduce heating cartridges that take surplus electricity and convert it into heating within a district heating network."

This all puts the virtual power plant in a position to collate measurement and meter data in real time, automatically put together energy supply schedules based on production and load fore-



casts, and trade in electricity in energy markets such as EPEX SPOT. "This is how we are able to compensate for the fluctuations associated with renewable energy, create a secure supply and market electricity flexibly and efficiently," says project manager Florian Schlögl. And in doing so, the virtual power plant far outstrips other energy providers when it comes to load management. Mackensen emphasizes: "Our goal is to turn a profit with such a system. The virtual power plant is perfectly integrated into structures of both power generation and consumption, which gives it great flexibility and maximizes profits."

The nerve center of the virtual power plant is its control system. It is equipped with a graphical user interface that connects the plant's backend server with the operator. All important information, such as the output of the energy producers, storage levels, wind or solar power output forecasts or the latest trend of the energy market, are brought together here for analysis and further processing and are displayed across four screens. Here, the marketing view shows the amount of energy sold and offers made on the market; the message view charts current and recent events in the virtual power plant; and the topology view keeps operators up to date on technical data and schedules.

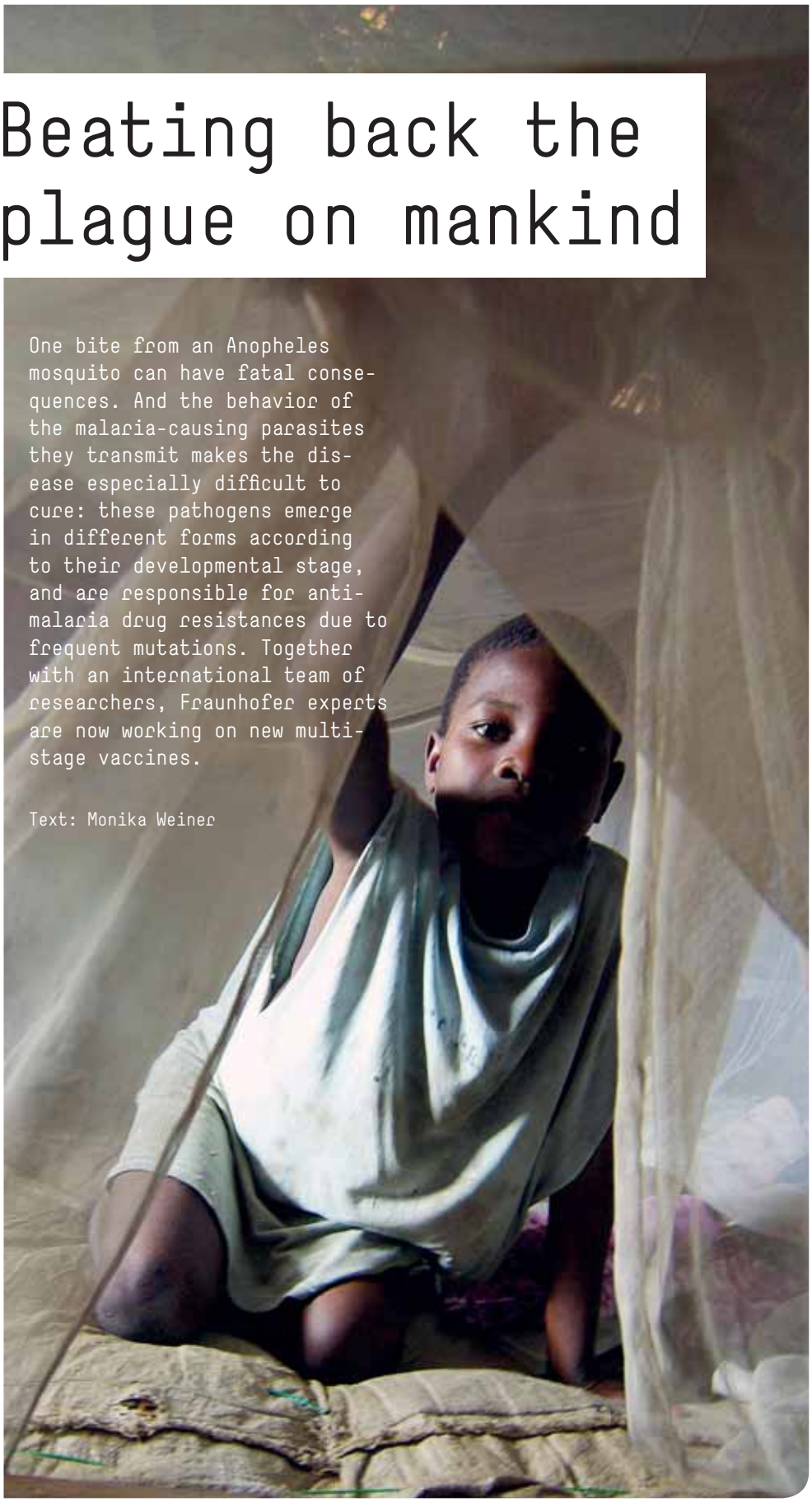
The control system takes on two jobs simultaneously: in its role as "energy plant manager", it administrates and monitors the facilities that make up the virtual power plant; as "pool coordinator", it is in charge of marketing the energy produced. If a fault occurs in the normally autonomous operation of the power plant, or if it then becomes necessary to intervene to correct it, the system helps the operator determine what is happening and what to do about it. "In providing such a system, we are offering our customers a comprehensive assortment of measures," says Mackensen. "We determine which producers are suitable on a case by case basis, and work out what their inclusion would mean for the system as a whole before going forward. The goal is to be able to set up and deliver the virtual power plant as a turnkey system. This entire process should be completed in just a few weeks." IWES expertise meets with particularly strong interest among municipal suppliers as many of them enjoy ideal conditions in terms of the size and diversity of producers and consumers they deal with. The high expectations placed on such systems by local politicians come as no surprise. They are reflected in statements made by mayors and local council members of the Stadtwerke Union Nordhessen SUN, who above all strongly favor keeping profits from renewable energy within the region, as opposed to handing them over to major national power companies. The virtual power plant fits the bill exactly.

The IWES is also satisfied with the results of the trial: "We have now technically proven that a regenerative combined power plant using renewable sources of energy, together with its control system, do work in practice, allowing this technology to emerge as a driving force in Germany's energy transformation," says Rohrig. "Our field trials have once again demonstrated that the shift toward using renewable energy has to happen at a local level." Renewable sources of energy have already come a long way in terms of the technical maturity of their production and distribution. "Now we have to find ways of getting them on the market, regardless of what ultimately happens with the German Renewable Energy Act." ■

Beating back the plague on mankind

One bite from an Anopheles mosquito can have fatal consequences. And the behavior of the malaria-causing parasites they transmit makes the disease especially difficult to cure: these pathogens emerge in different forms according to their developmental stage, and are responsible for anti-malaria drug resistances due to frequent mutations. Together with an international team of researchers, Fraunhofer experts are now working on new multi-stage vaccines.

Text: Monika Weiner



Worst affected are young children. According to a survey conducted by the World Health Organization WHO, half of all those who die from malaria are under five years old. Around a million people die every year from the effects of a disease that is spread by seemingly harmless mosquito bites, and an estimated half a billion people are currently infected with the disease. For millennia throughout most of Africa and Asia, malaria has been regarded as a plague on mankind.

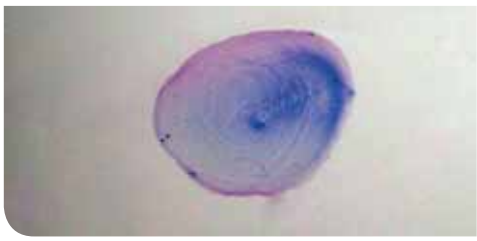
Many scientists have already dedicated their life's work to finding medication that will cure or prevent malaria, but there are several reasons why we still have not seen the decisive breakthrough: at present there are many different parasites responsible for spreading malaria, each one of these undergoes different life cycle stages, all mutate incredibly fast, and many have already developed resistance to medications currently used to treat the disease.

From mosquitos to us – and back again

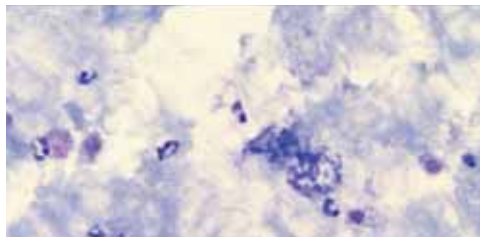
"Developing a multi-stage vaccine that covers all stages of the parasite's life cycle is a tremendous challenge," says Andreas Reimann from the Fraunhofer Institute for Molecular Biology

UNICEF warns: across the globe, malaria threatens children most of all. *© Katrina Manson/Reuters*

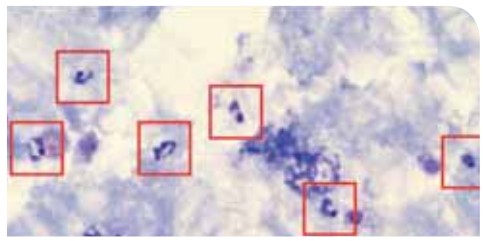
One drop of blood is enough to make a diagnosis.



Details become visible under the microscope.



Tagged red: malaria pathogens present in the blood.
© Fraunhofer IIS



and Applied Ecology IME in Aachen. "Each of the malaria pathogens, or plasmodia, goes through a complex life cycle. A change of host occurs twice – from mosquito to human and back again. While residing in a human host, the pathogens change shape, travel from the liver into the blood stream, infiltrate the red blood cells and proliferate dramatically. If we're serious about combatting the disease, we have to develop medications that break this cycle. We must be able to produce these cost-effectively in large quantities so that particularly people in developing countries can afford them."

Diagnosis, vaccine development, production – all from a single source

Finding a solution to this Herculean task is well beyond any one specialist. According to Reimann: "Anyone attempting to develop a malaria vaccine has to take an interdisciplinary approach to thinking and working." In a Fraunhofer-Zukunftsstiftung (Fraunhofer Future Foundation) project, Reimann heads up a team of biologists, computer scientists and engineers from three Fraunhofer institutes. This team is collaborating with a network of leading malaria specialists from a wide variety of specialist disciplines. This network includes tropical medicine specialists and infection biologists from the Bernard Nocht Institute for Tropical Medicine in Hamburg, the Research Center for Infectious Diseases in Würzburg, the Institute for Tropical Medicine in Tübingen, and RWTH Aachen University. They are joined by colleagues from other renowned international institutes, for example from Rijswijk in the Netherlands, Kumasi in Ghana, or from Antananarivo and Mahajanga in Madagascar. Together the researchers are developing a multi-stage vaccine to combat malaria tropica that is caused by Plasmodium falciparum, the most dangerous of all parasites known to cause malaria; in this case, infection can be fatal. The vaccine candidate is scheduled to complete its first round of clinical trials in five years' time. In order to be able to provide sufficient quantities of the vaccine candidate, engineers at the Fraunhofer Institute for Production Technology in Aachen, working together with biologists from Fraunhofer IME, are developing a new kind of plant production facility that meets the high standards set for manufacturing pharmaceuticals. In a complementary effort, colleagues at the Fraunhofer Institute for Integrated Circuits IIS in Erlangen are engineering an automated microscope system for the accurate detection of malaria infections by non-specialists (see box).

Reimann is optimistic that these ambitious goals are indeed achievable: "Each one of the project partners contributes valuable experience that benefits the group as a whole." A total of three different functional assays are required to assess the inhibitory efficacy that is induced by the multi-stage malaria vaccine candidate. This is because over the course of its life cycle, the pathogen takes on different forms and affects different cells in the human body. Each assay tests the effectiveness in a different life phase of the disease, enabling researchers to discover early on whether a new vaccine candidate stops, or at least impedes, the pathogen from multiplying. "Our aim is to achieve maximum protection by creating a vaccine that is effective against plasmodia in as many of their life phases as possible," says Reimann.

Researchers have already successfully vaccinated mice and rabbits using the malaria vaccine candidate: after being administered the protein – for which the patent process is already underway – the small animals produced antibodies to counter the various protein components. Follow-up testing showed that the induced antibodies were actually effective against the malaria pathogen in all three of its life phases.

The malaria vaccine candidate was produced using molecular farming: Reimann and his team at the IME successfully introduced the vaccine gene sequence in tobacco plants. Housed under specific conditions in growth chambers, the plants thrived and expressed the desired proteins which were then harvested and purified. In an alternative production approach. IME biotechnologists are using genetically engineered yeasts to produce the vaccine candidates. In order to carry out future clinical trials, a production license in accordance with the German Medicinal Products Act is required; the IME holds such a license for producing active pharmaceutical ingredients using plants and microbes. Together with their colleagues from the IPT, IME researchers are transferring the successful small-scale plant production process to an automated large-

Automated diagnosis of malaria

There can be no effective treatment without an accurate diagnosis. Establishing whether or not a patient has been infected with malaria determines the course of further treatment and can also be a matter of life and death. Up to now, doctors required experience and patience to make a diagnosis: once a drop of blood is finely distributed across the surface of a glass slide, the sample can be examined under the microscope for the presence of plasmodia – provided one is able to recognize them.

Researchers from the Fraunhofer Institute for Integrated Circuits IIS in Erlangen are in the process of developing an automated diagnostic platform. The full system comprises a microscope that is used in conjunction with automated digital image collection and evaluation.

Special algorithms are being worked out that enable the software to automatically determine the number and type of plasmodia present in a given sample. The new diagnostic system is designed to help doctors – whether they are practicing in central Europe, Africa or Asia – make a quick and reliable diagnosis.

Left: the African malaria-spreading mosquito "Anopheles gambiae". © *Jim Gathany/CDC/dpa*

Right: in the lab, blood samples collected in a malaria-endemic area. © *Fraunhofer IME*

scale process. In order to raise the production yield plants are to be cultivated vertically in a multi-story growth rack. The construction of the production facility including an eight-story plant growth rack is already underway. This "vertical farming" approach includes sensors and robots, controlled with the help of specially designed software, that are put in charge of the gardening duties to control each rack level and supply the correct amount of light, nutrients and water. Sowing, growing, harvesting and quality control processes are fully automated: experts from the IIS are developing 2D and 3D scanner systems that will be assigned the job of checking the size of the plant at regular intervals and reporting their findings to a central computer system.

The example of natural resistance

The scanners also check the production of the desired recombinant proteins in the leaves. The vaccine candidates are co-produced with fluorescent marker proteins which glow red under the light of a special lamp. A weak glow indicates a low protein production and reveals the plants to be removed at an early stage. Housed right next door to the multi-story plant hall are systems responsible for downstream processing and purifiying the recombinant proteins from the plant material. In future, these systems will allow researchers to provide high-purity material of the vaccine candidates or many other biopharmaceuticals for use in clinical trials.

But vaccination with recombinant plasmodium proteins, which cause the organism to form antibodies, is not the only solution to the problem. "Alongside active vaccines, it is also possible to produce passive vaccines which already contain the relevant antibodies," explains Reimann. The researchers are working on this alternative as part of the Malaria Vaccine Project. "Thanks to our collaboration with research centers in Ghana and Madagascar, we have access to blood samples taken from people who have been infected repeatedly with malaria pathogens and have survived the disease. These people are regarded as having developed semi-immunity, which means that upon malaria reinfection the antibodies present in their blood do keep the clinical symptoms in check," says the project manager.

He and his team are in the process of taking these blood samples and isolating B cells, which are responsible for producing antibodies. Once the genectic information is identified the antibodies can be produced recombinantly. As the vaccine candidates are co-produced with fluorescent marker proteins, they do not cause patients to experience any unwanted immune responses, which represents a considerable advantage over animal antibodies.

Scientists are now using the same assays they used when developing active vaccine candidates to examine whether or not antibodies taken from isolated B cells actually protect against malaria infection. "We do this to establish if, and in which development phases, the isolated antibodies are able to provide protection," says Reimann. "It's a drawn-out process, but in the meantime we have established a new technology platform and have used it to identify several effective antibodies that we can continue to work with." By the time the project is completed, Reimann's team aims to discover whether a passive vaccine is feasible and if so, supply the biopharmaceutical agents for clinical trials.

Reimann sums up: "The project's great advantage is its comprehensive concept. We are supporting the fight against malaria not only with innovations in vaccine development and diagnosis, but also with a technology platform that makes cost-effective production possible." ■

Partnership for Sustainable Energy

Fraunhofer and The University of British Columbia UBC in Vancouver, Canada will partner to jointly develop technologies for sustainable energy production and supply.

Text: Monika Weiner

The transition from fossil fuels to sustainable and regenerative energy concepts is a challenge that sooner or later all industrial nations will be facing. Mastering this difficult task will require new technologies. Currently the green-energy industries in both Germany and Canada have a globally recognised leadership role. The new alliance between Fraunhofer and the The University of British Columbia UBC will contribute to maintaining and enhancing this role. On December 21, 2012 Fraunhofer and the Canadian university signed a framework agreement, giving the green light for a collaboration spanning several years.

"The cooperation with the UBC will support us in one of our key topics" states Prof. Reimund Neugebauer, President of the Fraunhofer-Gesellschaft. "Sources of energy in the 21st century will change, and this brings up many questions we have to solve. In UBC we have found an excellent international partner for energy research". Project Leader Dr. Christopher Hebling, head of the division Energy Technology at the Fraunhofer Institute for Solar Energy Systems ISE, is excited: "Just like Fraunhofer, UBC recognizes the importance of environmental technologies for the future. Not only do both partners undertake excellent research in this field, but they also stand out due to their common strategy for cooperation with the industry. This alliance will strengthen and expand the leading position of the UBC and Fraunhofer in this market."

Fraunhofer Institutes for Environmental Safety and Energy Technology UMSICHT in Oberhausen, and for Machine Tools and Forming Technology IWU in Chemnitz, complement the expertise of Fraunhofer ISE in the research collaboration with UBC. Direct research partner for Fraunhofer will be UBC's Clean Energy Research Centre, CERC. Total funding of 4 million euros has been secured within Fraunhofer and UBC to support this unique partnership.

It has been demonstrated that using the surplus electricity from wind or solar power plants to generate hydrogen is a possible option for energy storage. In recognition of hydrogen's increasing importantance as a universal and renewable energy source for the storage of electricity as well as for emission-free mobility, the partners will examine the development of innovative electrodes as well as electrolysis cells for PEM electrolysers. The goal is to enhance performance and level of efficiency. An additional subproject investigates the recycling of the used hydrogen in the production of solar cells. Fuel cells make it possible to reclaim the energy stored in the hydrogen. In the field of fuel cell research UBC and Fraunhofer ISE have already developed a globally unique method for spatially-resolved characterization of fuel cells. Processes in the cells can be monitored in detail, thus revealing the potential for optimization. Building on this development the partners will continue their efforts to significantly improve the efficiency and reliability of fuel cells.

The collaboration will also investigate the efficient conversion of various, currently underutilized biomass materials. The investigation will concentrate on innovative cleaning methods to control and significantly reduce the tar content in the emerging product gas during gasification of wood and wood waste. The purified gas can then easily be supplied to combustion systems for a combined heat and energy generation. Wind is a significant component of the energy mix of the future. Therefore the partners will examine wind turbines from the viewpoint of production techniques. With the aid of innovative production technologies the opportunity to make the units more efficient will be explored. ■

Halting the ravages of time

The clock is ticking on Germany's cultural heritage. Historic buildings, documents, paintings and sculptures are at risk of being lost forever, threatened by environmental factors, weathering, corrosion and microorganisms. Fraunhofer has thrown down the gauntlet, and is challenging this deterioration head-on. Scientists at the Fraunhofer Center for the Energy-Saving Renovation of Old Buildings and the Preservation of Monuments in Benediktbeuern are protecting our cultural heritage with terahertz detectors, plasma-based cleaning agents and a "glass building site".

Text: Tobias Steinhäußer

"Being a preservationist is sometimes like being a detective", as Dr. Michael Panzner of the Fraunhofer Institute for Material and Beam Technology IWS in Dresden knows only too well. He and his colleagues are on the trail of historic wall paintings that are no longer visible to the naked eye. "Over the course of history, countless images were whitewashed over and became hidden from view. It is our aim to detect these invisible paintings and bring them to light," he explains. Using a terahertz scanner (THz), these historical detectives are able to look deep below the surface of old walls without causing damage to individual paint layers in the process. "THz time domain spectroscopy uses short electromagnetic pulses consisting of THz frequencies, which generates radiation that is significantly weaker than that produced by cell phones, for example. The technology should not only allow us to reveal hidden wall paintings, but also to analyze artifacts made of wood or textile materials for the presence of toxic substances," Panzner continues.

Research Alliance for the Protection of Cultural Heritage

Fraunhofer-Gesellschaft, the Leibniz Association and the Prussian Cultural Heritage Foundation have been pooling their collective expertise in the preservation of historic monuments as members of the Research Alliance for the Protection of Cultural Heritage since 2008. "The threats to art and cultural assets are very complex," explains Prof. Dr. Klaus Sedlbauer, spokesperson for the alliance. "Looking at ways to maintain and protect these assets inevitably calls for an interdisciplinary approach. Our job is to coordinate this process and encourage an exchange of knowledge between those carrying out the research and those putting it into practice." The scientists are working together on new sustainability concepts for museums, historic collections and archives, including the question of energy-efficiency. Their research encompasses the development of new methods to document, test and analyze historical monuments and sites, as well as work on modern conservation materials and cleaning technologies.

New cleaning techniques help restore historic silver objects in an environmentally-friendly and sustainable manner. © *Fraunhofer IST*

The Old Cooperage at Benediktbeuern Abbey is now the Center for the Energy-Saving Renovation of Old Buildings and the Preservation of Monuments. © *Fraunhofer IBP*

Plasma and electron beams

And cleaning is what it's all about at the Fraunhofer Institute for Surface Engineering and Thin Films IST in Braunschweig when Dr. Michael Thomas gets involved. He uses a plasma, an ionized or excited gas (one that has lost or gained electrons), to remove undesirable impurities. "Cold low-pressure and atmospheric pressure plasma treatment processes are ideal for cleaning valuable archaeological objects made of silver and iron. Low-pressure plasmas can be used to clean large surface areas of objects in a vacuum. Plasmas that work at standard atmospheric pressures have proven particularly effective in treating localized areas, where plasmajets are used, much like brushes, to clean the surface. Silver sulfide layers in particular can be reduced using cold plasmas, and tarnished silver can be brightened," explains the scientist.

Frank-Holm Rögner also makes use of plasmas to fight dirt and bacteria. "The electrons we extract from plasmas are used to disinfect and stabilize historic documents made of paper," explains the physicist, who works at the Fraunhofer Institute for Electron Beam and Plasma Technology FEP in Dresden. Rögner is kept very busy, since cultural assets made of paper are deemed particularly at risk. 19th and 20th century documents in particular face the threat of irreversible damage, attributable both to their acidity and improper storage. Attacks by mildew and bacteria, as well as ink corrosion and parasites, are further causes of damage. "We first treat the documents with low-viscosity monomers, and then fire accelerated electrons at them. This polymerizes the monomers, which

bind together within the damaged site to create a supportive lattice for the broken cellulose fibers. This support structure remains stable in the long-term, and the paper is permanently disinfected at the same time. In contrast to laminating, the feel of the paper remains the same."

Center in Benediktbeuern

Further south, it's all about historic masonry. The Fraunhofer Institute for Building Physics IBP has its outdoor testing facility in Holzkirchen near Munich. "Alongside the conventional conservation of historic monuments, we also deal with the interaction between indoor climate and works of art, and how to improve the energy-efficiency of museums and archives," says Ralf Kilian, a qualified conservator working at the IBP. "The real aim is to come up with solutions that are compatible with the historic structure itself, such as the reversible interior insulation methods we are now developing as part of a new project." In 2010, researchers at the Fraunhofer Center in Benediktbeuern set up a "glass building site" at the Old Cooperage of the Abbey, in order to investigate energy-saving methods of renovating old buildings and preserving historic monuments. Despite the uncomfortably chilly temperatures of a damp autumnal visit to the 18th century cooperage, the ground floor at the north wing of the building is pleasantly warm inside. It is packed to the rafters with sensors, cables and measuring instruments. "We're currently testing the efficiency of wall heating systems produced by our partners in industry. Researchers here analyze the indoor climate, levels of energy consumption and test various insulation materials," explains Christine Milch, building works and research coordinator at the site in Benediktbeuern.

The Old Cooperage was donated to Fraunhofer by the religious order based at the Abbey, the "Salesians of Don Bosco". Besides taking over the renovation and upkeep of the historic building, the site serves as a large laboratory for energy-efficient monument conservation.

"The range of topics we are focusing on at the moment extends from heating technology and insulation materials through to retrofitting windows for improved energy efficiency and room acoustics," explains Milch. Fraunhofer is working on this project together with the Bavarian State Office for the Preservation of Historic Buildings and Monuments, the Bavarian State Office for the Environment, the German environmental foundation Deutsche Bundesstiftung Umwelt (DBU), the Technische Universität München (TUM) and other institutions of further education and training. "Work at the Fraunhofer Center in Benediktbeuern primarily serves the needs of architects, engineers, building planners, skilled tradespeople, conservators of historic buildings, energy advisors, property developers and local authorities – but anyone interested in the topic is welcome to come and visit," adds Dr. Britta von Rettberg, who manages the center.

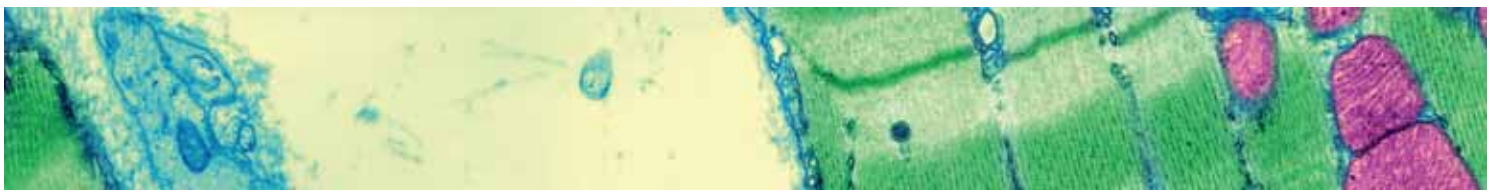
Renovation of historic town centers

Claudia Schindler is well aware that energy efficiency and the protection of cultural heritage are closely related concerns. A qualified restorer, she is responsible for overseeing the EFFESUS project at the IBP. "The EU is aiming to reduce its CO_2 emissions significantly by 2020. Over the next four years, the EFFESUS research project aims to show how historic districts can be made to consume energy more efficiently while still maintaining their unique character," says Schindler. The IBP is responsible for the technical coordination of the seven UNESCO World Heritage Sites that are taking part: Santiago de Compostela, Genoa, Budapest, Istanbul, Glasgow, Visby in Sweden and Bamberg in Germany. The institute is partnered by the Fraunhofer Center for Central and Eastern Europe MOEZ in Leipzig. The insulation materials developed by the project partners are being analyzed and tested at the testing site in Holzkirchen, with the MOEZ providing the market launch strategy and communications concept. ■

Research Alliance for the Protection of Cultural Heritage

The Research Alliance comprises 18 Fraunhofer institutes, eight Leibniz research museums and five institutions of the Prussian Cultural Heritage Foundation. They have come together to cooperate in developing and testing new processes and methods for restoring and conserving cultural assets. The Alliance also aims to accelerate and deepen the transfer of knowledge between those carrying out the research and those putting it into practice, while generating a stronger and more widespread awareness of the importance of our cultural heritage.

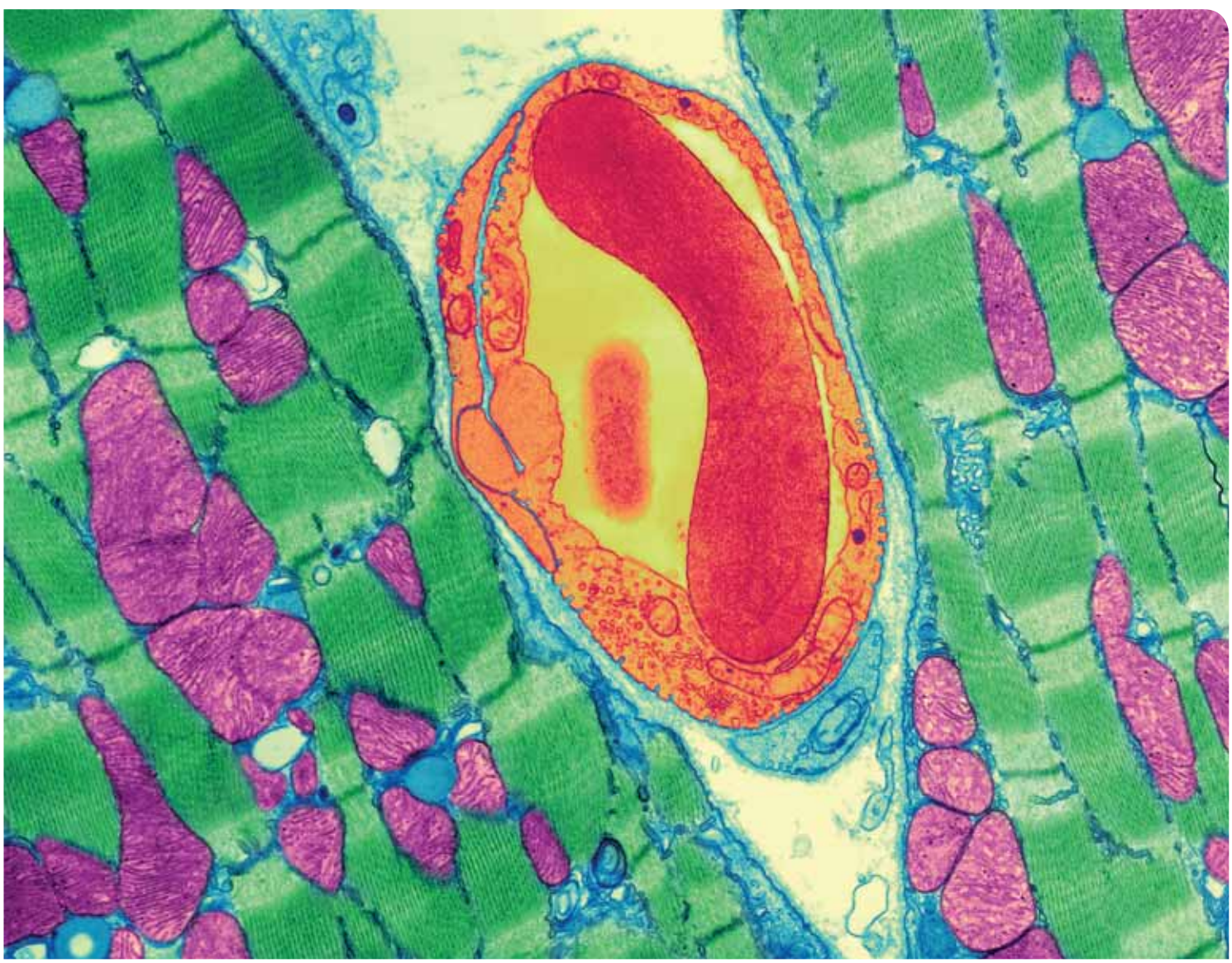
www.forschungsallianz-kulturerbe.de



Heart muscle cells from the Petri dish

Suffering a heart attack can have a devastating impact on heart muscle cells and many people never fully recover from the damage inflicted. Together with a group of top-class stem cell researchers from the USA, Fraunhofer scientists are currently developing a method designed to replace damaged cells.

Text: Monika Weiner



A glimpse into the heart: in this tinted image from an electron microscope,heart muscle cells appear green and blood cells red. © *Thomas Deerinck, NCMIR/SPL*

The heart regulates life, beating on average 60 to 100 times a minute. More than a thousand liters of blood are pumped around the human body every day. This steady flow ensures that our muscles, liver, kidneys and brain always have an adequate supply of oxygen and glucose. None of us would last a minute without the relentless efforts of our hearts and even slight malfunctions can cause us considerable harm: if blood supply to the heart becomes compromised, even just for a moment due to a blockage in one of the coronary vessels for example, heart muscle cells start dying almost immediately. Heart attacks are one of the most common causes of death, claiming the lives of 250,000 people every year in Germany alone. Worldwide that number reaches several million.

And although being able to provide good and timely medical treatment means the odds of surviving a heart attack are always improving, most people tend to suffer from the effects for the rest of their lives. Once we reach adulthood our heart muscle cells no longer regenerate, so after a heart attack the heart's power to pump blood around the body is often reduced, as is the person's quality of life.

This explains why researchers around the globe are working to develop new therapies. "We have been trying to find a way to replace dead cells with fresh ones for a long time," explains Prof. Dr. Katja Schenke-Layland. "But 'adult' stem cells, which we have used in previous research and development efforts as well as in the first clinical trials, failed to deliver the success we were hoping for. Although they do improve blood flow, these cells do not, however, end up integrated into the tissue and, more importantly, will not develop into fully functional heart muscle cells." The problem is that adult stem cells, taken from a person's spinal cord for example, are already extremely differentiated and as such are no longer particularly adaptable.

Cells for all occasions

A promising alternative comes in the form of our own progenitor cells. As these cells are in an earlier stage of development than adult cells, they are more adaptable. "These cells have the potential to form functional heart muscle tissue," explains Schenke-Layland. At the Stuttgart-based Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB, she worked together with a team of researchers from the University of California, Los Angeles (UCLA) on developing a new method of isolating progenitor cells for use in treating heart attacks. This is no easy task as adult cells first have to be reprogrammed: they must abandon what they have been programmed to do and can then be trained in their new role as heart muscle cells.

It is only recently that this has become possible. Research or treatments involving unspecialized or "pluripotent" stem cells had to obtain them from embryos. In the initial stage of human development, cells are not yet differentiated – each one has the potential to become skin, liver, brain or indeed heart muscle. However, the use of embryonic stem cells, obtained from fertilized egg cells, is considered by many to be morally questionable and is restricted in many countries. But now there is an alternative that does not raise any ethical concerns: Japanese scientist Shinya Yamanaka shared the Nobel Prize in Physiology or Medicine 2012 for his work on a new technique that enables the body's mature cells to be converted back into pluripotent stem cells. All that is needed are viruses that introduce four specific genes into each cell.

This technique enabled Schenke-Layland's German-American research team to be the first to turn cells of adult mice into undifferentiated stem cells and convert these cells into functional heart muscle tissue. In the lab, it is essential that pluripotent, undifferentiated cells are allowed to mature into progenitor cells. Using undifferentiated cells to regenerate tissue in animals or in humans carries a high risk of the subject developing tumors. Waiting too long means that cells transform unchecked, losing both their potential and ability to develop into heart muscle tissue. The biologist explains: "But if we get the timing just right, we end up with cells that are just beginning to specialize. This means they possess the necessary adaptability to be integrated into heart muscle tissue, for example, where they then will continue to develop."

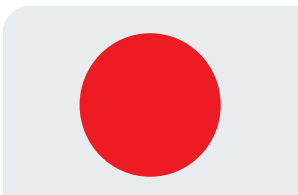
But how does one know when the right time is? Schenke-Layland invested many years of her life in finding an answer: "You have to monitor the cells day in, day out and perform a battery of varied tests. This is the only way to determine the precise stage in which certain proteins form, enabling us to find them when we need them.

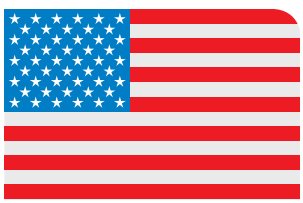
Out of the Petri dish and into the heart

Getting the timing right means that culturing of the cells can continue – provided one has the necessary expertise. The IGB research group has a lot of experience in exactly this area: its specialists have spent years developing strategies that allow controlled production of tissue- and organ-specific cells. The result: for a cell to develop into highly specialized tissue, it needs an environment that provides the right proteins, growth factors, pressure and blood flow. Achieving the suitable conditions allows the exact cells required for a particular clinical trial or treatment to be cultured in bioreactors.

The researchers' work with mice has now demonstrated that functioning heart muscle cells can be produced in this way. "We tagged the cells with a fluorescent marker so we could track them as they traveled around the organism," reports Schenke-Layland. "This enabled us to show that a month after implantation, the cells had become integrated into the beating heart of the mouse. Here we had the proof that this method has therapeutic applications."

It will still be quite a while before people who have suffered a heart attack will be able to benefit from the new method. The overall process has to be optimized to be able to engineer induced pluripotent stem cells from a few of the patient's skin cells, and to use these to obtain heart muscle progenitor cells. The researchers also have to find a way to multiply cells in bioreactors quickly enough so that when starting clinical trials, doctors can already have millions of cells for each patient. Until that day comes, Schenke-Layland is in for more long nights in her lab. But she remains convinced that her efforts will pay off: "Our method has the distinct advantage of using the body's own cells which it will not then reject. This gives us a good chance of using the cells to help regenerate damaged heart muscle and improving people's quality of life." ■





Joint research

More and more electricity and heat is being derived from the sun's energy. In order to improve the research network in this field, three solar research institutions signed a Memorandum of Understanding (MoU) in San Francisco in July 2012 to form the Global Alliance of Solar Energy Research Institutes (GA-SERI).

The cooperation agreement between the U.S. Department of Energy's (DOE) National Renewable Energy Laboratory NREL (USA), the National Institute of Advanced Industrial Science and Technology AIST (Japan) and the Fraunhofer Institute for Solar Energy Systems ISE (Germany) was signed as part of the fifth Intersolar North America conference and exhibition. The newly founded alliance aims to give solar research a global voice.

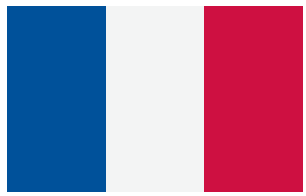
The first step taken by the institutes was to agree to a regular exchange of scientific knowledge, for which two scientists from each institute are to take up residence at each of the other research centers.

Fraunhofer in the UK

Glasgow is home to the first Fraunhofer center operating under the umbrella of the new Fraunhofer subsidiary in the United Kingdom. Scientists from the Fraunhofer Institute for Applied Solid State Physics IAF in Freiburg are cooperating there with scientists from the renowned University of Strathclyde in the field of photonics.

Photonics has long been considered an important topic in the United Kingdom. Its photonics industry is the second largest in Europe, after Germany. Over 80 manufacturers of laser-based products are located in Scotland alone, and scientists at the University of Strathclyde are internationally recognized experts in photonics. This local excellence, and close ties between research and industrial practice, create an environment that Fraunhofer finds attractive, as exemplified by the fact that Fraunhofer institutes have been cooperating with the experts in Scotland for many years. "We are delighted at the opportunity to work even more closely with the University of Strathclyde in future," says Fraunhofer Senior Vice President Prof. Ulrich Buller.

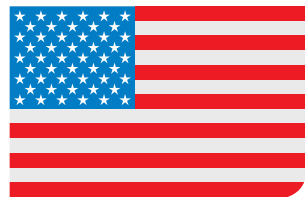
As soon as construction of the university's new Technology and Innovation Centre is completed, it will be home to Fraunhofer along with research groups from the university and industry. The British Fraunhofer team is still small, but the next four years should see staff numbers swell to 75. The center aims to cooperate with the best British research groups and develop solutions for industrial clients.



Terahertz security

Explosives and drugs are quick to hide and hard to find, making it a real challenge for security personnel to trace them. Technology is now able to help. Terahertz waves can be used to detect various dangerous materials quickly and safely. Fraunhofer research scientists have collaborated with French scientists from the Institut d'Electronique, de Microélectronique et de Nanotechnologie IEMN (Institute of Electronics, Microelectronics and Nanotechnology), a member of the Carnot institutes research network, to develop a high-performance and cost-effective sensor elements for terahertz radiation. These elements are key components for a postal scanner which has be developed in cooperation between Hübner GmbH and Fraunhofer IPM. This postal scanner can be used to identify explosives and drugs in letters, for example.

"Effective detection requires reliable, high-performance and yet cost-effective antennas," explains Joachim Jonuscheit from the Fraunhofer Institute for Physical Measurement Techniques IPM in Kaiserslautern. Jonuscheit worked alongside French colleagues to improve emitter and receiver units for practical application as part of the ARTEMIS project (Antenna aRrays for TErahertz Material Identification and Security applications). Single emitter and detector chips were combined to develop a fast and cost-effective inspection systems.



Diagnostics with an iPad

Breast cancer is the main cause of death in women aged 30 to 60 in western industrialized nations. More and more imaging techniques such as mammography, ultrasound and MRI are being used, and new ones constantly developed, to detect carcinomas early; facilitating effective treatment which is essential to the survival of patients. Researchers at the Fraunhofer Institute for Medical Image Computing MEVIS in Bremen have now developed an innovative new concept in collaboration with radiologists from Florida that enables doctors to better handle the available information in medical imaging data when making a diagnosis. The project proposes for doctors to use handheld tablet computers connected to the medical workstations.

The tablet is operated by hand gestures so that high-resolution monitors can be used almost exclusively for displaying images as a "use your hands to read" device. Clini- cians can now carry the information they need wherever they go – to brief a patient, attend a case conference or prepare for an operation.
This opens up new possibilities,"

Clinicians are suddenly able to evaluate the thousands of pictures and flood of information in an efficient, individualized and convenient man- ner," states Kathy Schilling. She is a radiologist at the Women's Center at the Boca Raton Regional Hospital and was one of the partners involved in developing the concept. The technology is patent pending.

Aboard the flagship

The European Commission has chosen two fields of research in which to develop new technologies and foster scientific excellence throughout Europe. The Human Brain Project is one of the two FET (Future and Emerging Technology) flagship projects set to receive substantial funding as part of efforts to promote Europe as a world-leading "knowledge superpower". In order to understand how the human brain works, an international and interdisciplinary team of researchers intends to simulate the brain using supercomputer-based models. These models will then be used to develop new technologies for applications in neuroscience, medicine and computer technology. Over 80 research groups, including two Fraunhofer institutes, are involved in the project.

Hardware is being developed as a sub-project that enables information to be processed in several places simultaneously, modeled on the way our brains work. The human brain is able to process images sent from the eyes and acoustic and tactile stimuli at one and the same time. Building a computer that works in a similar way involves connecting entire wafers with one another. Scientists at the Fraunhofer Institute for Reliability and Microintegration IZM in Berlin are developing the necessary wiring systems for this "parallel processing".

In another sub-project, research scientists at the Fraunhofer Institute for Algorithms and Scientific Computing SCAI are developing software, numerical algorithms and methods for using neuroscientific simulations on high-performance computers.

Ports of the future

Time is money – this is also true of loading or unloading container ships. That's why logistics specialists have optimized processes in the harbor to ensure everything runs smoothly.

But saving time isn't everything. Energy consumption also costs money. An international team of researchers, including members from the Hamburg-based Fraunhofer Center for Maritime Logistics and Services CML, has set out to improve energy management in sea and inland ports. The EU's Green EFFORTS project for Green and Effective Operations at Terminals and in Ports aims to introduce ways of increasing energy efficiency and reducing CO2 emissions.

The research partners develop concepts for introducing, using and storing renewable energies. A prerequisite for developing new environmental concepts is having an in-depth understanding of each and every process that takes place in port and at the terminals. "This is why we're developing a Port and Terminal Knowledge Landscape, or knowledge map, that will tell us exactly how much energy is being consumed or how high CO2 emissions are in different parts of the ports and terminals," says Prof. Jens Froese, project coordinator and Professor of Maritime Logistics at Jacobs University in Bremen.

Energy transition

The increasing scarcity of oil, gas and coal means that the demand for energy in future can only be met using renewable energy sources. Four years ago, 75 states founded the International Renewable Energy Agency, IRENA, with the aim of making renewable resources more readily and quickly available. To date, the organization has 159 members, including the EU. These members are working together to develop, foster and extend the use of solar energy, wind power, biogas and hydroelectric power.

The Fraunhofer Institute for Solar Energy Systems ISE in Freiburg will work in close partnership with IRENA in future. The two organizations signed a Memorandum of Understanding at the World Future Energy Summit in Abu Dhabi in January 2013. "Pooling our strengths will enable us to create synergies that will accelerate improvements in energy efficiency and the development of renewable energy sources worldwide," explains ISE director Prof. Eicke Weber at the official signing of the contract.

Research scientists from the ISE have been working with IRENA since the organization was founded in 2009. The scientists' work so far has included development of the cost-analysis methods used for "Cost of renewable energy" studies, and they are now investigating effective ways to integrate renewable energies into existing power grids. Another focus of their research is decentralized energy supplies for rural regions that are not yet connected to the power grid.

Energy off the roll

Encouraged by its buoyant economy, Brazil is investing more heavily in alternative energy. Conversion of solar energy into electricity is an important part of the strategy being pursued here, where organic photovoltaics should help to provide electricity in areas of Brazil characterized by poor infrastructure. This includes not only light, but also access to modern means of communication such as computers and smartphones.

This has led the Brazilian company Flexsolar in Joinville and Germany's Fraunhofer Institute for Applied Polymer Research IAP in Potsdam-Golm to join forces in developing flexible organic solar cells. Flexsolar aims to produce the required amounts of solar photovoltaic elements in a continuous roll-to-roll printing process. The techniques and procedures required will be developed by Fraunhofer IAP, who also intends to build a pilot plant in Brazil. Flexsolar is tasked with product development and marketing in South America. The contract for the project was signed on October 3, 2012, at the Brazilian Flexsolar headquarters in Joinville (State of Santa Catarina).

Dream home for Seoul

The "Energy Dream Center" in Seoul is the first zero-energy building in South Korea. This energy-efficient demonstration building was developed by researchers from Fraunhofer ISE in Freiburg on behalf of the city of Seoul.

Text: Monika Offenberger

The "Energy Dream Center" built by the municipal government of Seoul is a landmark in the use of renewable energy .
© Parsons Brinckerhoff Korea

How does a zero-energy house work? And how can you build one in a country like South Korea, where winters are just as cold as in Europe and the summers fiercely hot and humid? The Energy Dream Center in Seoul provides the answer to both questions: averaged out over the course of the year, this spectacular construction is capable of independently producing enough energy to meet its energy requirements in full. The showcase building was erected on behalf of the municipal government of Seoul within the 10 million strong metropolis; located in the World Cup Park, it opened its doors in mid-December 2012. Exhibitions and presentations spanning the three levels of the building allow visitors to learn about what is involved in building a zero-energy house and how they themselves can save energy on a day-to-day basis. The concept for the demonstration building was developed by a team of German and Korean scientists, engineers and architects under the management of the Fraunhofer Institute for Solar Energy Systems ISE in Freiburg.

The mandate for this innovative project was given to Prof. Dr. Eicke Weber, director of the ISE, in May 2008, coming straight from the then mayor of Seoul, Oh Se-hoon. It was no coincidence that the ISE was chosen for the task, as the institute is known for its experience in planning energy-efficient buildings. "No less than 15 years ago, we teamed up with project partners to analyze two dozen selected construction projects on behalf of the Ministry of Economics. This analysis covered a broad cross section of buildings in Germany designed to fulfill stringent energy-specific requirements," points out ISE engineer Dr. Jan Wienold, who was involved in developing the energy concept for the Energy Dream Center. "Deciding what technical equipment to put in the building is not the critical factor. The first job is to keep energy consumption as low as possible. Only when all the potential for energy savings has been fully exhausted do we consider what technologies we can use to supply the energy to meet the remaining energy requirements," says Wienold, explaining the researchers' approach.

Shape and function go hand in hand

Saving energy begins with the shape of a building. The Berlin-based architect Thomas Winkelbauer, commissioned by the ISE to design the building, envisioned a square shaped building rotated on its own axis and enclosed by a flat roof. "We made changes to the original design so that the various areas of the façade provided their own shade when the sun gets hot, meaning that less energy has to be expended on cooling them," explains Arnulf Dinkel, Wienold's colleague at the ISE and himself an architect. This was achieved by angling all exterior façades at 45 degrees, so that the building broadens out from its base upwards in a conical shape, says Dinkel: "This has created four big overhanging angular surfaces. The windows positioned beneath them are provided with their own shade in the summertime and the rooms inside the building can be illuminated by natural light during the day." This saves on electricity for artificial lighting – in the same way as the square interior courtyard at the center of the building provides the inward-facing windows with natu-

ral light. In places where artificial lighting is unavoidable, light sensors enable efficient use of energy-saving LEDs.

In order to satisfy the level of comfort its occupants expect, a building not only has to be lit properly but also kept suitably cold/warm and ventilated. Here, too, architectural design is decisive: "The compact size of the building, which boasts ideal placement of window and wall areas and uses appropriate materials, assures a high level of insulation," explains Arnulf Dinkel. The building envelope is particularly important as it must provide protection from heat and cold while meeting structural requirements in terms of airtightness, waterproofing, moisture transport and channeling of rain water.

In Germany, extended experience with passive and zero-energy houses, built with government support, enables the construction industry to call upon tried-and-tested materials and techniques. Not so in Seoul: "Our Korean partners didn't have any experience of how best to go about building the individual layers of the outer shell. We had to go through a lot of structural calculations with them before they got to grips with the underlying principle," says Gert Hintennach from the Freiburg firm of engineers "solares bauen". The company was part of the planning team at the ISE from the beginning of the project and helped to develop the building services concept as well as later supervising the concept's implementation on site. The contract issued by the city of Seoul for the Energy Dream Center stipulated that the work should be carried out by local construction companies as far as possible. Coordination of the building work was entrusted to the Korean planning office of the consulting firm Parsons Brinckerhoff. Detailed monitoring of any construction processes relating to the field of energy nevertheless remained the task of Gert Hintennach, who since the end of 2011 has travelled to Seoul a total of five times, staying a week or two on each visit.

The biggest challenge was communicating the overarching concept of zero-energy buildings to the Korean technicians and engineers, since this concept depends on the best possible interplay of the building components and individual technical systems. So Gert Hintennach and the ISE team first took a close look at all the electrical components – computer networks as well as lighting, fire alarm and door locking systems – with the aim of minimizing their energy consumption. "Initially, each of these systems had its own computer with its own power supply. Of course, this amounted to a huge demand for power, exceeding all the rest of the building's energy requirements for heating, cooling and lighting," recalls Jan Wienold. This prompted the Fraunhofer team to push for a design that would control as many of the IT systems as possible via a single computer, with built-in energy-saving regulators. This enabled the building's energy requirements to be reduced dramatically. "It was nothing short of a revelation for our partners, since of course every kilowatt hour you can save means fewer photovoltaic cells are needed," says Wienold. The building's remaining power requirements, amounting to some 280,000 kilowatt hours a year, are met by solar cells placed on the flat roof of the Energy Dream Center and on the small grassy area in front of the building, which feed their energy into the public grid. By feeding back as much energy to the grid as it consumes over the course of the year, the Center is an energy- and climate-neutral net zero energy building.

Building consumes 70 percent less energy than the Korean average

The geothermal energy system, including its measurement and control equipment, was produced in South Korea and installed directly at the site. It heats the building as required, as well as cooling it in places. The three probe arrays required a total of 37 boreholes extending to a depth of 50 meters; these were fitted with double-tube probes. Here, the earth is used as an energy store: in summer, the probes enable direct cooling of the building, while in the winter connected heat pumps see to the heating of the interior of the building, as well as providing hot water all year round. The installation of the system is another example of how energy can be saved in the long term, emphasizes Gert Hintennach: "Initially, the Koreans hadn't really thought about the dimensions of the pipes and their plans revealed them to be for the most part far too big, and poorly insulated. Opting for new sizes of pipe with smaller diameters allowed us to reduce pressure losses dramatically and consequently the energy consumption too."

When temperatures reach over 30 degrees Celsius in the summer, accompanied by humidity levels of up to 80 percent, the air pumped in to ventilate the building is cooled and dehumidified by a refrigerating unit complete with turbo compressor. The geothermal probes cool the rooms via cooling circuits laid in the floor and convectors located on the second floor. One of the few technical components not to be produced in Asia – apart from the heat pumps from Swiss manufacturer Saga – is the ventilation system featuring two-stage heat recuperation and evaporative cooling. This system was provided by Menerga Apparatebau GmbH, based in Mülheim an der Ruhr. The skillful integration of the various systems that comprise the building services, combined with the building's passive measures for saving and generating energy, has paid off – the Energy Dream Center consumes 70 percent less energy than the Korean average to heat and cool the building.

"The completion of this zero-energy building has turned the flagship project into a real and exemplary showcase for state-of-the-art energy-efficient construction, and brings this technology to the attention of a wide audience," points out Arnulf Dinkel. The Fraunhofer architect is now hopeful that the example of the Energy Dream Center could lead to it being replicated elsewhere: "Energy prices are sure to rise across the world – even in places like North America or Saudi Arabia, where energy is still very heavily subsidized. This is leading the governments of these countries to set new energy targets for buildings. We can help them realize those targets." ■

Tasty and gluten-free

Cereals are good for you, supplying the body with carbohydrates, proteins and vitamins. Yet some people are intolerant to the gluten protein they contain. Now, researchers are developing new recipes for tasty, gluten-free pasta and pastries.

Text: Britta Widmann

People suffering from coeliac disease are only allowed to eat pasta and bakery products made with gluten-free types of grain. © *Fraunhofer IVV*

Not every person can eat what they like; far from it, one in every 250 people in Germany is intolerant to the protein gluten, which is chiefly found in the cereals wheat, spelt, barley and rye. Experts call this intolerance coeliac disease. For those affected, this means giving up bread, pizza, pasta and cakes, while ice cream wafers, dumplings and pretzels also pass onto the list of banned foods. Those suffering from coeliac disease, a chronic bowel disorder, must keep to a strict diet if they are to avoid diarrhea, stomach ache, vomiting and other symptoms. Accordingly, only gluten-free products make it onto the menu.

Indeed, demand for these food products, mainly offered by small and medium-sized enterprises, has risen steadily over the past years. Nevertheless, many consumers dislike gluten-free pasta and bakery products because they are unappetizing, lacking in texture and leave a disagreeable sensation in the mouth. This is a view confirmed in consumer tests involving coeliac disease sufferers and healthy volunteers. The tests form a key part of the EU project GlutenFree (www.glutenfree-project.eu), which is being coordinated by the Fraunhofer Institute for Process Engineering and Packaging IVV in Freising. Partners include ingredient providers and food producers as well as research institutes from Germany, Ireland, Italy and Sweden. The aim of the project is to enable SMEs to develop premium, tasty gluten-free products that the consumer will eat with real enjoyment and satisfaction. The focus is primarily on bread and pasta, and on improving their taste, smell, appearance, texture and sensation in the mouth.

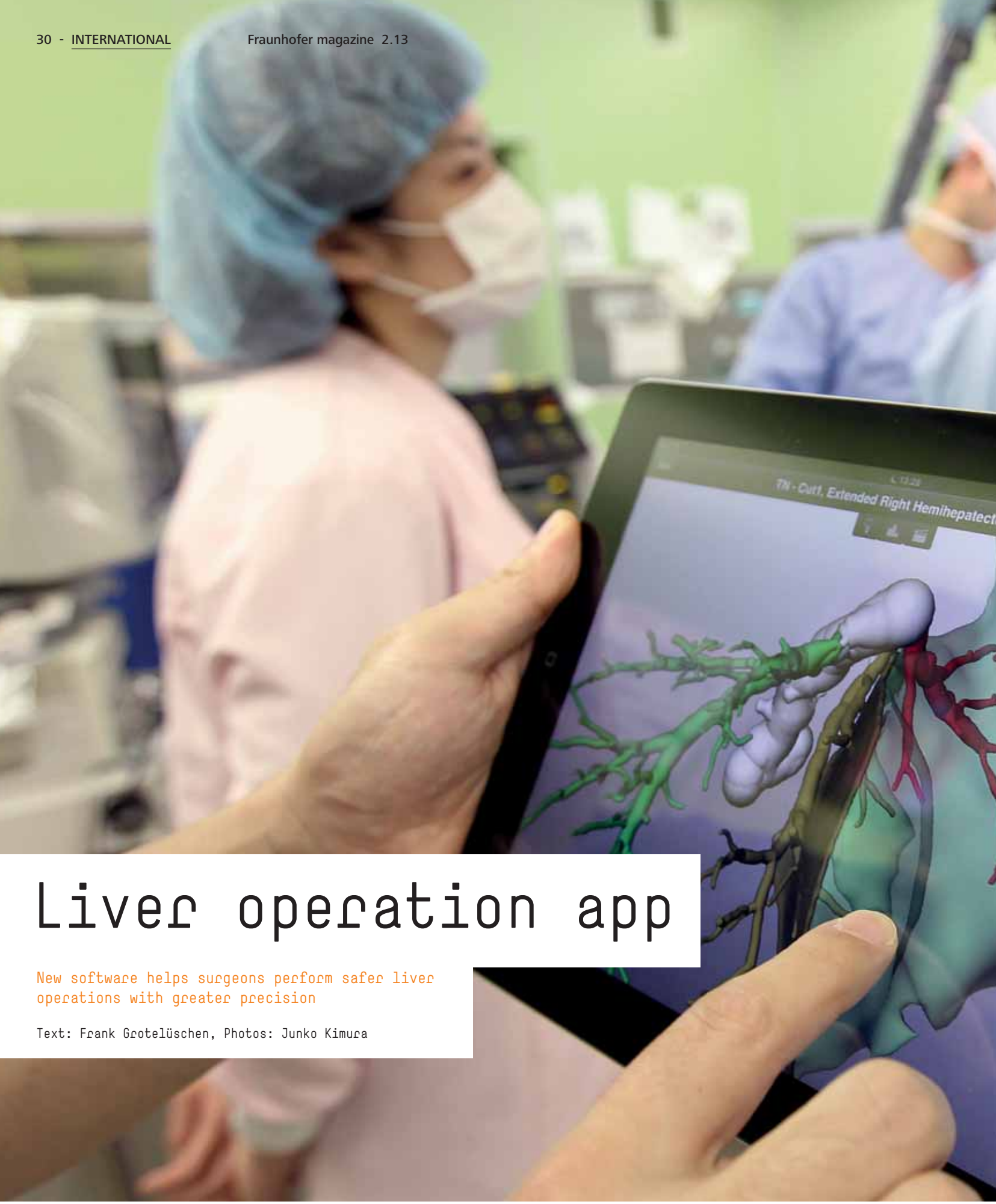
Gluten is good for baking because it holds the dough together. "Gluten contains two protein fractions, the gliadins and the glutenins. These form a network-like structure – the dough matrix, if you like – giving the dough good porosity and a viscoelasticity that allows it to keep its shape and remain elastic in the baking process," says Dipl-Ing. Jürgen Bez, scientist at IVV. Gluten-free bakery products dry out more quickly, crumble more easily and have a shorter shelf-life. Pasta without gluten overcooks more quickly, and is sticky and less elastic. "As a result, finding ingredients to compensate for gluten's positive properties is a challenge," says Bez.

It's the combination that counts

The process begins as early as the selection of raw materials: quinoa, for instance, often produces a bitter taste. Nevertheless, researchers have been successful in finding ingredients such as plant proteins, which lend pasta and bakery products the same structuring effect as the protein gluten. Hydrocolloids like xanthan gum, HPMC and dextran have all been examined carefully, as well as seeds taken from cereals and pseudocereals like amaranth, quinoa and buckwheat. In addition, scientists analyzed protein isolates taken from potatoes and pulses like lupins, broad beans and peas, as well as investigating the interaction of a variety of recipe ingredients during the production process, and the ways in which this affected texture, sensory properties and aroma profile. A whole range of recipes were tested; for example, researchers combined proteins with soluble fibers like xanthan gum and HPMC or with insoluble citrus fibers.

"Adding the hydrocolloid xanthan gum succeeds in giving dough a particular elasticity, though here the end result is heavily dependent on the concentration, the proportion of water, the type of flour and the other ingredients. Getting the right combination is crucial," summarizes Bez. "As a rule, hydrocolloids alone are not enough to offset the lack of gluten, and proteins need to be added to recipes." Thanks to a special production technique, scientists are able to extract a protein isolate containing viscoelastic properties from the seeds of lupins and broad beans. This was another technique developed by Bez and his team at Fraunhofer IVV. "By adding lupin proteins, we were able to improve the volume of baked goods," says the researcher. Scientists also established that adding sourdough helps prevent loaves from going moldy so quickly, observing that dough becomes more elastic and that loaves stay fresh for longer. What's more, some gluten-free flours are more nutritious than wheat flour. Test subjects rated oatmeal, rice flour and teff flour particularly flavorsome.

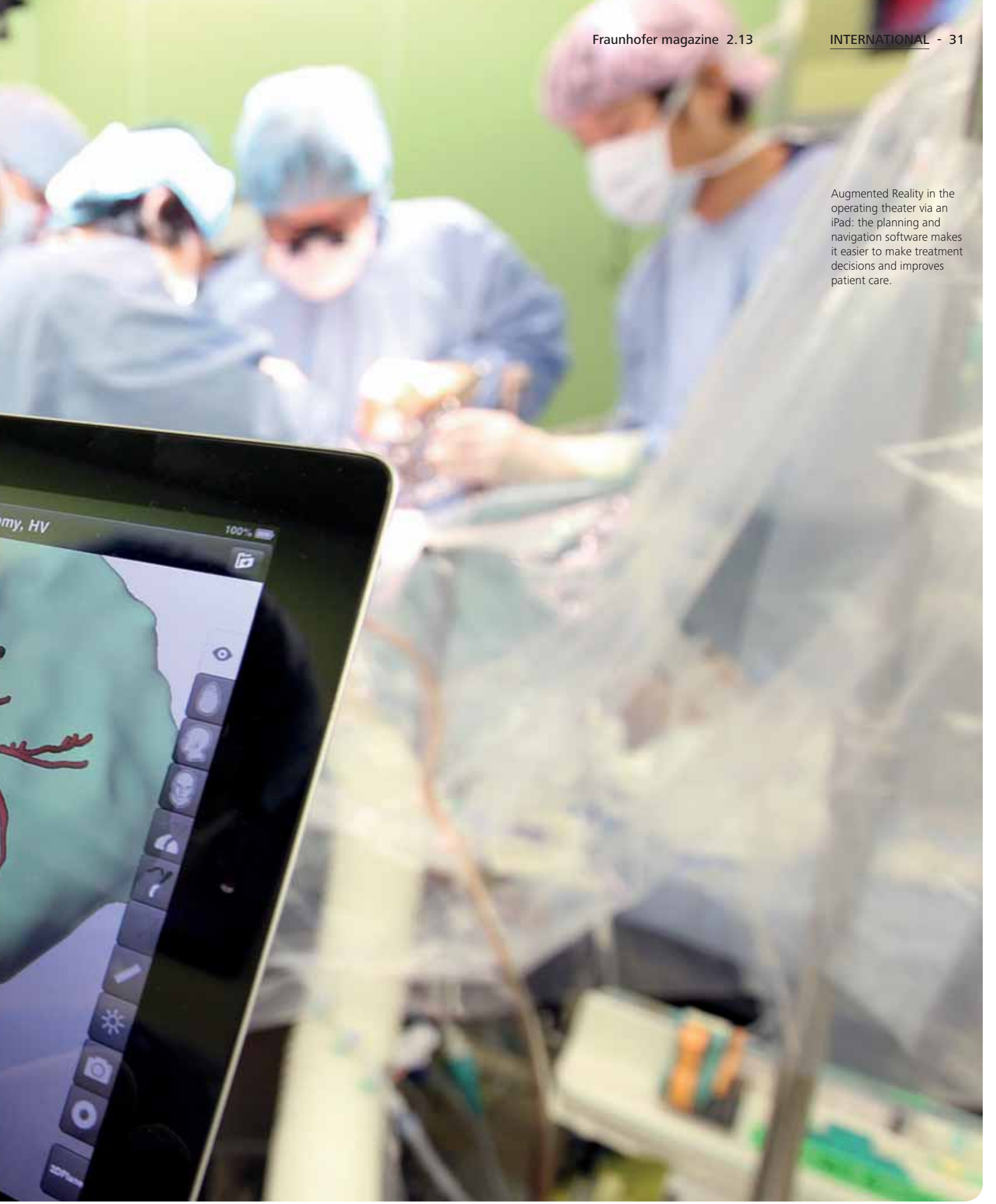
Bez considers the project a success, pointing to project partners' success in producing a range of new and improved gluten-free breads, including toast bread, leavened bread and oat wholemeal bread, ciabatta, baguettes and pizza dough. Four of the baked goods producers involved in the project are already using the recipes for ciabatta, wholemeal bread and pizza dough. Furthermore, researchers were able to produce tasty, gluten-free spaghetti with a high fiber and protein content. Now it won't be long now before we see some of the new products lining bakery and supermarket shelves. ■



Liver operation app

New software helps surgeons perform safer liver operations with greater precision

Text: Frank Grotelüschen, Photos: Junko Kimura



Augmented Reality in the operating theater via an iPad: the planning and navigation software makes it easier to make treatment decisions and improves patient care.

The operation demands extreme concentration and utmost care from the team of surgeons, who are attempting to remove a dangerous liver tumor from their patient. Since the liver is a complex organ, operations are difficult and can last several hours. "There are countless blood vessels running through the liver that supply the organ with 1.5 liters of blood every minute," says Andrea Schenk, head of liver research at the Fraunhofer Institute for Medical Image Computing MEVIS in Bremen. "It is vital that surgeons know exactly where the blood vessels are located when they are operating, as one false incision could result in the patient losing a great deal of blood, with potentially serious consequences."

New technology developed at MEVIS will help minimize this risk. The key feature of this new tool is that it is based on an object that many of us use every day for surfing the web, reading or to entertain ourselves – the iPad. The initial idea came from Itaru Endo and Ryusei Matsuyama, two surgeons at the Yokohama City University School of Medicine in Japan who have been working with software developed in Bremen. The software uses computer tomography images to calculate the precise location of blood vessels running through each patient's liver in 3D. This helps the surgeons to plan each operation more precisely, and allows them to gauge the exact location of necessary incisions in each individual case.

Planning operations using an iPad instead of paper

"We've been using MEVIS software since 2003," explains Endo, "and it has helped to significantly reduce patients' blood loss in over 60 surgeries." However, the Japanese surgeons had requested one improvement. In order to view the images generated by the MEVIS software during an operation, the surgeons had to print the pictures out and hang them on the walls of the operating theater. But since not all the information including the 3D data the surgeons needed could be printed out, they were forced to make additional mental notes.

So Endo and Matsuyama asked the institute in Bremen if it would be possible to transfer the planning data onto an iPad, so that they could access them during each operation. Fraunhofer was immediately taken with the idea, and expressed a keen interest in pursuing further collaboration. After some initial preparatory work, Alexander Köhn, a computer scientist at MEVIS, packed his bags and traveled to Japan for three months to develop the software in collaboration with the surgeons.

The experts quickly realized the ipad's full extent of the iPad's potential. Not only can it display all the necessary planning data during the operation, it also helps to extend reality and offers a host of other useful benefits. "Augmented reality" allows the surgeons to visualize the entire system of blood vessels inside the liver using the tablet. Köhn demonstrates how this works using a model of a liver on his desk. The scientist holds the iPad over the model and switches on the camera. "I'm effectively looking through the iPad and seeing the liver underneath," he says, describing the effect. "Now I can superimpose the virtual data provided by our planning software, which lets me see the blood vessels inside the liver!"

The vessels resemble trees in winter, with thick stems branching out into innumerable thinner branches that become finer and finer. To help distinguish between the veins and arteries, the different vascular systems are depicted in different colors. The surgeon can use the iPad to "project" this delicate pattern onto the liver, and then precisely mark the position of the vessels onto the organ using a special pen. This offers the surgeons the significant advantage of making their incisions in exactly the right places.

Köhn continues by demonstrating another aspect of the software, namely its "eraser" function. Once a surgeon has cut through particular blood vessels, there is no longer any need to see them as part of the images shown on the iPad. These obsolete blood vessels are simply obstructive, and could block the view of other important vessels in the surrounding tissue. This problem has been solved by giving surgeons the option to "erase" the blood vessels on the tablet. Köhn simply has to do is swipe his finger over the branch of blood vessels on the touchscreen for that branch to disappear.

The app has other tools that are helpful when complications arise, as is often the case with liver operations. Sometimes tumors are found to be larger than anticipated, and surgeons have to change their plans unexpectedly. This occasionally makes it advisable to cut away more branches of blood vessels than originally intended, although doing so increases the risk of causing extensive damage to the patient's liver. The app helps surgeons to weigh up these risks. Alexander Köhn taps the blood vessel in question with his finger on the screen. A split-second later, the iPad shows a cloud-like shape appear at the end of the vessel; this is the liver volume supplied by the vascular branch that would cease to function if the blood vessel were cut. "It's 37 milliliters in this case," says Köhn. "Now the surgeon can decide whether the remaining volume is large enough for the patient to make it through safely."

It took the MEVIS computer specialist several weeks to write the software in Japan and to adjust it to suit the surgeons' requirements. Then the first version was ready. "The surgeons were impressed, and could hardly wait to try out the new software in the operating theater," says Köhn. It wasn't long before the new Fraunhofer app made its surgical debut on an iPad covered with sterile plastic developed specially for medical purposes.

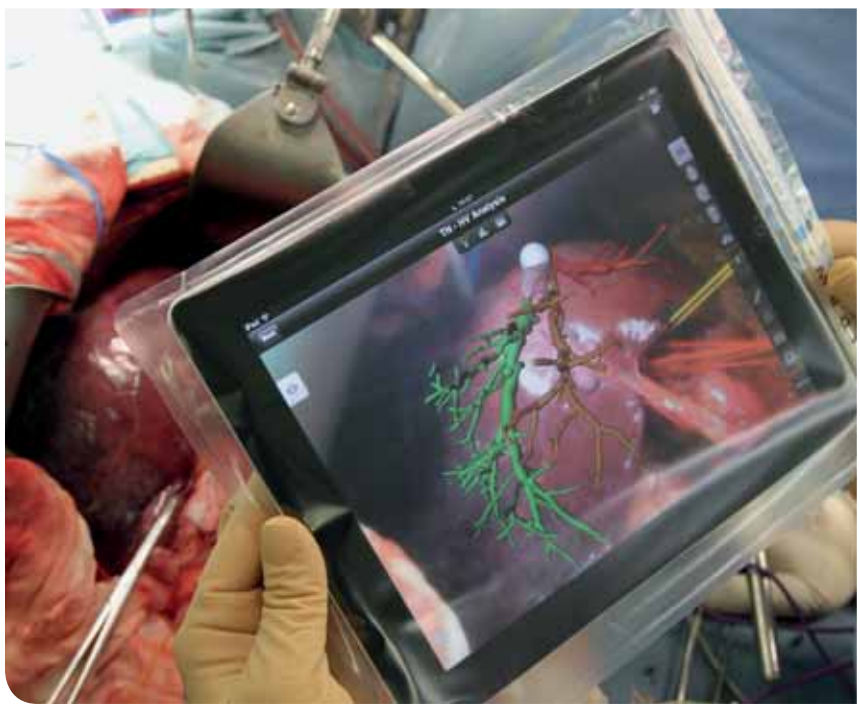
The surgeons were quickly able to align the real and virtual images of the liver on the iPad display and show all the blood vessels. "When Dr. Endo saw it, he exclaimed 'sugoi', which means 'super'," remembers Köhn. "The new software made a real difference straightaway, in the very first operation." The surgeons were able to precisely mark the location of the blood vessels on the surface of the liver. This meant they knew the exact locations of the vital vessels that could under no circumstance be severed accidentally and could guide their scalpels safely.

"The new technology could further reduce the amount of blood lost during surgery," hopes Itaru Endo. "It would result in fewer complications, and shorten the amount of time spent in hospital after an operation." Initial tests are now to be followed by clinical studies, including in Germany. "These studies are to provide quantative confirmation of the value our new tool adds to surgical practice," explains Andrea Schenk.

And this is only the beginning. MEVIS experts are already thinking about other possible uses for the iPad beyond the operating theater, and are considering how iPads could be used throughout the entire hospital. When doctors visit patients on their rounds, a chip at each bedside could automatically transfer relevant medical data to the doctor's tablet. "This could be used, for example, to show patients their own unique liver images and explain to them exactly what will happen during the operation," says Schenk. "This would be very helpful for both doctors and patients." ■

In order to be able to view planning data during the operation, surgeons had to print out images and hang them on the walls of the operating theater.

Dr. Ryusei Matsuyama using the iPad whilst performing a liver operation at Yokohama City University Hospital.



Augmented Reality: the liver is shown via the iPad's camera, and virtual data from the planning software is superimposed over the image so that the blood vessels become visible.

Data on the move at the speed of light

Cloud computing, augmented reality and 3D television have all contributed to a worldwide explosion in data volumes. As the petabytes mount up, this has been accompanied by a need to find new ways of transferring data from A to B quickly, reliably and as energy-efficiently as possible. That is why Fraunhofer researchers are now working on optimizing optical technologies to make even better use of light as a transfer medium.

Text: Mandy Kühn

PhoxTroT project profile

- Aim: To improve the energy efficiency and capabilities of big computer centers
- Launch: October 2012
- Duration: Four years
- Research budget: 12 million euros
- Project coordination: Fraunhofer Institute for Reliability and Microintegration IZM, Berlin
- Project partners: Fraunhofer IZM, Fraunhofer HHI, Vertilas GmbH, Xyratex Technology Ltd., ams AG, Meadville Aspocomp International Limited, AMO GmbH, National Technical University of Athens, DAS Photonics SL, Phoenix B.V., Centre for Research and Technology Hellas, Compass Electro Optical Systems Ltd., Bright Photonics BV, Computer Technology Institute and Press – "Diophantus", Centre National de la Recherche Scientifique, Karlsruhe Institute of Technology, University of Southern Denmark, Universitat Politècnica de València, Interuniversitair Micro-Elektronica Centrum vzw.

www.PhoxTroT.eu

Dr. Tolga Tekin operates between two extremes. On the one hand, he works with tiny optical microchips which are to revolutionize the way we transfer data using light. On the other, he oversees a huge project with a budget of 9 million euros that brings together 18 companies and institutes from across Europe, so he has to keep sight of the big picture. Tekin works at the Fraunhofer Institute for Reliability and Microintegration IZM in Berlin, where he heads up the EU-sponsored "PhoxTroT" project. The project aims to cut the energy consumption of computer centers by half while doubling the capacity of optical data links from one to two terabytes a second (Tb/s).

Server farms such as those of cloud provider Google chew through 2.3 million megawatt hours of electricity each year. That's enough to supply a large-sized town of 200,000 households – meaning that the pressure to save energy is correspondingly high. At the same time, users are getting more and more impatient. These days, nobody wants a long wait for their data – everything has to be immediately on tap. This calls for more powerful technologies. Here, optical data transfer methods show great potential in comparison to wireless systems and other conventional techniques, as optical transmission uses only a fraction of the energy, while also being significantly faster, cheaper and immune to wireless interference.

Rethinking existing approaches

It is true that optical technologies have already been well researched individually; what has been missing is the unifying thread. "The PhoxTroT project is about researching the synergies that exist between individual components and linking them together in a new research concept," explains Tekin. What's more, when the project ends in 2016 completely new technologies should provide answers to as yet unresolved questions. For instance, how can you use light to assure an unbroken data connection even over hundreds of kilometers? To answer this question, project partners have been using three demonstrators to implement and investigate optical transfers on board, board-to -board and rack-to -rack. In the foreseeable future, combining these interfaces should enable optical data transfer spanning longer distances as well. Researchers are also developing single-mode solutions that integrate optical chips on a circuit board. Instead of following multiple paths as has been the case in the past, the signal is then transmitted along a single light path. Consequently, this technology is particularly suitable for transferring data over long distances at extremely high data rates.

Optical data transmission could slash the energy consumption of big computer centers by 50 percent. © *MEV*

Receiving data through overhead lighting

Researchers at the Fraunhofer Institute for Telecommunications, Heinrich-Hertz-Institut, HHI in Berlin on the other hand have been focusing their attention on the light produced by standard LED lamps. Ceiling lighting has the potential to open up new data highways in places where a wireless network is either not feasible or too slow. This might be true of some offices, but candidates here also include the passenger cabins of planes, trains, or areas sensitive to radio signals such as operating theaters and production halls. The new "Visible Light Communication" technology permits data transfer rates of up to 1.25 Gbit/s, meaning that even broadband video data can be streamed effortlessly in HD quality. The upshot is that soon anyone travelling on a plane or train could be able to use the reading lights to receive individual data packets and entertainment programs directly from their seat.

By adding just a few extra components, standard, commercially available LED lamps can be transformed into powerful optical WLAN transmitters. A special modulator turns the diodes on and off in a rapid flickering motion and this is what is used to transmit the digital information. Since the modulation occurs extremely rapidly, it is invisible to the human eye. To maximize the flow of data, scientists at the HHI are using LEDs that provide white light illumination by combining three colors – a red, a green and a blue diode. This means that there are three parallel optical routes available to transfer data.
"If in the future the development and production of LED lighting could be made to take into account the extra data transmission function as well as LEDs' primary role as a light source, we could see a significant extra boost to the data transfer speeds achieved," says the HHI's Dr. Anagnostis Paraskevopoulos confidently. The fact that we will soon be able to shape the way we transfer data through the design of lighting is, he believes, a revolution in indoor communications. His team is currently working on ways to prevent interruptions in direct light contact between the LED and the photodetector from simply terminating the transfer of data as well. If a hand obscures a clear line of sight, for instance, the transfer software is still in a position to ensure that the streaming of data is resumed without data loss or errors once the connection has been re-established.

Optical data transfer for mobile devices

Researchers at the Fraunhofer Institute for Photonic Microsystems IPMS in Dresden are also investigating new approaches to optical communications. Designed as an alternative to solutions tied in to the use of cables such as USB or Gigabit Ethernet, the researchers have developed a full duplex communications module capable of transferring data wirelessly at three gigabytes a second. This means that tangles of wires could soon be replaced by high-speed wireless connections. "Assuming a clear line of sight between the transmitter and the receiver, this allows us to transfer data up to 100 times quicker than is the case with the solutions currently available to us – and with a lower bit-error-rate at that (10-9). Plus, transferring data optically only requires 15 percent of the energy per data byte transferred," explains Dr. Frank Deicke from the IPMS. Mobile, battery-operated devices such as mobile phones or digital cameras would benefit most from this technology.

Using the technology is easy. It allows users to connect all their USB-enabled devices together without needing any extra app or drivers, whether it's a flash drive, a camera, a mobile phone, a PC, a hard drive, an MP3 player, a mouse, a keyboard or a screen. A Giga-IR adapter allows users to exchange data wirelessly at high speed. The adapter also comes with an integrated module for wireless energy transfer, allowing devices to be powered and batteries to be recharged without the need for any cables at all. Frank Deicke and his team are constantly working to expand the technology in the hope that it might be able to replace even faster cable-based data transfer methods such as USB 3.0, GigE, HDMI or Thunderbolt. ■

The shift in energy is necessary

Where will future generations get the power for their living and transportation requirements? A Fraunhofer researcher is looking for a solution – not only for Germany but for Europe.

Interview by Monika Weiner

Andreas Hornung, you have worked in multiple European countries, including Austria, Italy and the UK. Can you describe how the shift from fossil fuels to renewable energy resources is dealt with in these different countries?

What they have in common is that the shift from fossil to renewable energy resources has been deemed to be a necessary move, although motives do vary. The motivation to develop renewable energy technologies in a regional context has for years been led by the aim to become less dependent on energy imports. Only in recent years have technological advances made renewables economically competitive too, making them interesting for the common market in multiple countries. The UK, due to its rich national fossil resources, is by comparison quite far behind in market development of renewable technologies. However, enterprises are now excited to pick up brand-new developments in order to bypass their competitors on the continent. This, plus government incentives is really boosting the market.

Are these differences something that affects your work as a researcher?

Although being united in the European Union and with common regulatory guidelines in place, the realization of energy projects varies greatly in the different European countries. Take the acquisition of funding, for example. In Germany it is considered to be essential to have the support of industrial companies when applying for research grants. In the UK even individuals have the possibility of presenting their ideas or products to councils and companies at innovation events, and have a chance of being heard.

Is this how you implemented your biomass conversion technology?

My goal is to bring the developed "Pyroformer" to market as soon as possible, a green technology that turnes waste into liquid propellants and gas. These can then be stored or used oi combined heat and power systems. When I started, I found it hard to get appropriate support in Germany because the organizations and companies there tended to follow a narrow main track of development. I initially found a company in Italy to support my work and later on Aston University showed interest to help me develop my vision. This was also one of the key partners that enabled me to realize the project idea on a technical scale.

Interestingly enough, now that we have the first units up and running, it turns out that the technology fits perfectly into the German "Energiewende" concept: the shift from centralized large-scale energy production units to a decentralized conversion system.

Could you outline the basic principle of your technology for us?

"Pyroformer" technology is based on thermal conversion processes such as pyrolysis, in combination with gasification and combustion. We use waste and residue biomass as feedstock, which are heated in a thermal unit. At intermediate pyrolysis conditions, i.e. temperatures around 400 degrees Celsius and oxygen free conditions, the "Pyroformer" converts the feedstock to flammable gases, liquids that can be stored, and char for fertilization, for use in coal fired powerplants or for heating purposes.

The great thing about the "Pyrofomer" is that it can be fired with any kind of biomass, including residues from anaerobic digestion, agricultural residues, manure, and sewage sludge, or a mix thereof. Due to the nature of our feedstock, we do not compete with alternative food

Prof. Andreas Hornung

Professor Andreas Hornung studied chemical technology in Darmstadt and received his doctorate from the University of Kaiserslautern. He worked in Austria, Italy and Karlsruhe, Germany before moving to Birmingham, UK in 2007. There, he joined Aston University and founded the European Bioenergy Research Institute (EBRI), which he continues to lead as director. His research focuses on energy conversion and related engineering sulutions. He holds 18 patents and has published more than 150 scientific publications to date.

Since January 1, 2013 he is also the director of the Fraunhofer Institute for Environment, Safety and Energy Technology UMSICHT Branch in Sulzbach-Rosenberg. The 70 employee strong institute has a long tradition and competence in the development of heat, chemical and electrical storage systems. Connected through Andreas Hornung, both institutes now have a unique opportunity to produce and integrate ground-breaking novel technologies for green energy production and storage.

or feed use. This is a highly sensitive issue, which has led to multiple controversial discussions in earlier energy crop projects, which we are proud to be able to avoid.

What is the development status of the "Pyroformer"?

We have installed a plant consisting of pyrolysis, gasification plus combined heat and power, which produces 400 kW-electric, as well as heat and cooling for our new research building in Birmingham. This is a great success and a showcase for commercial plants, which we will be introducing to the market through our spinout next year. A 5 MW-electric plant will cost around 25 million Euros.

But surely you require additional electricity from the grid to operate the plant?

In comparison to conventional energy plants, wind and photovoltaic plants cannot be regulated by the operator, but are dependent on weather conditions. Due to the lack of effective energy storage solutions to date, this results in a net overproduction at certain times, which goes unused. This is where we step in and tap into the grid, converting the excess energy into storable products like char, gas or liquids. So principally, we are just using the power which otherwise would go unused anyhow.

Simply speaking, we just adapted what people in agriculture have been doing for as long as we can remember: We harvest and store the excess power generated by sun and wind in summer and autumn. In the following winter, we are able to access and consume the stored energy products. In addition, we can help balance power production and energy demand in the other seasons, as and if required.

Couldn't batteries do the job just as well?

Batteries are great for power storage at the present day mainly for short periods at small to medium capacities. For the use in cellphones, laptops or even electric cars they are the best technology solution on the market to date. However, nowadays they are reaching their limits with higher capacities and storage durations. In addition, due to the size and weight of such high capacity models, the energy stored becomes immobile. Intermediate pyrolysis produces energy carriers in form of combustible gases, solids and liquids directly in the process itself. These can either be used directly for power production, or they can be stored over a longer period of time, or also transported.

What is the argument se for your technology? Is it the ability to use residual waste streams for energy production? Or the ability to store this energy over time to balance demand?

This largely depends on the region where the plants will be established. In the UK, due to the still developing status of renewable technologies, I largely see the use of residual biomass waste for direct production of electricity as the main implementation scenario. In Germany, renewable energy technologies are already largely established and the main use will be for the storage of excess energy in form of liquids, solids and gases.

Could the technology provide enough green energy to cover the demand of an entire city?

Absolutely! We have calculated the energy production requirements for Birmingham city council. To cover the power and heat demand for the city council owned buildings, fifteen 5 MW units are sufficient. These could be powered purely by the waste residue streams from the city itself, such as sewage sludge or green waste. A green council based on city waste, I think you will agree that this is one of the best demonstrators out there! Birmingham's goal to reduce its CO_2 emissions by 60 % by 2026 could be realized by 70 units, fueled by regional waste.

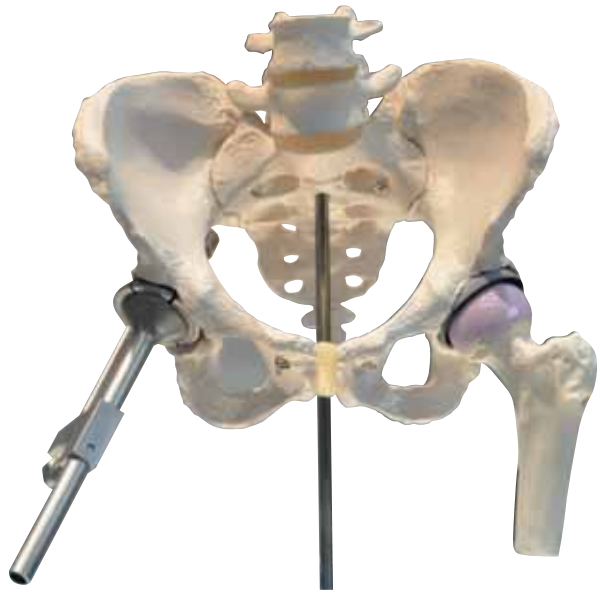
What are your plans as the director of the Fraunhofer Institute Branch in Sulzbach-Rosenberg?

In Germany we are now planning the first installations of demonstrator units at our site in Sulzbach-Rosenberg and in the region. Biomass use is already well established in Germany, which makes the market more competitive than in the UK. However, even there, we can still optimize and utilize residues which to date have not been recognized as resources. In this context, we are aiming to couple intermediate pyrolysis units to anaerobic digesters in already established biogas plants. Using the overproduction of power through wind and photovoltaics, we will be converting the large quantities of residues from anaerobic processing into storable products. ■

Hip implant for long-term use

Hip replacements are carried out frequently. But often the artificial hips need to be replaced just ten years later. In an EU-funded project, researchers are developing a new long-lasting implant.

Text: Britta Widmann



The ceramic femoral head fits perfectly into the PEEK hip socket. © *Fraunhofer IPA*

Thanks to artificial hips, people with irreparable damage to the joint have been able to lead active, pain-free lives for the past 50 years. Still, some hip replacements do not function completely as intended, and metal-on-metal implants in particular demand accurate positioning in surgery while implants positioned non optimally are often susceptible to premature failure notably in small female patients. Physicians are even calling for a prohibition on the use of artificial joints made of cobalt-chromium alloys in which the joint's metal ball rubs against its metal socket whenever the wearer walks. Poorly designed or positioned metal-on-metal implants can lead to higher wear rates and this releases elevated cobalt-chromium ion levels that spread out through the blood and lymph systems, potentially damaging organs and triggering inflammation. Metal ions are also suspected carcinogens. Because these hip replacements are so robust, however, to date they have often been implanted in young, active patients.

A metal-free composite

Researchers at the Fraunhofer Institute for Manufacturing Engineering and Automation IPA in Stuttgart, partnering in an international team on an EU-funded project entitled "ENDURE" (Enhanced Durability Resurfacing Endoprosthesis), have now developed a new kind of hip implant that, unlike the conventional counterpart implants on the market today, provides a metal-free solution and bone-like elasticity. This is the result of a metal-free, high-tech composite: The hip socket is made of carbon fibre-reinforced PEEK – a high-strength, wear resistant, biocompatible polymer composite. For the femoral head, ceramic was used. In addition to this, a hydroxylapatite coating at the interface to the bone helps ensure that the bone tissue will fuse thoroughly with the surface structure of the implant. "The cobalt-chromium implants in use to date are very rigid, and the load transfer to the bone is non-optimal leading to potential adverse bone adaptation. Thanks to the new combination of materials, the transmission of force through the PEEK hip socket to the pelvic bone is modeled on natural conditions. And there are no metal ions released," notes IPA engineer Dr. Urs Schneider. His team was able to confirm the good wear resistance in initial tests of the new hip replacement using a robot that simulated various series of movements such as walking or climbing and descending stairs. The experiments used a prototype of the implant.

Tiny pins protect bone tissue

The ENDURE implants follow the bone-preserving principle of hip resurfacing: they are thin-walled shells which replace the bearing surface of the joint articulation alone, instead of employing large metal stems for support, which require a substantial volume of bone to be removed. Researchers have also redesigned the way the prosthesis is mechanically attached to the bone. Without cement, and using a press-fit and an integral scaffold-type structure on the surfaces of the implant that contact the bone, the hemispherical ball and socket are tapped onto the prepared femoral head and into the acetabulum – the natural, concave surface of the pelvis – and anchored in place.

To ensure the best possible positioning of the artificial hip, the researchers at IPA have developed a size-scalable tool that attaches the implant to standard surgical instruments, enabling implantation, re-alignment and removal. The tool can be discarded after a single use – like a disposable surgical glove. The challenge is to attach instruments to the very thin-walled cup implant, with sufficient strength for implant repositioning. The instrument features a smart collet pin combination allowing strong, quick, single-position attachment and detachment by the surgeon. The scientists have already submitted a patent application for the tool. A team of physicians at the University of Newcastle has demonstrated in operations performed on cadavers that the new hip can be set in place and, if necessary, removed without any difficulties. Meanwhile, the preclinical studies have been completed, and final development work is being planned to allow clinical studies to commence. Partners in the EU-funded project are Aurora Medical, Medicoat, Hunt Developments, Ala Ortho, CeramTec, Invibio, Biomatech and the Universities of Gothenburg and Southampton. ■

Smart search engines for news videos

Searching for video recordings regularly pushes search engines to their limit. The truth of the matter is that purely automatic algorithms are not enough; user knowledge has to be harnessed, too. In an EU project, researchers are making automated engines smarter.

Text: Tobias Steinhäußer

NewsHistory makes the most of user knowledge, searching through video databases to find video sequences with identical content. © *Fraunhofer IDMT*

Anyone who has visited one of the big online video portals or TV broadcasters' media libraries to search for a video clip is already familiar with the search engines tasked with seeking out and flagging video footage. However, these engines have their weaknesses. Their results are based on automatic search algorithms that often go by text-based information alone. Although they can be used to locate and identify videos, a comparison of individual sequences is still very difficult. To make search engines even smarter, the Fraunhofer Institute for Digital Media Technology IDMT in Ilmenau has developed a piece of software called "NewsHistory" that will now make full use of user knowledge as well.

Technology learns from users

"NewsHistory provides users with search algorithms, a data model and a web-based user interface so that they can locate identical sequences within various news videos," explains Patrick Aichroth from Fraunhofer IDMT. He is responsible for coordinating the institute's R&D work within the EU's CUbRIK project. Here, researchers are harnessing user knowledge to optimize and extend the capabilities of automated analysis techniques. "The search engine learns from each individual user, allowing it to keep improving search results. Not only does this improve the quality of results, but the resources needed to undertake the analysis are also cut down," Aichroth continues. NewsHistory allows each user to add additional information to the results generated by the search engine, including production and broadcast date, sources and keywords for videos. It is also possible to rate the results. Finally, the user's search itself is a source of information, providing data that is incorporated into the search engine; the metadata of a newly uploaded video, for instance, passes into the database.

"Comparing digital video data online or within video databases is very complex," explains Christian Weigel from the Audio-Visual Systems research group at the IDMT. "Videos that share the same content have for the most part been edited, meaning that they are scaled and encoded in a variety of formats. Also, search engines are often unable to distinguish images cropped from a larger picture, lower thirds or the zoom shots so popular with US news channels."

The demonstration version being presented at CeBIT will investigate how a selection of TV channels have made use of film footage, changed its form and broadcast it. The user interface displays commonalities and appraises them in graphic form. The search itself is conducted either by inputting text or by directly uploading individual video sequences. The researchers' aim is to make the software sufficiently robust that it could also be used in the future to compare the multimedia content found on big online media portals. The scientists do not imagine archivists or journalists will be the only users. "NewsHistory is of particular interest to media and market researchers, say if they want to assess the televised political duels coming up this year," concludes Weigel. ■

Extraordinary perspectives

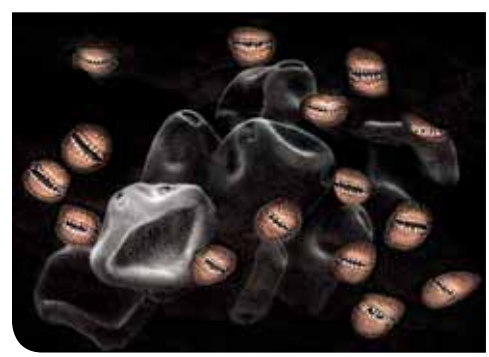
The seventh German science photo contest “deutscher preis für wissenschafts-fotografie”, worth a total of 20,000 euros, was awarded to four prizewinners. The jury, headed by renowned photographer Wolfgang Volz, also decided to award an additional special prize to one of the 136 entrants.

“Lord of the mice”
Sven Döring
First prize in Best Single Picture category

A witty photograph of a brain researcher at the TU Dresden, composed with an ironic twist: alluding to the scientific research he conducts on the brains of mice, a cheery invasion of little white soft toy mice populate his desk and seem to be taking an interest in him personally.

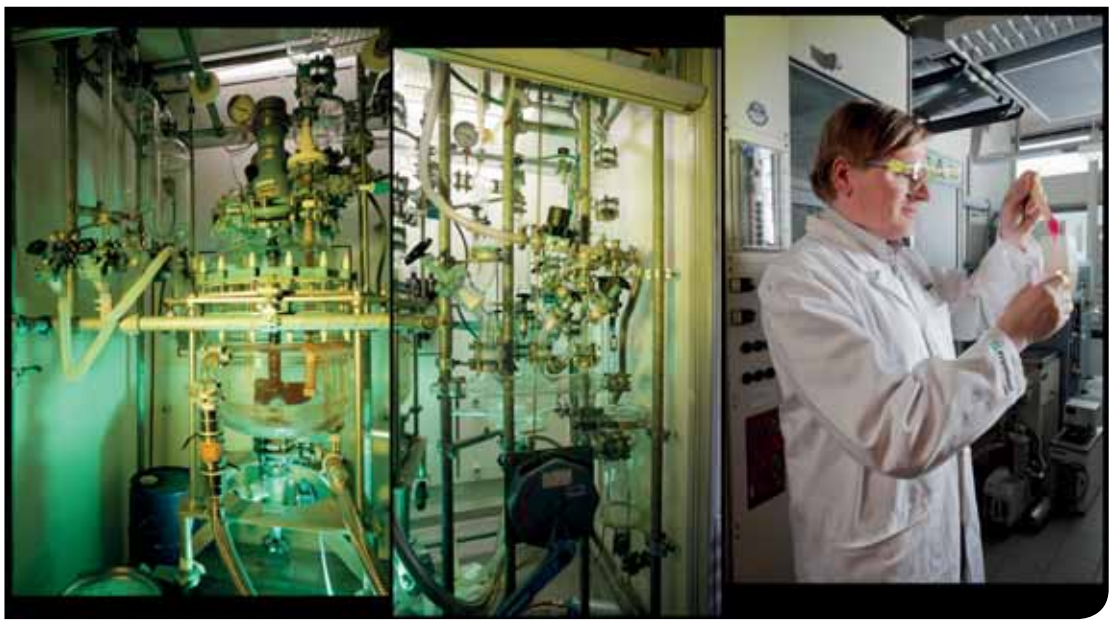
"Spherical panorama"
Volker Steger
Second prize in Best Single Picture category

An extraordinary look into the giant plasma chamber at the Max Planck Institute for Plasma Physics in Garching. The spherical panorama projection depicts the complete interior as though it were a mysterious scene from a science fiction movie.



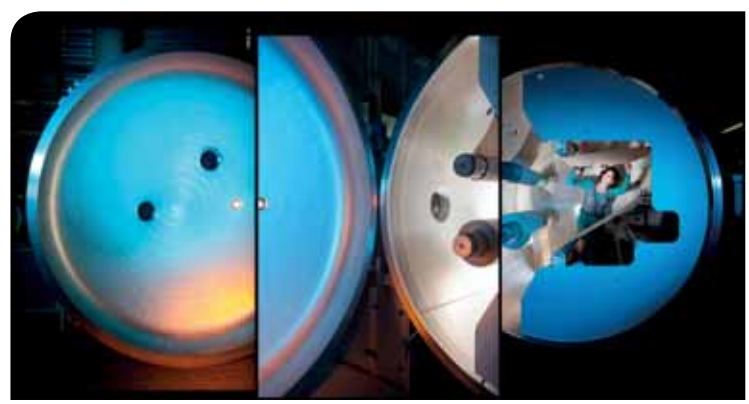
"Microscopic mythical creatures"
Anita Reinsch
Micro/Macrophotography category

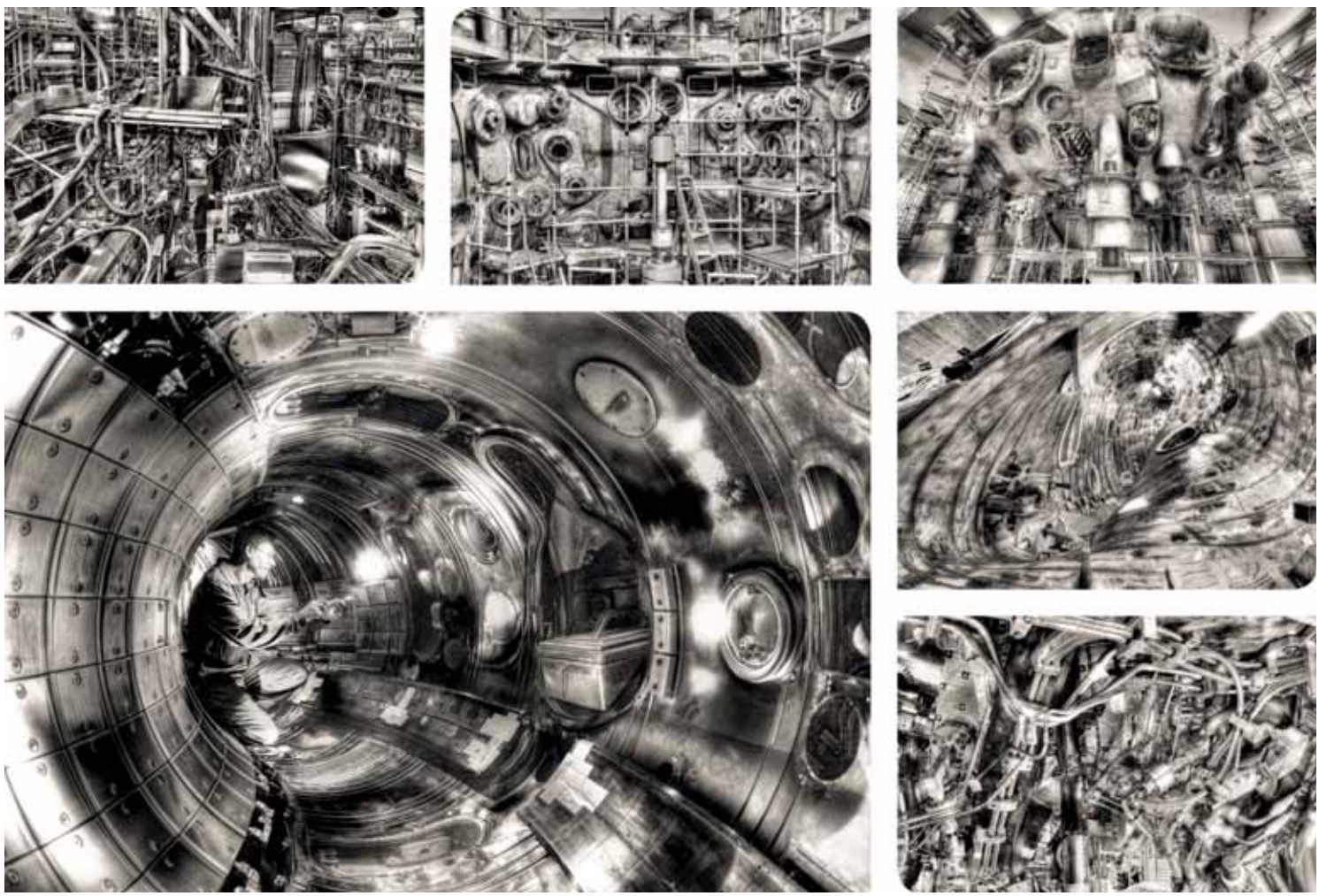
A grass flower and some horsetail with alder pollen, viewed through a macro lens, appear like mythical creatures leading the observer off into the realm of fantasy.



"Taking triple trouble"
David Klammer
Reportage category

A fascinating series of pictures about adhesives research. The photographer from Cologne carefully composed each picture as a harmonious triptych.





“In the labyrinth of nuclear fusion”
Christian Lünig
Special prize

The high quality and unusual visual effect created by Christian Lünig, in his black and white photos of the inside of nuclear fusion reactors, led the jury to spontaneously award him a special prize.

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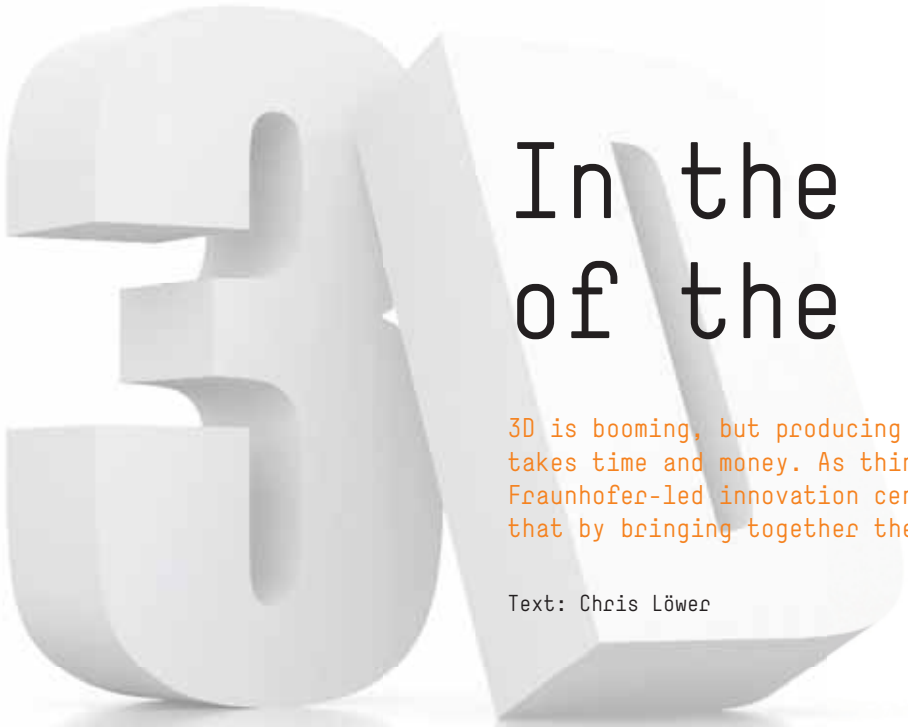
Photography prize 2013

Pictures may only be entered that have not previously won any awards. Detailed conditions are available from:

bild der wissenschaft
»deutscher preis für wissenschaftsfotografie«
Ernst-Mey-Strasse 8
70771 Leinfelden-Echterdingen
Germany
www.wissenschaft.de/fotopreis

Closing date for submissions is July 31, 2013



In the middle of the action

3D is booming, but producing high-quality content takes time and money. As things stand. But a new Fraunhofer-led innovation center is looking to change that by bringing together the key players.

Text: Chris Löwer

Whether you're at an international film festival or visiting the IFA consumer electronics show in Berlin, one thing is for sure: these days, 3D films are a must. Jeffrey Katzenberg, a co-founder of Hollywood studio Dreamworks, goes so far as to say 3D is the next big cinema revolution, and puts it on a par with the momentous decision to add a soundtrack to silent movies. Market research suggests that in the medium term, one in two U.S. movie theaters will be a 3D cinema. And 3D films and sporting events are even beginning to conquer our TV sets.

But it's not just in entertainment that the third dimension has a starring role to play: industry, too, has long relied on spatial simulations and videos (see box). This is another reason why developing more powerful 3D technologies is a central plank of the German government's "Deutschland Digital 2015" information and communications technology strategy. The newly founded 3D Innovation Center – 3DIC for short – at the Fraunhofer Institute for Telecommunications, Heinrich-Hertz-Institut, HHI in Berlin will serve as a meeting place on this road.

"We want to offer all the players in 3D development a platform for a pre-competitive exchange of ideas, where they can build up contacts, test products and systems, and jointly present themselves to various different target groups," says Dr. Ralf Schäfer. As director of the 3DIC steering committee, he is responsible for determining the strategic focus of this center, which aims to foster networking between science and business. Up to now, the kind of hub where one might also discuss business models and market strategies has been sadly lacking. As Kathleen Schröter, 3DIC's executive manager, says: "Brainstorming doesn't really work when you're all on your own!"

www.3dinnovationcenter.de

But the need is there and it is urgent. However promising the market is, today's technology is not even close to meeting expectations; not only is the choice of glasses-free 3D displays still very limited and in need of improvement, but production costs are high, with limited possibilities for converting content into different formats. "Above all, it is the high production costs and the lack of opportunities to experience high-quality 3D films without glasses that are the main hindrances to the widespread uptake of 3D technology in the home," says Schäfer.

That is why so many research institutions, industry development labs, universities, public and private broadcasters, and telecoms companies are working at fever pitch to develop and refine 3D production. Unfortunately, though, these entities have tended to work alone, which means valuable synergies have gone untapped. Now, that is about to change: the innovation center has signed up almost 50 companies and organizations as partners, and further technology drivers are welcome to collaborate by way of partner agreements. "3DIC partners then have the option of playing an active part in a wide range of working groups and panels," says Schröter, adding that the research center would also like to place more emphasis on considering medical and industrial applications.

Research partners will be aided in making progress on all these fronts by the Berlin center's facilities, which include opportunities for 3D production and a 3D cinema, as well as laboratory and exhibition areas. The HHI's R&D lab facilitates development work on technologies, innovations and standards. This makes the institute a key contributor to the standardization of 3D encoding processes, which is currently being driven by international discussions on MPEG within OIPF, the Open IPTV Forum.

Further development work is also required in the areas of self-calibrating cameras, cost-effective filming, post-production and distribution, as well as in the glasses-free 3D experience and in perfect surround sound – all areas on which Fraunhofer researchers are working. There is somewhat of a chicken-and-egg situation, especially when it comes to television offerings and specialized productions such as panoramic

films: a lack of content means demand is slight, and vice versa. And until production costs and timeframes start to come down, there will be almost no incentive to produce high-quality 3D content. James Cameron's science fiction epic "Avatar", hailed as the first 3D blockbuster, single-handedly gobbled up some 237 million US dollars in the four years it took to produce – and one reason for this was all the manual adjusting and processing it took to achieve a spatial audiovisual experience.

The Fraunhofer Digital Cinema Alliance's four institutes, all of them also cooperation partners to the 3D Innovation Center, are out to change this through their recently launched "SpatialAV" project. Project manager Dr. Siegfried Fößel outlines the alliance's aim as follows: "Cameramen will once again be free to focus on staging the story, instead of getting bogged down by all the technical settings and details that have deluged film sets since the advent of 3D."

What makes this possible is a smart, modular, multi-sensor recording and production system on which researchers from Fraunhofer IIS, HHI, IDMT and FOKUS are working. A further aim is to simplify the production of 3D films for three-dimensional projection surfaces, such as panoramic and dome cinemas. And there's more: "Up to now, content for these cinemas has been produced almost exclusively on computers. We want to pave the way for authentic dome films recorded using cameras," says FOKUS project manager Ivo Haulsen.

To this end, the 3D experts are developing a software tool that calibrates two fish-eye cameras with each other and can capture the data stream needed to create a fulldome 3D video. Alternatively, videos can be compiled from recordings taken with a number of smaller cameras. The software automatically connects individual recordings seamlessly, corrects for differences in geometry, color and brightness, and adjusts the image format to create a homogeneous image – one that viewers can get right into the middle of, as it is no longer limited by a frame.

Haulsen sees this as part of a long-term trend: "Just as surround sound has become the norm in the field of audio, so film is now headed in the direction of surround video, and a cinema's walls and ceiling will be played on, too." ■

One of the factors currently hindering a widespread uptake of 3D technology in the home is high production costs. © *istockphoto*

Play, have fun, learn something!

A way of learning that offers the chance to play and move around is not just more fun, it is also more effective. This is exactly the thinking behind HOPSCOTCH – the interactive learning system.

Text: Chris Löwer

Teachers, pediatricians and sports medicine specialists all agree that combining learning with physical exercise makes it easier for people to learn and boosts their retention. It is slightly ironic then, that the first thing we teach children to do when they start school is to sit still. Göttingen-based sports scientist Professor Jürgen Schröder is not the only one who is baffled by the fact that after going to the trouble of teaching our children how to walk, we actively stop them doing it as soon as they reach the classroom.

Study after study has proved the link between good learning performance and our natural desire to move around. Physical exercise causes connections to arise in the brain that lead to higher performance by increasing brain activity. American molecular biologist and brain researcher John Medina, director of the Brain Center for Applied Learning Research at Seattle Pacific University, puts this down to our ancestors: hunter-gatherers spent around twenty times longer on their feet than today's average office worker. The brain appears to be genetically programmed to keep the body moving and interprets our staying still as a sign to rest.

Movement builds momentum in the brain

It therefore comes as no surprise to see teachers bringing physical exercises into the classroom in an attempt to activate inattentive classes, reenergize pupils' brains and clear the mental blocks that impede learning. They know that learning and retaining new information is easier when the brain is getting a good supply of blood. So why not take advantage of this effect in a way that is also fun? This thought occurred to Dr. Martina Lucht from the Fraunhofer Institute for Digital Media Technology IDMT in Ilmenau. She and her team have developed a novel kind of teaching aid that goes by the name of HOPSCOTCH.

The name is taken from the British children's game where players draw squares in chalk on the sidewalk and then hop from one square to another. This game inspired Lucht in her quest to find a new way to learn that is both fun and long-lasting at the same time. As she observed children hopping up and down the sidewalk and reflected on her own childhood, it became clear to her that learning and physical activity can be successfully combined.

The Fraunhofer researchers' high-tech version of the classic game is based around a mat equipped with pressure sensors. The mat is divided into nine squares and each square is marked with a letter and a number, recalling a format children will find familiar from texting or playing games on a cell phone. The problems to be solved are displayed on a monitor; for example: "What's the German word for plum?" And right away, the children hop from square to square of the mat's keypad to spell out the word "Pflaume". If they have given the right answer, a kangaroo appears on the monitor and leaps into the air shouting "yippee!" The sophistication of HOPSCOTCH from an educational standpoint lies in encouraging players to work out the right answers. As the system only accepts the correct solution to each problem, players have to keep trying until they find the right answer. The faster they work their way through the questions – and the faster their feet race around the mat – the more points they get. This motivates the children and encourages them to work as a group.

"The digital system is adaptive; it adjusts itself to match the pupils' standard of knowledge," explains Lucht. If difficult questions fail to illicit correct answers, HOPSCOTCH generates easier tasks, which helps avoid children getting frustrated. And it is not just the questions that are tailor-made: future versions of the system will also run background statistical analysis, enabling teachers to identify where children could be having problems. "This provides the basis for more targeted and individual ways of helping children learn," emphasizes Lucht.

It is also conceivable that this system could be used as an early, definitive indicator of whether a child is having trouble

Children learn while playing: HOPSCOTCH. © *Fraunhofer IDMT*

with arithmetic (dyscalculia), experiencing difficulty processing written language (alexia) or is suffering from learning disability affecting their reading and writing skills (dyslexia). Before that can happen, though, Lucht and her team will have to work with educators to come up with reliable questions and evaluation criteria. Analysis of the information gathered will always be carried out by experts and not by the technology itself. "It's similar to how a lab carries out blood tests, but it's the doctor who interprets the results."

And HOPSCOTCH is useful for more than improving players' vocabularies. The game also allows children to practice their multiplication tables or be quizzed on matters relating to health or history. "Essentially, the system could accommodate virtually any subject matter, just as its methods are suitable for all age groups," says Lucht. "We saw how a two-and-a-half-year-old girl came along expecting just to play and went home at the end of the day having learned the entire alphabet." Lucht reports that senior citizens are also enthusiastic about the game, as tests involving a history quiz showed: "Here we have the opposite effect: older people, including those with physical disabilities, use their knowledge as motivation for keeping active."

It does not occur to users to consider the amount of movement playing the game requires of them – which means the system is also suitable for treating children suffering from obesity or helping patients through a course of physical therapy. The Fraunhofer researchers aim to delve further into this area and, in doing so, to find out to what extent this kind of learning format can actually retain its motivational power. Positive results would indicate the system's suitability for long-term rehabilitation programs.

Surprisingly, it is the tricky questions that result in the greatest learning success when playing HOPSCOTCH, as can be seen from initial studies involving children. Researchers believe that their mat will prove most effective when children are introduced to a new subject or topic at school. It could even help kindergarten and elementary school children develop their spelling and counting skills. And it is not just among children that HOPSCOTCH is proving a hit. In summarizing overall feedback to the game, Lucht says: "Almost every educator we consulted was enthusiastic about the idea of using this technology in the classroom – which is unusual for a digital system."

Many companies have already expressed an interest in bringing HOPSCOTCH to market. Lucht certainly has high hopes that this new way of learning will soon be bringing new impetus to the classroom: "We could start by incorporating a physical learning component into a morning's lessons." She goes on to say that the experiences gathered in schools indicate that the system could be used in more and more areas – making maintaining mental and physical health literally child's play. The time has come for a new way of learning by doing! ■

Children with dyslexia sometimes have trouble distinguishing between words or individual letters that sound or appear to be similar. © *MEV*

An early test for dyslexia

Early detection is a crucial step toward being able to provide timely help to those affected by this reading and writing disorder. Researchers are working on a diagnostic test for dyslexia in children of pre-school age.

Text: Monika Offenberger

Stop or spot, skin or sink? Slight differences in appearance can affect the meaning of individual words and determine whether they make sense when strung together in a complete sentence. Children generally learn how to recognize written language quickly and confidently in the first grade and cement these skills in each subsequent school year. But five out of every hundred – or a total of 35,000 children each year in Germany alone – find this an impossible exercise when they start school. Try as they might, they keep making the same mistakes over and over again. Not being able to read fast enough and with written work littered with mistakes, they also often achieve poor marks in math, biology or geography. This remains the case even when they are just as bright as their classmates or have higher IQs. Such children suffer from dyslexia. In most cases this is a congenital condition and is carried through into adulthood. But special training makes it possible to largely offset its effects.

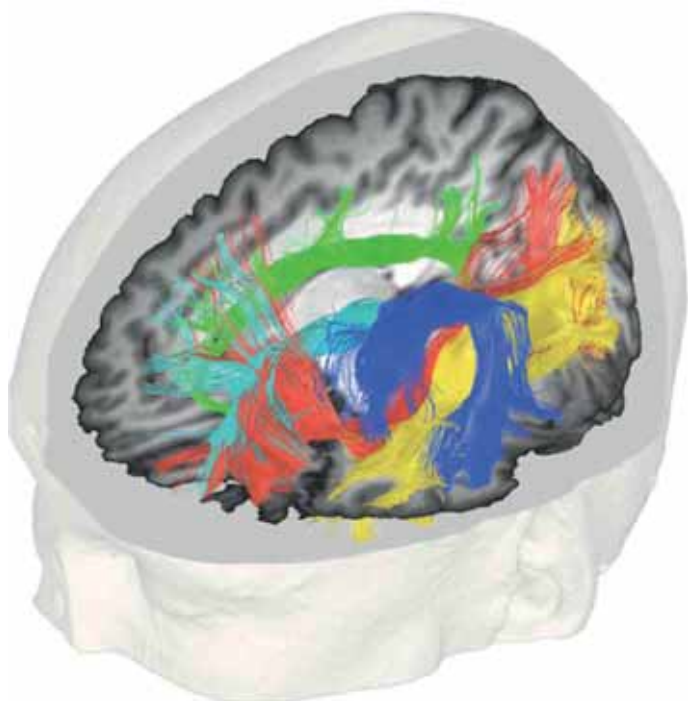
Impaired language development

Dyslexia has many faces. Some children experience particular problems with reading; others have difficulties predominately with spelling. Although it has yet to be explained in detail just how these deficits come about, we are sure that they can be traced back to impaired language development. This means that dyslexic children benefit from rhyme games and other exercises designed to help them distinguish between similar sounds and syllables. "The best time for children to be given such assistance is before they start school. And this means being able to determine very early on whether or not a child is prone to reading or writing difficulties," explains Dr. Holger Kirsten from the Fraunhofer Institute for Cell Therapy and Immunology IZI in Leipzig. Yet this is precisely the problem. At present, in the case of most children suffering from dyslexia, a diagnosis is made only when they should already be able to read and write, or about the time they approach the end of their second year at school. "That's far too late," says Arndt Wilcke, one of Kirsten's IZI colleagues. "At that age, a child's language development is largely complete. But these days it's clear that dyslexia is a language-based disorder, making it easier to correct the sooner an appropriate therapy takes hold." This is why Fraunhofer researchers have set out to develop a simple but effective early test capable of assessing the risk of dyslexia in children as young as three to five.

This endeavor is receiving decisive support from Dr. Jens Brauer at the Max Planck Institute for Human Cognitive and Brain Sciences, also based in Leipzig. The Pact for Research and Innovation, agreed between the Fraunhofer-Gesellschaft and the Max-Planck-Gesellschaft six years ago, lays out the framework for this collaboration. Among its members, the team possesses expertise in all disciplines relevant to gaining a more profound insight into the phenomenon of dyslexia. As a neuropsychologist, Brauer understands the anatomy and functions of the brain; through his training in German studies and psychology Wilcke is able to offer insight into the complex processes involved in language development; and as a biochemist and geneticist, Kirsten can provide a comprehensive overview of the congenital components of dyslexia. For many years now, it has been known that certain gene variants are significantly more common among those who suffer from dyslexia. According to Wilcke, "Meanwhile it is known that many of these genes lead, in one way or another, to disruptions in brain development. Certain nerve cells fail to reach the intended areas of the brain or show evidence of structural malformation. By examining the anatomy of the brain, it can be seen that neurons in certain areas of the thalamus are smaller and less evenly distributed. As Fraunhofer scientists, we are naturally interested in how to apply this knowledge. And we are prone to ask ourselves how genes that are known to play a role in dyslexia can be incorporated into an early test designed to assess the chance of the condition occurring"

The interdisciplinary team is now determined to find an answer to this question as part of the LEGASCREEN project. The two research associations (Fraunhofer and Max Planck) have committed a total of 2.5 million euros to LEGASCREEN over a three year period. Having the two Leipzig-based institutes share their specialist knowledge is of huge benefit to the cooperation project. The IZI is offering its extensive experience in the analysis of gene variants. Particular attention has already been given to examining a gene called FOXP2; it plays an important role in acquiring language as well as helping to regulate other genes. Together with Dr. Carolin Ligges from the Institute for Pediatric Psychiatry at Jena University Hospital, Kirsten and Wilcke were able to uncover an interesting connection over the last year. Sufferers of dyslexia are more likely to carry a particular variant of the FOXP2 gene. What is more, carriers of this risk variant display unusual activity in an area of the brain associated with language capabilities, making FOXP2 a potential candidate that should be included in an early test for dyslexia.

In a large-scale study of ten-year-old school children, the LEGASCREEN researchers were able to trace a further four genetic variants that could be connected to the occurrence of dyslexia. This would make these variants viable candidates for markers used in an early test. Now, a more precise examination of the regions surrounding these and other genetic markers is to be carried out using the latest gene sequencing techniques. "Once we have recorded the total number of genetic variations present



Modern imaging techniques such as diffusion imaging decode the nerve fiber connections responsible for processing language. © *MPI CBS*

within these regions, we may indeed find more suitable candidate genes with even closer ties to dyslexia," says Kirsten. But the geneticist knows only too well that the genome's presence alone is no guarantee that the child in question is at risk of developing dyslexia. "At the moment, there are too many gaps in our knowledge of how any given gene variant actually affects language development."

Max-Planck scientist Jens Brauer intends to close these gaps. He measures the brain activity of his young test subjects using an electroencephalogram (EEG), because young children who later turn out to be dyslexics show certain irregularities early on in their EEGs when attempting to discern sounds or syllables. "Brains that have developed normally are able to differentiate precisely between similar sounds. When we constantly hear the syllable pa, for example, only occasionally interspersed with the syllable ga, we are able to register these sudden deviations. We don't have to concentrate to do this, it just happens automatically," explains Brauer. The brain normally reacts to the less commonly occurring stimulus with a characteristic activity known as mismatch negativity, or MMN for short. This auditory MMN is far weaker among those suffering from dyslexia; something that can be picked up very well on an EEG.

It is already possible to test how developed MMN is in very young children. Brauer describes how he tests his young subjects: "The child wears a little cap fitted with electrodes and sits on a chair or on the mother's knee. We play a sequence of syllables through a speaker, during which the child can watch a silent movie or engage in some other activity. After about 20 minutes we will have collected enough data to evaluate the brain wave activity." As part of LEGASCREEN, each child undergoes a total of three EEGs and a further two sessions are allocated for various speech tests as well as to perform magnetic resonance imaging (MRI). Brauer intends to use this method to generate a picture of the anatomy of a child's brain – or, more precisely, a picture showing the degree of maturation of each area of the brain participating in the production or processing of language. This procedure, too, neither requires the young test subjects to complete specific tasks, nor even pay particular attention; nor must they be subjected to the use of a contrast medium or other agents. "We use merely water, performing an MRI to measure how it diffuses in the brain," explains Brauer. "This is because water can diffuse far more easily along the path of nerve fibers than across them."

The aim is to establish a simple and cost-effective early test

Measuring the extent of this diffusion indirectly provides a picture of how bundles of nerves in the brain's white matter are configured, whether they can be characterized as thick or thin, how often they branch out, and whether they run parallel or perpendicular to one another. The diffusion also indicates how well individual nerve fibers are insulated against the surrounding tissue. "Altogether, these parameters give us a picture of how well information flows between different areas of the brain," explains Brauer. Comparative MRI studies of adults with and without dyslexia have shown that in those with the condition, information does not flow as well within a particular area of the brain. "We now want to also take a close look at exactly what happens in this area in children," says Brauer. Part of the LEGASCREEN study is designed to help improve understanding of the connections between specific gene variants and deficits relating to language development and the acquisition of writing and reading skills. "This is pure basic research, necessary to uncover the root causes of dyslexia. It is far too elaborate and expensive for serial testing," adds Brauer.

A practicable early test that covers the broadest possible number of preschool-age children has to be simple and cost-effective. The test is therefore to be made up of just two elements: a straightforward saliva sample to analyze genetic markers, and an EEG to record the MMN signal. Brauer concludes, "The best thing about our approach is that we combine these two different indicators, enabling us to minimize the inconvenience we cause our test subjects, while being able to reliably predict each individual's risk of developing dyslexia." ■

LEGASCREEN

Legascreen is a cooperation project between the Fraunhofer-Gesellschaft and the Max-Planck-Gesellschaft. The aim of the project is to develop an early test for dyslexia in order to provide therapy and support early on, when it will help the most. Dyslexia is largely congenital, which explains why children whose closest relatives suffer from the condition tend to be three and a half times more likely to develop dyslexia than other children. For the development of an early test, the scientists are still looking for children from all over Germany aged two to five, whose siblings or parents have already been diagnosed with dyslexia.

www.legascreen.de

Portable systems can help to improve the airport capacity. © *fotolia*

Measuring aircraft jet blasts

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As jet aircraft move along the taxiways at airports, their engines produce powerful currents of air. When a plane takes off, these jet blasts can be strong enough to send nearby vehicles flying, too.

Scientists at the Fraunhofer Institute for Material Flow and Logistics IML are measuring the force of the jet blasts made by new aircraft on behalf of Fraport AG. Sophisticated analyses of air currents occurring at ground level help the airport operator to improve traffic planning systems designed to manage the limited space around airport terminals.

At the core of the specially designed measuring setup is an ultrasonic anemometer. Measuring air flows with this portable system adds to the options available when deciding possible aircraft positions, ultimately contributing to higher airport capacity.

Trapping malware with honeypots

Contact: Jan Gassen, jan.gassen@fkie.fraunhofer.de

Hackers systematically scan the Internet for vulnerable systems with the help of self-distributing malware. On average, accessible systems are targeted every three minutes in attacks that aim to exploit possible security loopholes. In order to better protect these systems, cyber experts are looking closely at how their opponents operate. And one way they can find out is to use "honeypots". These refer to computers that are hooked up to the Internet for the express purpose of recording attempted attacks.

Researchers at the Fraunhofer Institute for Communication, Information Processing and Ergonomics FKIE evaluate these attacks and collect valuable information about hackers' current methods and the malware they use.

In the "HoneypotMe" project, researchers have taken this approach a step further, by redirecting attacks made on conventional systems to an external analysis computer, for example. As the attacking system is unaware of this forwarding, HoneypotMe can be used to make even active assaults on monitored systems more difficult.

Robot provides concrete findings

Contact: Sabine Burbes, sabine.burbes@izfp.fraunhofer.de

The automated BetoScan® scanner system inspects the concrete surfaces of parking garages, bridges and industrial floors. The results of the scan help architects, company managers and construction companies to detect damage early on, giving them a realistic idea of what can be done to correct it. The robot platform was developed jointly by researchers at the Fraunhofer Institute for Nondestructive Testing IZFP and their partners.

BetoScan®, which can be operated by one person alone, is fitted with nondestructive testing sensors capable of examining several hundred square meters of the parking lot in a single day. Its findings can then be supplemented by additional data, plans and images. These are accompanied by clear graphic presentations that provide building experts with a solid foundation for deciding just how renovations are to proceed. The project was funded by the German Federal Ministry of Economics and Technology BMWi.

Are there fissures in the concrete? The automated BetoScan® scanning system identifies damage to the parking deck. © *MEV*

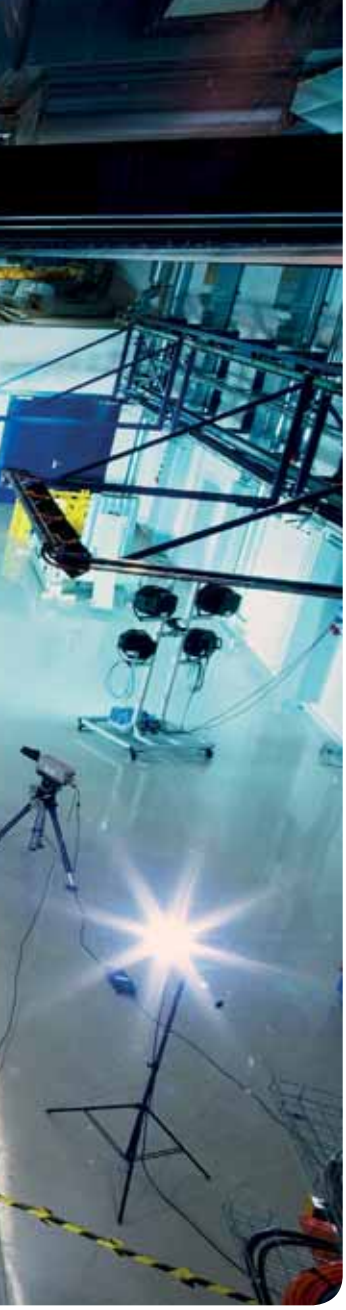
A carefully planned write-off

Are modern, lightweight vehicles safe? What happens in a crash involving an electric car? These are the sorts of questions scientists are investigating - along with many others - at the new, versatile crash-test facility in Efringen-Kirchen, Baden-Württemberg.

Text: Marion Horn

"We're about to start. Please leave the room!" calls crash expert Kirsten Lin. A yellow signal light flashes above the blue steel door. Lin checks to make sure that all doors in the 500-square-meter hall are closed. The safety system confirms that now nobody can enter the hall. Lin climbs the stairs leading to the control room, where she and her colleagues Dr. Ingmar Rohr and Wilfried Harwick from the Fraunhofer Institute for High-Speed Dynamics, Ernst-Mach-Institut, EMI operate and monitor the control computer and measuring devices. The three look down into the dazzlingly illuminated hall. There is an air of anticipation.

Safely behind the security glass of the cockpit, the three get the costly test underway. Today they are examining what can happen when a steel ramrod collides with the rear of the red Audi A6 currently sat in the test hall. This involves performing a carefully orchestrated crash on the car, which has been fitted with black-and-white reference markers to allow 3D measurements. The whole scene resembles a film set. At the moment, our hero's red finish gleams in the glittering light. Just before the test begins, sixteen specially designed floodlights mounted on movable blue metal cross beams in the ten-meter-high test hall are trained at the car. Each flood casts 2,000 watts of light down on the scene, eliminating all shadow so that seven carefully positioned high-speed cameras can document the stage-managed crash in



A crash expert casts an eye over test preparations. In the hall, a fellow scientist checks the position of the lights and high-speed cameras so as to eliminate all shadow and allow high-resolution images.
© *Thomas Ernsting*

high definition. Once the experiment is over, the scientists will use the many images and the extensive test data collected to create 3D simulations of further crash scenarios.

The testing facility is highly versatile

Harwick explains: "The testing facility is highly versatile. Right now we're about to test a rear impact at a speed of 30 km/h and with a 50 percent overlap, meaning the metal sled collides only with one half of the vehicle's rear end. But we can also execute frontal or side collisions if needed. Our facility is designed to carry out inverse crash tests, in which objects are sent crashing into the car, rather than the other way around." The required one- to two-square-meter walls or ramrods are affixed to a catapult along with cube-shaped force sensors. The sensors are deformed by the impact, giving the experts accurate information that allows them to analyze which forces affect which areas.
It has taken several days to prepare this test. At last everything is ready and Harwick hits the start button. He and his colleagues follow the proceedings on one of a bank of computer screens. Rohr points to another screen: "Here you see the two hydraulic units that are really the key components of the facility. One is responsible for the brake mechanism, the other for generating the power needed to drive the catapult. The hydraulic supply system is marked in red. Nitrogen – shown here in blue – is fed into the two pressure cylinders. The gas is then compressed to a maximum pressure of 200 bar, and it is this high pressure that generates the thrust."

At this point, the brakes are still holding the ramrod in place. The catapult will fire as soon as the twelve brake blocks are released. In a matter of milliseconds, a weight of up to three tons accelerates up to a speed of 80 km/h over a distance of just 20 centimeters before slowing back down. "Today's test has the car positioned just two hands' breadth from the ramrod. This short distance is sufficient to effect a collision at 30 km/h," says Harwick.

There is an excited silence in the cockpit. Rohr counts down: "Five, four, three, two, one… action!" A silver-colored crash sled bearing a weight of one and a half tons races toward the red Audi. Crash – the car is sent fifteen meters by the collision with the concrete block. There is the unmistakable sound of splintering metal; fragments fly everywhere and the back window pops out of its frame. The car is totaled. Although the scientists have gone to great lengths to plan and control what happens, they cannot help but wince at the sight of the crash. Thankfully it is just an experiment, and the only occupant of the crash vehicle is a dummy sporting a number of sensors. Had it not been wearing a seatbelt, it would have been thrown from the car.

Before the scientists can re-enter the hall, the air in the space is exchanged to ensure they do not breathe in any noxious gases. The facility is equipped with a sprinkler system in case a fire breaks out during testing. The three crash experts descend the steps into the testing hall and examine the mangled car as an institute colleague sweeps up the shards of debris. "People really have no idea how bad the damage can be from a collision at 30 kilometers per hour," says Rohr.

The scientists can now get started with their extensive follow-up work. "We've developed special measuring and evaluation techniques in order to analyze how different materials, structures and components deform. We make the data collected under these highly realistic conditions available to automotive manufacturers and suppliers to help them design the cars of tomorrow." Software tools help to process this information using numerical simulation, so that the specific values can be referenced when planning further virtual accidents. This puts scientists in a position to answer many questions, including: Which of the rear-end components absorbs the most force? How have the car's body and supports been deformed? How much force hits the chest of the dummy inside the car?

"For more than ten years, our scientists have been testing individual parts in the modular crash-test facility that was developed by the institute itself. Our crash center now enables us to furnish the automotive industry with a comprehensive concept for designing cars that are safe. Leading automakers do have their own testing facilities, but usually these are neither as well furnished with technical equipment as ours, nor are they as versatile. Our new test facility allows us to examine the effects of collisions with a wide range of elements, including trees, other vehicles, a dummy or a wall," says a delighted Prof. Klaus Thoma, director of the EMI. "Depending on the needs of automotive manufacturers or suppliers, we are able to put anything to the test, from instrument panels made from new materials to side supports or headrests."

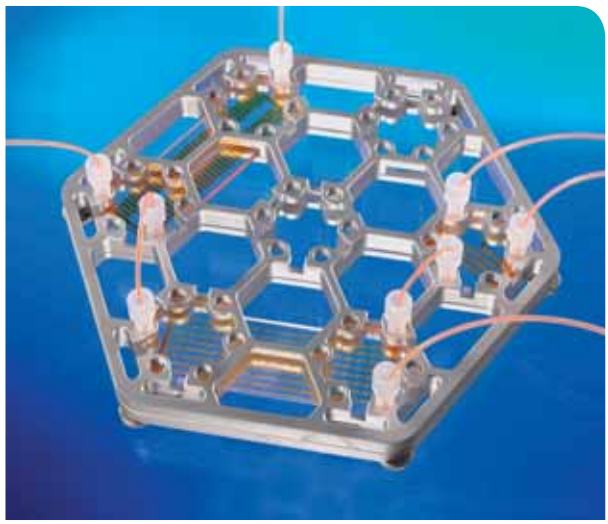
Despite sophisticated computer simulations, when it comes to safety crash tests remain the most reliable way of really putting vehicles through their paces. At the EMI, plastic parts, electric motors and battery packs all have to show just what they can withstand should the worst happen. ■

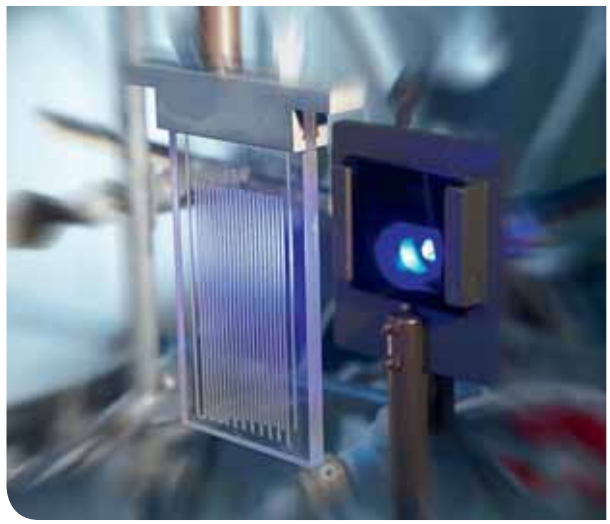
Small reactors, faster production

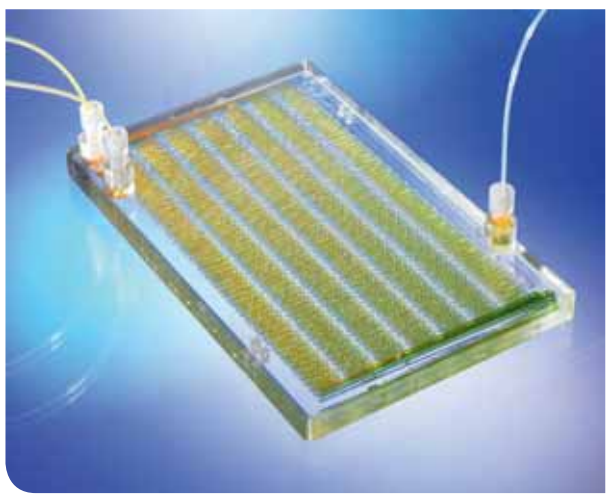
Dangerous substances like nitroglycerine can be made more quickly and safely in micro-reactors than by using conventional methods.

Text: Janine van Ackeren and Marion Horn

Micro-reactor installation in a production facility. © Fraunhofer ICT







Modular laboratory system (above left). By means of micro-channels, the process can occur continuously (below left). Photochemistry in micro-reactors (above right). Remotely controlled process (below right). © *Fraunhofer ICT*

Many patients are thankful for premium-grade nitroglycerine: it is a fast-acting antidote to pain and the feeling of tightness in the chest. As a medication, it is used in the prevention and treatment of angina pectoris. The active ingredient dilates blood vessels, arteries and veins, lowers blood pressure, and relieves stress on the heart as a result. Acute pain is reduced.

Nitroglycerine, in a very diluted form, is used as a medicine, but it is also a dangerous explosive. It is, for example, the main component of dynamite. The slightest disturbance can cause nitroglycerine to detonate. Production of nitroglycerine calls for extreme caution, so that it does not reach the point where it might explode in the laboratory. As heat is generated during its production, the process must be slow: the base substance glycerine is introduced drop by drop to the mixing vessel containing sulphonitric mixed acid. This requires great care. If the mixture heats too vigorously, it can explode. The heat generated cannot be permitted to exceed the heat that can be dissipated.

A method to produce nitroglycerine more safely and quickly has been developed by researchers at the Fraunhofer Institute for Chemical Technology ICT in Pfinztal. It is a micro-reactor process, tailored to this reaction. Greater safety is attributable to the tiny volumes in the reactor, which means less heat is generated, while the surface-area to volume ratio in small reactors is very large, allowing more effective cooling of the system.

The micro-reactor is in continuous operation

A further advantage is that a small reactor manufactures this dangerous substance far more quickly. While a mixing vessel must be filled before allowing the reaction to progress slowly, a micro-reactor is in continuous operation. The base substances flow through tiny channels into the reaction chamber, where they react for a few seconds. However, the product still contains impurities that must be removed. To this end, the raw product flows through further channels into a second micro-reactor, where it is treated and washed.

"Nobody else has thought of using micro-reactors in a process both for the synthesis of a substance, and for its final treatment," says Dr. Stefan Löbbecke, deputy head of department at the ICT. The micro-reactor process has already been put to use in many sectors of industry. Alongside explosives and medication, this includes the production of colorants, polymers, surfactants, adhesives and agrochemicals. The technology is especially well suited to high-value, small-volume substances, where production based on conventional methods meets its limitations. Researchers adapt the reactors as needed to the reactions required by their industrial partners. They have

Passive mixing setups intensify mass transport within micro-reactors
© *Fraunhofer ICT*

many questions to answer: How big should the channels be to facilitate good heat excharge? Where in the channels should obstructions be built in to allow fluids to mix properly and the reaction to proceed as intended? Another important parameter is the speed at which the fluids flow through the channels. They must have sufficient time to react with each other. Furthermore, the reaction must stop as soon as the product is created, to avoid the synthesis of too many unwanted by-products.

Fewer imperfections in polymers for organic LEDs

"There are several, often hair-raising, reaction stages necessary to achieve the right result. With micro-reactors, we can offer a cost-effective and safe technology. Another advantage is that micro-reactors can be integrated into automated processes without the need for significant modifications," Löbbecke says. One example is the manufacturing of polymers for organic LEDs (OLEDs), which are typically used for displays and screens. The polymers from which they are made radiate color. But imperfections can occur easily in their synthesis, which partially reduces their luminosity. "By controlling the process precisely, we can minimize the number of these imperfections," Löbbecke says.

To find out how, researchers first undertook a detailed analysis of the reaction: when do the imperfections occur? How quickly should the process run? "Many reaction parameters used routinely in large-scale or batch processes turn out to be unsuitable for micro-reactors. The base substances often don't need hours to react – a few seconds are enough," the researcher adds. Running the process for a long time can cause the products to decay, or lead to unwanted substances. In order to develop and optimize a micro-reactor for a new reaction, researchers observe the reaction in progress, looking into the reactor itself. Different process analytical techniques provide a helping hand. Some, such as spectroscopic methods, reveal which substances evolve in the micro-reactor. They also show how to increase specifically the yield of the desired product, and how, in some cases, to avoid the creation of by-products in the first place. Other analytical techniques, such as calorimetry, give scientists information about the heat generated during a reaction. These measuring methods show how quickly and completely the reaction occurs. They also give pointers on which process conditions should be chosen to allow the reaction to proceed safely.

Experts have a good grasp of these small-scale chemical reactions, and can fine-tune them as required. They modify the process conditions until they have established the ideal parameters for the desired product, such as heart medication. ■

New representative office in India

The Indian market is booming and continues to evolve dynamically, attracting German and European industry. Siemens, Bosch and Hella, for example, have had a successful foothold in the Indian market for decades now. And for the Fraunhofer-Gesellschaft too, the Indian market is gaining increasing significance: In 2012, twelve Fraunhofer institutes were active working there.

"Beside cooperation with partners of scientific excellence, our focus lies on following our German and European customers to India. This way, we will be available for our current industry customers as a competent partner, help their Indian suppliers reach the requisite quality standards, and thereby strengthen their ability to compete in the Indian market," says Prof. Dr.-Ing. Reimund Neugebauer, President of the Fraunhofer-Gesellschaft.

Just recently Fraunhofer opened the doors of its new representative office in Bangalore, India's "capital" for science and research. Among the goals of this representative office is establishing contacts among leading partners from industry and science, and bundling the activities of the Fraunhofer institutes. One of the key industries the Fraunhofer institutes will focus on is automotive manufacturing. More than one billion Indians must be supplied with goods that come from point A to point B – and for this purpose, gigantic vehicle fleets are needed. Fraunhofer researchers intend to work together with their Indian colleagues to advance ecological and economical automotive production: Over the next few years, they will be developing a simulator for electric vehicles, a software standard for compact cars, an automated 3-D inspection system as well as new joining technology that facilitates improvements to the joining of aluminum and synthetics to car bodies and engines. These subjects represent just one of four planned projects that comprise a cooperation agreement between Fraunhofer and the Coregroup of Automotive Research CAR, one of the initiatives associated with India's Prime Minister.

The Fraunhofer Representative Office in Bangalore will be headed by Ms. Anandi Iyer, who has provided consulting services to Fraunhofer, and for several years. She has been involved with germany's Federal Ministry of Education and research BMBF, the GTZ (now known as GIZ, or the German Agency for International Cooperation), the Confederation of Indian Industry CII and the International Technology Cooperation Network INTEC.

Opening Ceremony with Dr. Ingo Carsten, Consul General Bangalore, Anandi Iyer, Head of Fraunhofer Representative Office India, Prof. Hans-Jörg Bullinger, Senator (from the left) © *Fraunhofer*

Prof. Dirk Elias, Director of Fraunhofer Portugal is a leading specialist for GPS applications. © *Fraunhofer*

Award for excellent navigation

The Director of Fraunhofer Portugal, Dirk Elias, was awarded with the Galileo Master 2012, assigned by European Satellite navigation Competition (ESNC). It concerns the development of an application for smartphones that uses a local positioning technology, like GPS, but for enclosed places such as stores, large buildings, underground car parkings and tunnels.

The technology developed by Fraunhofer, "Seamless Navigation trough ultra low-frequency Magnetic Field Communication" (ULF-MC), consists in an intelligent navigation system that allows a precise localization of the place where we stand, using magnetic fields of very low frequency to establish reliable communication with smart phones in an enclosed ambiance.

GALILEO
Master

Eco-Computer wins a European prize

A work tool, a leisure activity resource, a personal assistant - computers are ubiquitous. Yet the environmental performance for today's computers leaves a lot to be desired: they rapidly become obsolete, typically contain toxic substances as flame retardants and have individual components that are difficult to recycle. Moreover, they consume plenty of power whose production, in turn, causes the release of CO_2 into the atmosphere.

In cooperation with MicroPro Computers in Ireland researchers at the Fraunhofer Institute for Reliability and Microintegration IZM in Berlin have engineered a wooden-frame computer with reduced environmental impacts. The "iameco" (pronounced "I - am - eco") was awarded the "EU Ecolabel".
"The touch-screen PC has a very low energy consumption over the entire lifecycle of the unit – starting from production, through the use phase to its ultimate recycling," explains Alexander Schlösser, scientist at IZM. The carbon footprint is 70 percent smaller than for a typical desktop PC with monitor. In addition, it can be recycled easily.

Eco-Computer with a very low energy consumption over the entire lifecycle.
© *MicroPro*

"Ordre National du Mérite"

For her achievements in scientific research Prof. Agnès Voisard was honored with the French National Order of Merit – "Ordre National du Mérite". On Febrary 14 she was awarded the rank of chevalier. The laudation was held by the French ambassador Maurice Gourdault-Montagne.

Besides being a researcher at the Fraunhofer Institute for Open Communication Systems FOKUS in Berlin, Agnès Voisard holds the position of Professor for Computer Science at the Freie Universität Berlin. In addition she is an economic advisor at "Conseillère Economique de la France (CCEF)".

High ranking award for computer scientist Prof. Agnès Voisard.
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Editorial notes

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