Fraunhofer magazine

1/13 special issue

Carbon fiber time

International
Sailing with nerves of glass

Logistics
Easily digestible food chain data

Life Sciences
The laboratory of the future

Fraunhofer magazine

Clearly arranged and informatively illustrated, Fraunhofer magazine presents the latest in research, technology and innovation - for companies with a future. If you like this issue, you are welcome to request a free subscription.

We welcome you as a subscriber.

www.fraunhofer.de/magazine

Striking out in a new direction

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

Currently, planet Earth is home to 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". The latest 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 a new, more sustainable approach that enables us to optimize the way we use natural resources, drastically reduce pollutant emissions and develop new 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 67 institutes and research 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 this issue of Fraunhofer magazine, we describe how lightweight carbon composites are moving out of the laboratory and into the production environment. Even at this early stage, it is becoming increasingly evident that carbon fiber reinforced plastics will make it possible to substantially reduce the weight of cars and aircraft, with corresponding reductions in fuel consumption and carbon dioxide emissions. Another advantage of carbon composites is that they open up a wealth of new design opportunities, for instance for the manufacturers of wind turbines. This in turn will help to reduce our dependency on fossil fuels.

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.

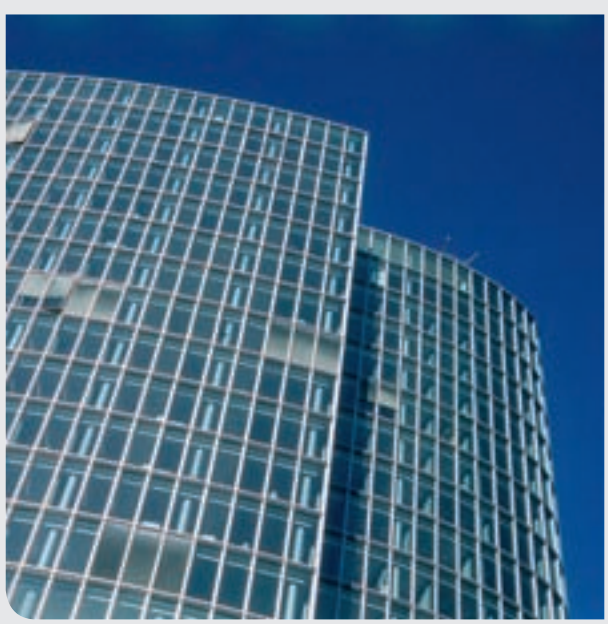
Content

Health-giving light

People these days spend a lot of time indoors – in their homes, in offices, in residential care centers – and hence under artificial lighting. But melatonin levels in the body can become imbalanced if the retinal receptors in the eye don't receive enough light at wavelengths in the 380 to 580 nm area of the spectral range.

Disruption to melatonin cycles can adversely affect wellbeing, with symptoms extending to insomnia and depression. The blue light region of the visible spectrum plays a significant role in the regulation of melatonin levels. Researchers at the Fraunhofer Institute for Silicate Research ISC are developing special coatings for window glass that make the glazing almost invisible and anti-reflective. This allows the maximum of light to enter a building at the wavelengths that act positively on the melatonin levels of the building's occupants.

Special glass coatings help to improve the wellbeing of building occupants. © *MEV*

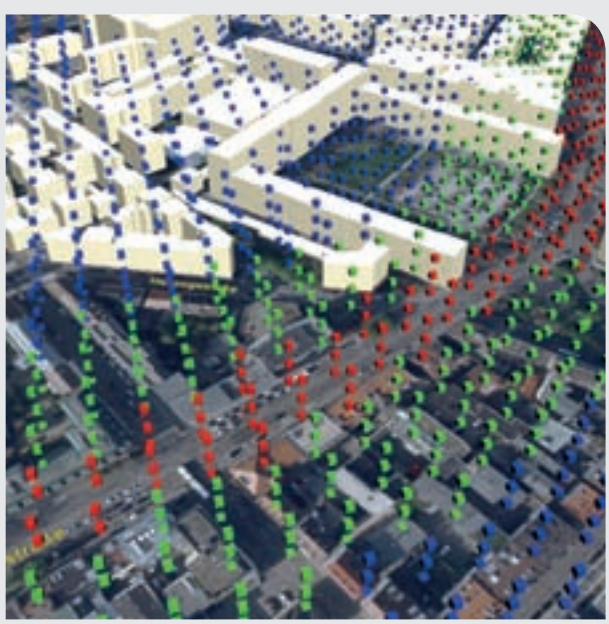


Planning the city of the future

Fine dust, aircraft noise and the buzz of speeding vehicles are a nuisance for city-dwellers. Urban planners have to take a lot of information into consideration when planning new highway construction or airport enlargement projects. What is the best way to execute a building project? To what extent can the ears – and nerves – of local residents be protected from noise? Until now, experts used simulation models to evaluate these factors, based on the latest EU directives. They obtain the data in the form of 2D survey maps; however, these are often difficult to interpret because they lack the third spatial dimension.

In future, this task will be easier. A computer-assisted tool will enable urban planners to navigate through a three-dimensional view of the city – to take a virtual walk through the streets. As the user moves through different locations on the 3D map, the corresponding values from the simulation "float" above the current position. Noise data, for instance, might be represented by a number of red, yellow or green dots. The 3D map was developed by researchers at the Fraunhofer Institutes for Industrial Engineering IAO and for Building Physics IBP.

Red, blue and green dots indicate the level of noise pollution. © *Fraunhofer IAO*



Apps for farmers

In spring when crops are sown or in early summer or fall when asparagus and wheat are ready to be harvested, farmers' workload is at its highest. They have to ensure that all farm hands and machines are working to full capacity and as efficiently as possible. Depending on the size of the property, a harvest worker might have to work on up to ten fields each day. The farm manager's instructions are usually transmitted in the form of handwritten notes, and if there are any last-minute changes they are communicated by cellphone.

Smartphones are set to change all this. The farm hands will in future receive their instructions by means of a smartphone application that allows the farm manager to enter the necessary information by means of an Internet-enabled PC or tablet computer. This has the advantage of allowing the instructions to be adapted to the current situation. The app also facilitates the record-keeping process.

Researchers at the Fraunhofer Institute for Experimental Software Engineering IESE in Kaiserslautern worked with the John Deere Corporation as a strategic partner to develop the app in a joint project. The researchers also performed a field analysis from the point of view of the farm hands. The questions they asked included: What is the surface area of the cultivated fields? How long does a worker need to complete this work? What variety of seeds do they plant? On the basis of the answers obtained, the scientists were able to adapt the program to the farmers' specific needs.

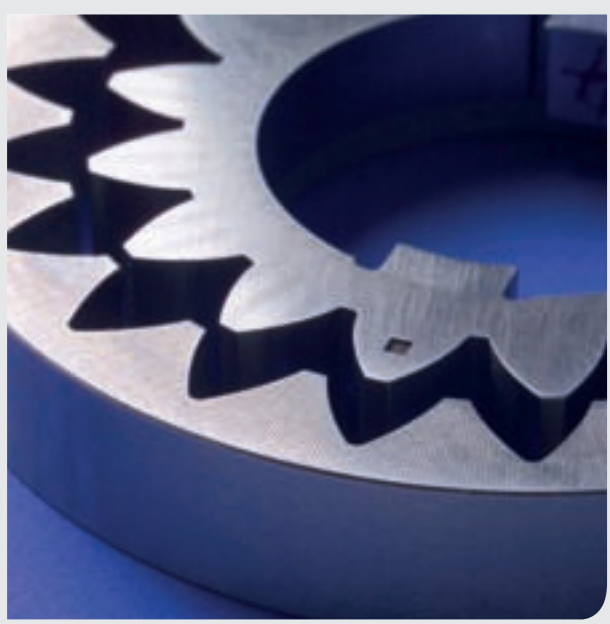
Instead of the old system of handwritten notes, farm workers now receive their instructions on a smartphone or tablet PC. *© John Deere/Fraunhofer IESE (m)*

Lower frictional loss

The durability and efficiency of motors, pumps and sealing systems is strongly dependent on the loads to which they are exposed. The rate of wear to the surface of moving parts in industrial equipment is particularly high, due to constant friction. Even applying lubricants can only slow this process, not halt it altogether. To solve this problem, researchers at the Fraunhofer Institute for Production Technology IPT and seven partners from six European countries are collaborating on the "Stokes" project, which aims to develop an industrial-scale process to reduce the frictional forces acting on the surfaces susceptible to wear.

Their solution involves etching microstructures in the contacting surfaces of pumps and seals using laser technology. This allows the moving parts to slide over one another more easily, and also helps to distribute lubricants more evenly. As well as reducing the wear on these highly loaded components, the solution also improves their performance and energy consumption.

Friction-reducing effect of laser surface structuring on hydraulic components. *© Fraunhofer IPT*



Carbon fiber time

This bicycle can be manufactured in a fully automated process. © *Christoph Knoch*

Lightweight, crash-proof and corrosion resistant, carbon fiber reinforced plastics have a lot going for them. This expensive material has been in use for some years in Formula One and in aerospace. But until now it has been seen only rarely in automotive production. This is down to the difficulty of producing and processing large volumes of the ultra-lightweight material. However, that is set to change.

Text: Birgit Niesing

Most buyers of new cars want something big, powerful and with as many features as possible, including air conditioning, seat heating, parking assistance or a navigation system. But all this extra power, comfort and safety means cars have put on lots of weight. Even small and medium-sized models weigh over 1.2 tons these days. In comparison, the 1983 VW Golf Mark II weighed in at just 870 kilograms.

Car manufactuerers need to do something about the weight of their products. New regulations state that all car manufacturers are obliged to bring their models' average CO_2 emissions down to 120 grams per kilometer from 2015 onwards, with the permitted level dropping to below 95 grams by 2030. This can only be achieved by drastically reducing vehicle weight. The lighter the car, the less carbon dioxide it emits into the atmosphere. A reduction of just 100 kilograms in weight translates into a cut of 8.8 to 12.5 grams in CO_2 emissions per kilometer. Electric cars are the ones that really need to go on a diet, since they have the added bulk of a battery on board – and rechargeable lithium-ion batteries can easily weigh several hundred kilograms.

These CO_2 regulations will cause a boom in lightweight construction, according to consultants McKinsey. A study published at the beginning of the year suggests the market will grow from today's 70 billion euros to more than 300 billion euros by 2030. In future, cars will incorporate more and more high-strength steel, aluminum, magnesium and composites. One of the most promising materials for lightweight construction is carbon fiber (carbon fiber reinforced plastic, CFRP; also known as carbon fiber reinforced polymer). Demand for CFRP is likely to rise by almost 20 percent each year, the study predicts.

Current demand for carbon fiber is still small. Last year some 55,000 tons were produced, states Germany's Federation of Reinforced Plastics, an industry body. Much of this material is going into aircraft manufacturing. However, by 2030 the automotive industry is set to overtake the aerospace sector to become the primary user of carbon fiber, McKinsey believes. Automakers are already positioning themselves for this development, with almost all of them looking for a carbon fiber production partner.

But why are car manufacturers so keen to use this matt black material? "Carbon fiber reinforced plastics have enormous potential as lightweight construction materials," says Professor Holger Hanselka, Chairman of the Fraunhofer Group

Cross-section of a carbon fiber composite wheel with motor housing and wheel hub motor.
© *Fraunhofer LBF*

for Materials and Components – MATERIALS. Although it weighs only around half as much as steel, CFRP is just as strong, crash-proof, and cannot rust. It is also 30 percent lighter than aluminum. But this wonder material does have some drawbacks. Carbon fiber is very expensive; CFRP parts currently cost around six times as much as the same parts made of steel. They are usually made by hand (see box on page 13). If working with epoxy resins, the plastics need to be polymerized, which takes hours. This state of affairs is hardly compatible with a mass-production setup that requires thousands of parts each day. What's more, the composite material is currently very difficult to recycle.

Things are set to change. The Fraunhofer Group for Materials and Components worked up a strategy five years ago for how Fraunhofer can support industry in ensuring take-up of this new material. Fraunhofer is focusing on two key points: At the CFRP North research center in Stade, scientists from the Fraunhofer Project Group Joining and Assembly FFM are working on new automated assembly technologies for large-scale parts made from carbon fiber reinforced plastics. Meanwhile, the Fraunhofer Function-Integrated Lightweight Construction Project Group, founded in 2009 as a branch lab of the Fraunhofer Institute for Chemical Technology ICT in Augsburg, is looking to ready carbon fiber for series production. In addition, the Group's scientists are studying the behavior of carbon fiber parts in accidents to see which damage mechanisms come into play and to work out how to predict the parts' service life. The Fraunhofer Lightweight Structures Alliance and the Technologies for Hybrid Lightweight Construction (KITe hyLITE) innovation cluster are also carrying out important basic research into how to apply carbon fiber.

For this material to have a future in mass production, its price will have to come down. "We're aiming to reduce the production costs for CFRP parts by 90 percent," says Prof. Dr.-Ing. Klaus Drechsler, head of the Function-Integrated Lightweight Construction Project Group and Chair of Carbon Composites at the Technische Universität München (TUM). "We mean to go about this first and foremost by employing new manufacturing processes that are suitable for mass production."

Fully automated CFRP production

The Augsburg-based research scientists have already developed a novel manufacturing process for the automotive industry, combining a weaving machine familiar from the textile industry with a pultrusion line that has been modified by researchers from the ICT. The weaving machine gives the dry carbon fibers the correct shape, while the pultrusion line coats them in resin. What marks this process out is that all its steps are fully automated. It is no longer necessary to feed

BMW has begun production of carbon fiber parts for the BMW i3 in Landshut. © *Harry Zdera*

the fibers manually into the tool and align them by hand, as has been the case up to now. Audi AG and mechanical engineering company Voith are development partners in this project, which has received funding from Germany's Federal Ministry of Education and Research. The researchers chose to demonstrate that production of CFRP parts can be fully automated by using bicycles as an example, and the carbon fiber bike that is the fruit of their labors is about to be brought to market by a TUM spin-off. The Fraunhofer Function-Integrated Lightweight Construction Project Group is a member of the MAI Carbon cluster, which brings together 72 companies, educational and research institutes, and supporting organizations in the Munich-Augsburg-Ingolstadt region, with the shared objective of making carbon fiber reinforced plastics suitable for use in series production.

Automakers working on series production

Above all it is automakers and their suppliers who are working on integrating the production and processing of carbon fiber into their series-production processes. A few months ago in Landshut, Bavaria's BMW began producing parts for its i3 electric car from the matt black material. This electric model is due to enter series production in Leipzig next year, which will make it the first mass-produced vehicle with a carbon fiber passenger cell.

Carbon fiber is a particularly attractive proposition for electric vehicles, since the ultra-lightweight material helps to extend their range. Researchers at the Fraunhofer Institute for Structural Durability and System Reliability LBF in Darmstadt have developed a CFRP wheel with an integrated electric motor. This matt black car wheel measures 6.5 x 15 inches and weighs just 3.5 kilograms – without the carbon fiber housing for integrating the electric motor. Compared to a cast aluminum wheel, this represents a weight reduction of up to 60 percent.

For many years now, aircraft manufactuers have been using CFRP in wing flaps and empennages. In future, they are set to use the ultra-lightweight material for entire fuselages or wings – for instance in the new Airbus A350 XWB (Xtra Wide Body) or Boeing's Dreamliner. If these carbon fiber parts are produced manually, there is no way the industry's planned rates of aircraft production can be met. That is why manufacturers are pushing for automation. Research institutions, companies and higher education institutes are working together in the CFK NORD research center in Stade on forward-looking solutions for how to apply carbon fiber in aerospace. One of the main parties involved is the Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM's Fraunhofer Project Group Joining and Assembly FFM, founded in 2009. Researchers are developing automated manufacturing technology for large-scale CFRP parts.

The parts that aircraft manufactuers work with are often gigantic; individual segments of fuselage can measure over ten meters. And yet these parts need to be fitted together with extreme accuracy: assembly tolerances for aircraft are no more than 0.2 millimeters. In order to bring the heavy parts into position, manufacturers have until now relied on enormous production facilities known as assembly cells. But putting systems of this kind in place takes lots of time and effort. Moreover, they need to be redesigned for each new type of aircraft, which adds to construction and manufacturing costs. What is needed are concepts for making aircraft assembly more flexible, simple and economical – especially as regards the extremely high-precision tasks of drilling, milling and adhesive bonding. The FFM Project Group's experts propose that in future the mechanical working, and increasingly also adhesive bonding, of aircraft should be done by teams of small industrial robots, in much the same way as happens in the automotive industry.

In order for this to come about, robots will have to learn to see, since parts can be so varied in shape and size that a robot running on a fixed program is of no use. "That's why we're developing a precise recognition system to measure parts with extreme accuracy during assembly," says Dr. Dirk Niermann, head of the FFM in Stade. They are also developing powerful software that takes just fractions of a second to provide robots with the coordinates they need, so they can alter their processing paths to take account of workpiece shape and position, and ensure everything fits together in the end. Together with Hamburg University of Technology (TUHH) and partners from industry, FFM researchers have already built a test facility in which milling robots automatically cut openings for windows in a CFRP fuselage. The researchers have also produced another key component for their assembly line: a plant featuring specially developed grippers for shape and position adjustment. This equipment is capable of dealing flexibly with aircraft parts of various geometries.

Using robots

The Function-Integrated Lightweight Construction Project Group has developed another automation solution for the aerospace sector in conjunction with Premium Aerotec and Eurocopter. The approach taken here centers on a robot with a laying head: it grips the carbon fibers once they have been coated with resin and lays them onto the tool for curing. This automated process is suitable for use in mass production, providing consistently good quality with no wastage. The robot is currently working day and night in a lab in Augsburg, and the parts it produces are being evaluated by Airbus.

Making CFRP components is very labor-intensive. The carbon fibers must be coated in plastic and then left to harden in a mold at high temperatures. Just as in home baking, this mold must be "greased" beforehand to make sure the finished part detaches easily. The drawback is that the part is often left with traces of release agents such as wax or silicone. Before a part can be processed, these traces must be painstakingly removed.

Experts at the IFAM have developed a clever alternative approach. Their FlexPlas® deep-drawable release film sticks to the part like a second skin thanks to vacuum. The elastic polymer film features a flexible plasma polymer release coating which lets parts separate easily from the mold with no need for subsequent cleaning of either part or mold. A further benefit is that researchers can use FlexPlas® to carry out additional functions. For example, applying paint to the film means the part leaves the mold ready-painted. Leaving the film on the parts produced protects them from dirt and damage. It can be easily removed before the parts are used, perhaps by a robot.

Fraunhofer researchers are still working on other approaches to automating the production and processing of carbon fiber parts. For example, engineers from the Fraunhofer Institute for Production Technology IPT in Aachen have developed a process known as tape laying, which uses rolls of thermoplastic tape containing integrated carbon fibers. Several layers of tape are laid up, melted by a laser shortly before application, and then compressed to give a compact structure. This allows carbon fiber reinforced plastics to be produced in a fully automated process. It takes optimized and economical bonding processes to ensure that bonds between carbon fiber parts are highly loadable. The adhesive bonding experts at Fraunhofer IFAM in Bremen are one of several groups working on this. Carbon fiber parts can also be bonded together using lasers. Experts at the Fraunhofer Institute for Laser Technology ILT in Aachen are developing solutions of this kind. The laser is also an ideal tool for cutting, structuring and drilling carbon fiber parts.

It is not just manufacturers of aircraft and cars who keep an eye on the weight of their parts. Mechanical engineers, too, are keen for their machines to be more productive without adding further drives. They can achieve the necessary high operating speeds by using parts that are more lightweight. Researchers at the Fraunhofer Institute for Machine Tools and Forming Technology IWU in Chemnitz have come up with a carbon fiber composite crossbar for laser cutting equipment. Not only did they manage to halve the part's mass, they also made it twice as rigid. Compared to an optimized steel version, their part boasts a fourfold increase in dynamic rigidity. This equates to a productivity increase of some 70 percent. Using this expensive material has paid off for Trumpf Sachsen GmbH, since the additional costs incurred were recouped in just 3.5 months. This just goes to show that carbon fiber is an attractive material for many different sectors. ■

More and more aircraft parts are made of carbon fiber. © *dpa*

CFRP – light and safe

Carbon fiber reinforced plastic, also known as CFRP or simply carbon fiber, is seen as the lightweight material of the future. This high-strength material's secret is the fibers of carbon it contains. At just 5 - 8 micrometers thick, they are ten times thinner than a human hair. These are gathered together in bundles of between 1,000 and 24,000 individual fibers. The resulting black thread can be processed into fabrics. Then the carbon weave is embedded in a plastic matrix before being cured in a mold – usually at high temperatures. Only after "baking" does the compound assume its final, hardened form.

Carbon fiber has been around for almost fifty years. Until now, the material has been used predominantly in aerospace, Formula One, high-end bicycle manufacture or in certain top-of-the-range sports cars. Science and industry are working to make the material suitable for mass-production applications.

A milling robot cuts window openings in a CFRP aircraft fuselage. © *Fraunhofer IFAM*

Researching to improve efficiency

Professor Reimund Neugebauer took over as the new President of the Fraunhofer-Gesellschaft in October 2012. In an interview with Fraunhofer magazine, the mechanical engineer describes the challenges to be met by the research organization in the coming years.

Interview by Birgit Niesing

Professor Neugebauer, you have just taken over as President of Fraunhofer. How is the research organization currently placed?

Fraunhofer has progressed very well in the past ten years. We have succeeded in raising our profile in government and industry, and have significantly increased our revenues. We are also very well positioned internationally, where we pursue different forms of cooperation, ranging from representative offices through to subsidiaries. Commercialization of research results is also an area that has been significantly strengthened – our mp3 technology being the most popular example. In addition, we have successfully further upgraded our internal networks. Thanks to reviews of our research portfolio and overall strategy, alongside ongoing systems research, we now achieve greater synergy. These are all aspects that I would like to keep on developing in the future. In particular, I see great potential in systems research, as exemplified by the now established electromobility project headed up by Professor Buller and Professor Hanselka. If it can be extended across the Fraunhofer-Gesellschaft, taking advantage of opportunities for collaboration with industry, systems research should enable individual sectors to take quantum leaps forward.

What other areas would you like to focus on?

If the Fraunhofer-Gesellschaft is to operate successfully, it must fulfill the criteria of adaptability and scientific excellence. Our mid-term goal is to keep on developing these characteristics of how we work. In the future, Fraunhofer must also act as a strategic partner for German industry. The important thing in this respect is establishing a scientific foundation for sustainable value creation in Germany.

Are there any particular challenges to be faced in the coming years?

One significant challenge will be securing funding in the future. Even though research and development are highly regarded in Germany, the tight public budgets we see today will restrict the funds available for such projects. The economy is also beginning to show signs of only sluggish growth. But Fraunhofer has over the last few years developed a carefully planned, long-term and transparent commercialization strategy. One idea being pursued here is to increase the degree to which we commercially exploit publicly-funded projects, transferring results more effectively to industry.

The Fraunhofer-Gesellschaft has grown rapidly in recent years. How do you envisage further development?

Growth is the sign of a healthy organism, provided this growth is genuine and in keeping with the values held by the organization. In our case, I see it as growth generated by the success of the institutes, and this must be strengthened. Looking further afield, growth generated by synergies derived from the merging of institutions also makes sense. But research institutions should not make growth in itself a target to achieve. It is more the natural outcome of being successful in what you do. So we must aim to create impact, through excellence.

Prof. Reimund Neugebauer

Reimund Neugebauer takes up the post of president having already seen long service as an institute director. The 59-year-old engineer and university professor studied mechanical engineering at the Technische Universität Dresden and obtained his doctorate in 1984. This was followed by leadership roles within the mechanical engineering industry and the acceptance of his post-doctoral thesis in 1989. Subsequently, Neugebauer was made University lecturer at the Technische Universität Dresden. In 1990, he took over the general management of the Institute for Machine Tools. Then, in 1992, he became director of the newly established Fraunhofer Research Institution for Machine Tools and Forming Technology in Chemnitz. This was successfully turned into a fully-fledged institute, Fraunhofer IWU, only two years later. Since 1993 he has been Professor of Machine Tools and Forming Technology at the Technische Universität Chemnitz. It was here that he also founded the Institute for Machine Tools and Production Processes, which he has directed since 2000.

Reimund Neugebauer has developed Fraunhofer IWU into a world-leading partner for the automotive and machine tool industries. Sites in Dresden, Augsburg and Zittau have allowed mechatronics, medical technology and light-weight construction to be added to the areas under research. Equally, important initiatives to safeguard and build on Germany's prosperity have come from Neugebauer's focus on resource-efficient production.

Prof. Neugebauer is a member of numerous scientific societies and associations, both national and international. These include acatech, the National Academy of Science and Engineering, as well as CIRP, the International Academy for Production Engineering. In 2010 / 2011 he was president of the German Academic Society for Production Engineering (WGP). He is also a board member of the Industrial Network of Saxony, founded in 1828.

© Jörg Lange

How will the Fraunhofer-Gesellschaft position itself in future on an international level?

Fraunhofer has no choice but to continue its international activities. Borders do not define where knowledge is generated around the world these days. Fraunhofer has become well-established on the international stage in recent years. Some countries, like Brazil, are meanwhile looking to set up institutions similar to Fraunhofer. Even U.S. President Barack Obama would like adopt the Fraunhofer model as the framework for the National Network for Manufacturing Innovation (NNMI). That is an incredible tribute to us. But it also means that we are being imitated. We need to develop strategies here to ensure that Fraunhofer remains an important research and development partner for German business into the future, and that industry does not one day relocate its research abroad.

You were successful in developing the Fraunhofer Institute for Machine Tools and Forming Technology (IWU) into an important institute with numerous branch facilities. What were the criteria behind this success?

One of the factors that contributed most to success was the incredibly high motivation of my colleagues. They were particularly determined at the beginning of the 1990s to make the most of being part of Europe, through their own energy, knowledge and ideas. A positive working atmosphere and open communication also made their mark. From the beginning, we operated on a decentralized basis, delegating significant responsibility to the individuals involved. This means that heads of department and group managers are responsible for acquiring their own projects. Nevertheless, even if a high degree of autonomy is particularly important in research, as the institute's director you must be prepared to intervene when projects go awry. A uniform and visible brand is essential to projecting the values you identify with. Major lead projects – involving sums of up to 30 million euros – also contributed to our success. We ourselves were even responsible in many instances for getting them underway.

You opted very early on for the topic of resource-efficient production. Why did you choose to address this particular issue?

We face various major challenges on a global scale. For one thing, there is the issue of changing demographics; while the world's population constantly grows, that of developed countries is rapidly aging. The effect is twofold, and places different demands on value creation. On the one hand, ageing societies require new products – such as implants and prosthetics. On the other, as populations rise, more products will be needed to serve the needs of a growing number of people. If people in newly-industrialized and developing countries want to even approach our standard of living, something will have to be done about our current level of consumption of energy and resources. In the future, we will have to make a lot less go a lot further. And this will call for a fundamental shift away from looking for maximum profit from minimum capital investment, towards maximum added value from minimum resources, accompanied by the best possible profits. Taking a look at another global challenge, climate change, it turns out that we not only have to make a lot less go a lot further – we also have to do so without increasing pollutant emissions. We can also not afford to forget people when we address the issue of resource-efficient production. Ergonomic design will be at a premium in the future, particularly if people are going to be working longer.

Are there already successful examples of resource-efficient production?

Fraunhofer IWU is working on some big projects. The Green Car Body Technologies Innovation Alliance (InnoCaT) has brought together 60 partners from across Germany. These include big automakers and suppliers, but also Fraunhofer institutes – all aiming to significantly reduce the resources used in the manufacture of vehicle bodies. The target is to reduce the amount of materials and energy used, by 30 and 50 percent respectively. These are huge numbers, but we are now well on the way to meeting these ambitious goals. Energy-efficient Product and Process Innovations in Production Engineering (eniPROD), a cluster of excellence based in Saxony, aims to drastically reduce energy use in the production process by the application of bionic structures and kinematics. Our vision is a production process almost entirely free of emissions. The first results of this undertaking are already finding their way into industry in the form of energy-efficient machine tools.

How can Fraunhofer help to create more added value in Germany?

If we want to maintain the added value we generate within Germany, our products must offer more originality and more quality than goods manufactured in other countries. This also means designing processes so that production can be kept in a high-wage country. In this regard, Fraunhofer makes a significant contribution – not only through the Fraunhofer Production Alliance but through all of its alliances. To give but one example, software developed by the Information and Communications Technology Alliance (IuK) helps to ensure that German industry remains competitive, by safeguarding its expertise. ■


Solar-powered hydrogen filling station.

Driving on solar and water power

Contact: Dr. Christopher Hebling
christopher.hebling@ise.fraunhofer.de

On the premises of the Fraunhofer Institute for Solar Energy Systems ISE in Freiburg, there is a hydrogen filling station for cars, buses and bikes. As well as serving as a research platform, it is also open to the public as part of the network of hydrogen filling stations currently being established in Germany and throughout the world.

In a sustainable energy economy, electricity generated from renewable resources is used to run electrolysis plants in which hydrogen is extracted from water for use in fuel cells that serve as the power source for hydrogen-fueled electric vehicles. It only takes three minutes to fill the hydrogen tank, which allows the latest generation of fuel-cell vehicles to travel for 350 to 500 kilometers between refueling stops.

The hydrogen filling station in Freiburg, which is subsidized by the Baden-Württemberg Ministry of the Environment, is one of the few such facilities to encompass the entire energy supply chain – from renewable electricity generation and the electrolysis process to the filling pumps. The energy required on average over the year to produce and store the hydrogen is expected to be largely covered by arrays of photovoltaic modules on the roof of the filling station and neighboring buildings, with backup from the grid only if necessary.

Claiming travel expenses

Contact: Yvonne Ortiz Guadalupe
yvonne.ortiz@iese.fraunhofer.de

Researchers at the Fraunhofer Institute for Experimental Software Engineering IESE in Kaiserslautern have developed a new app that simplifies the reimbursement of travel expenses. Up to now, business travelers had to have a perfect memory to keep track of arrival and departure times and the number of hours spent working during each business trip – or failing that write everything down. A new smartphone app promises to simplify the record-keeping process: The user merely has to touch the relevant icon when he arrives at his destination, and the date, time and place are automatically stored on his smartphone, and linked to the appropriate appointment.

The entire process is automated: The app already knows the planned destination, which was entered with the travel form. The smartphone's GPS function issues a message when the destination is reached, which the user merely has to confirm in order to store the data. Another often wearisome task, especially after a relatively long business trip, is that of sorting receipts for public transportation and taxi fares and assigning them to specific appointments. The new app can help here too: The user simply takes a photo of each receipt and the app automatically assigns them to the relevant appointment so that the expenses can be reimbursed accordingly.


Kohlrabi resists attack by the cabbage root fly thanks to cyanobacteria. © *panthermedia*

Resistant to insect attack

Contact: Dr. Ulrike Schmid-Staiger,
ulrike.schmid-staiger@igb.fraunhofer.de

When cabbage root flies lay their eggs on young seedlings, organic farmers often lose their entire vegetable crop. In future, eco-friendly pellets made of cyanobacteria and fermentation residues from biogas production will repel these insects – and simultaneously fertilize the growing plants.

These pellets were developed by researchers at the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB in Stuttgart in collaboration with agricultural scientists at the University of West Hungary in Mosonmagyaróvár on behalf of a group of organic farming organizations. When the pellets are spread around the base of the young plants, the soil flora break down the cyanobacteria and release an aromatic compound that acts as an insect deterrent.

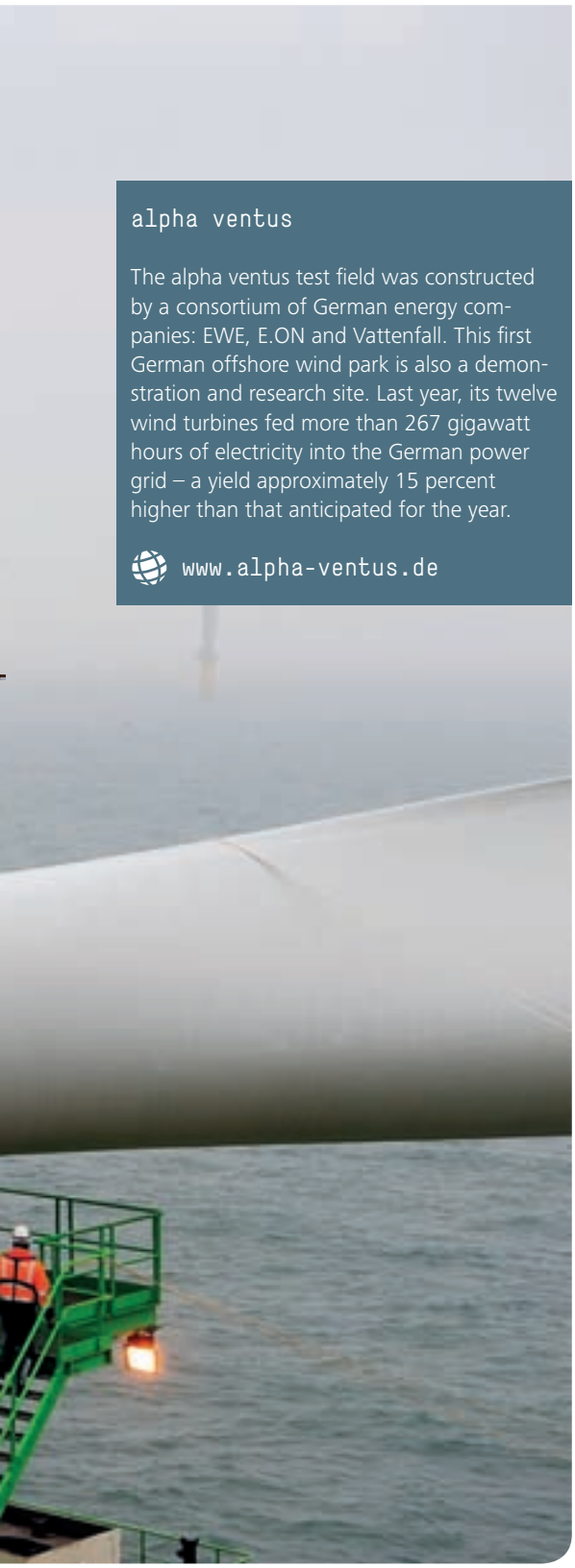
The researchers have tested the insect-repellent properties of the pellets in open-field experiments in Hungary and Spain. The fields of cabbage and kohlrabi showed no signs of damage by cabbage root flies. The fertilizing effect was also confirmed: The kohlrabi bulbs harvested from the treated plants were twice the size of those obtained from the untreated controls.

Giant wind generators

By 2030, Germany will have offshore wind farms boasting a total installed output of 20 to 25 gigawatts. That's the ambitious goal laid down by the federal government. In order to meet this target, very large wind turbines with outputs of up to 20 megawatts will have to be erected on the high seas. To date, however, offshore wind generators have typically produced up to five megawatts.

Text: Daniel Hautmann

Wind generators erected far out at sea will be much bigger in future. © *Matthias Ibeler/alpha ventus*



alpha ventus

The alpha ventus test field was constructed by a consortium of German energy companies: EWE, E.ON and Vattenfall. This first German offshore wind park is also a demonstration and research site. Last year, its twelve wind turbines fed more than 267 gigawatt hours of electricity into the German power grid – a yield approximately 15 percent higher than that anticipated for the year.

www.alpha-ventus.de

Bigger and bigger, more and more output: It's easy enough to sum up the development of wind power so far. In the 1990s, the benchmark was 250-kilowatt turbines on 30-meter towers; these days we have two-megawatt (MW) turbines mounted on 100-meter towers. And in offshore waters, a rated output of five megawatts is now the norm. Yet that's just the beginning.

Under the recently-concluded EU project 'UpWind', 120 researchers from various European institutions, including experts from the Fraunhofer Institute for Wind Energy and Energy System Technology IWES in Bremerhaven, pondered the future of wind power. Together, they explored what would be technically feasible, and agreed that 20 MW wind generators are a realistic prospect. Professor Andreas Reuter, director of the IWES in Bremerhaven, believes "we could see the first very large turbines by 2020."

www.upwind.eu

IWES researchers have built a new rotor blade test facility at their north German base. It contains a 90-meter high test rig which can take even the biggest turbines (those that generate more than 10 MW of power). At the heart of the test facility lies a block of reinforced concrete weighing almost 1000 metric tons, which can be tilted like a lift bridge. It can be used to bend enormous rotor blades as if they were made of straw – blade tip flexing of up to 25 meters has been recorded during tests. These flex tests and other experiments allow the researchers to establish whether or not the huge rotor blades are capable of withstanding the operational stresses to which they will be subjected at sea.

There is a reason why wind turbines are steadily growing in size to produce more output: Many governments are looking to renewable energies in order to cut their CO_2 emissions and reduce their dependence on fossil fuels. The stated aim is for around 20 percent of the EU's energy to come from renewable sources by 2020, and offshore wind power will play a central role in meeting this target. If the European Wind Energy Association is to be believed, we will have the capacity to generate 200 gigawatts (GW) of power off the coasts of Europe by 2030 – the equivalent of 40,000 five-megawatt or 10,000 20-megawatt installations.

Larger turbines have certain advantages. Firstly, they save space: The new class of giant generator will have less of a footprint yet will produce the same output as a cluster of four smaller turbines erected with the required clearances. Secondly, weather windows – one of the most critical factors in the erection of any offshore installation – can be used to better advantage: Instead of four separate units, only a single turbine will need to be set up and connected to the grid.

But what will these giant wind turbines actually look like? Uniformly upscaling all the components – e.g. simply doubling the size of the tower, generator and rotors – will not produce the required outcome. As Bert Janssen of the Energy Research Centre of the Netherlands (ECN) wrote in the UpWind Final Publication, "Upscaling the current designs with the existing technology has its limits. New designs and/or materials are needed." Professor Reuter shares this opinion, and says: "I can easily imagine turbines being designed differently in 2020."

Wind turbines with two blades

2-B Energy, a Netherlands-based company, has come up with one possible solution – an innovative turbine with two blades. Both blades are long and can therefore be given a thinner profile, which cuts down on construction material. The platform is additionally designed as a downwind machine, so the propeller turns behind the tower, i.e. on its leeward side. Consequently, there is no requirement to continually adjust the blades as the wind changes direction – downwind machines realign themselves, which saves on components. They also have another advantage, in that the blades cannot possibly collide with the tower, even in the event of extreme flexing. And their final benefit: Two-bladed installations are easier to erect – the turbine housing and blades can be assembled on the jack-up barge.

The first two prototypes of 2-B Energy's six-megawatt installation are to be built in the Scottish town of Methil in 2013. If they prove successful, other offshore platform manufacturers could likewise do away with the third rotor blade in the future. That said, the two-blade design would never be deemed acceptable on land: It is too loud, and the motion of the blades too disharmonic.

Expert opinion is similarly divided when it comes to the ideal drive train for a 20 MW offshore turbine. Should it be geared or not? At present, the majority of manufacturers seem to favor gearless installations. "A number of extremely interesting generators have emerged in the last two years," notes Reuter. Almost all turbine manufacturers also believe in permanently excited generators, since these facilitate compact and light-weight constructions. Lean turbine design and no gearing have a significant impact on the entirety of the structure: The foundations and tower can be lighter because they have to bear less weight, and this in turn makes it easier to erect the installation as a whole. Somewhat more problematic is their reliance on rare earth elements: The innovative generators cannot be produced without these materials.

Use of carbon fiber materials

The rotor blades on the new generation of turbines must be able to withstand significant stresses. At up to 135 meters in length, with a blade root diameter of 6.5 meters and profile depths of up to 10 meters, they will flex by as much as 35 meters during operation. Add to this the tremendous weight of the rotors themselves – approximately 50 metric tons – and it is clear that these components cannot possibly be built without carbon fiber. But carbon is currently only produced in small quantities and is horribly expensive.

Manufacturers will find a way to build these massive blades, of that there can be no doubt. But in return, the blades will have to prove their worth. The experts want 'smart blades' – blades that incorporate wireless sensors, piezo elements and/or shape memory materials that can provide continuous information on stresses and, if necessary, react without delay to undesirable measurement values. In-built control flaps, for example, could be used to reposition the blades in a way that actively reduces load peaks. Of course, only a small number of installations would actually need to be fitted with these measuring devices: These so-called 'flight leaders' would always face into the wind, and when hit by gusts, could simultaneously transmit the order to all neighboring wind generators to turn their blades out of the wind. Using such technologies, even the biggest turbines could be protected against storms.

By 2030, offshore turbines with a total output of 200 gigawatts (GW) will be in situ off the coasts of Europe.
© *Paul Langrock/Zenit/laif*

The RAVE (Research at Alpha VEntus) initiative runs in tandem with the construction and operation of Germany's first offshore wind farm – 'alpha ventus' – and is a rich source of information relating to offshore installations. The pilot project is situated 45 kilometers north of the island of Borkum, in water 30 meters deep.

www.rave-offshore.de

RAVE is seeking to prove that it is possible to generate electricity in the middle of the North sea both reliably and economically. At the alpha ventus test site, more than 150 scientists are studying the impact of wind, weather and waves on nacelles, steel towers and rotor blades, and investigating whether or not the components are capable of withstanding the stresses to which they would be subjected far out at sea over a 20-year period, as well as the effect the installations would have on the sensitive ecosystems that exist in the North sea. IWES researchers are coordinating the project, which is funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety.

Professor Jürgen Schmid, director of the IWES in Kassel and a member of the German Advisory Council on Global Change (WBGU), says: "The alpha ventus wind farm offers research opportunities unparalleled anywhere else in the world. Around 1000 continuous measurements from the turbines are fed into a central research archive."

Schmid goes on: "A number of the current approaches to harnessing wind energy on the high seas appear promising. However, we must continue to integrate the knowledge we gain from practical experiments into future research and development so we can further develop this technology, which is still relatively new." Wind energy will then be able to play an even bigger part in meeting Europe's power requirements. ■

How to plan solar power plants

The photovoltaics industry is booming, and the market for solar farms is growing quickly all over the world. Yet the task of planning PV power plants to make them as efficient as possible is far from trivial. Fraunhofer researchers, working with Siemens Energy Photovoltaics, have developed software that simplifies conceptual design.

Text: Britta Widmann

The share of renewable energies in the overall energy mix is rising rapidly worldwide. With three-figure growth rates, photovoltaics (PV) play a major role. According to market research organizations, the PV market grew by 139 percent in the year 2010. Germany is among the world's leaders in this technology, which uses solar cells to convert sunlight straight into electrical energy. Yet the task of planning large-scale PV power plants spanning several square kilometers is a complex one.

With customer specifications, regulations and government subsidy programs to consider, designers must also account for numerous other factors including weather, climate, topography and location. These factors, in turn, influence the selection and placement of the individual components, including the PV arrays with their solar modules, inverters and wiring, not to mention access roads. Until now, engineers have designed solar power plants using CAD programs, with every layout and every variation painstakingly generated separately. This is a very time-consuming approach. To improve a planned power plant in terms of certain criteria, or to compare different concepts with one another, oftentimes the entire planning process has to be repeated.

Several hundred plant designs at the push of a button

In the future, this approach will be improved considerably: researchers at the Fraunhofer Institute for Industrial Mathematics ITWM in Kaiserslautern, in collaboration with Siemens Energy Photovoltaics, have developed a new planning software that makes it possible to build solar power plants better and more quickly.

"Our algorithms programmed exclusively for the Siemens PVplanet – PV Plant Engineering Toolbox – software provide engineers with several hundred different plant designs in a single operation. It takes less than a minute of computation time," ITWM researcher Dr. Ingmar Schüle points out. The only user inputs are parameters such as the topography of the construction site and the module and inverter types that will be used. The user can also change a number of parameters – such as the orientation, spacing and inclination of the solar arrays – to study the impact on the quality of the planning result.

Cost estimates and income calculationsincl uded

To evaluate the designed PV power plants, an income calculation is performed that includes a simulation of the weather in the region in question, the course of the sun throughout the year and the physical module performance including shading effects. With the results of this computation and an estimate of the investment and operating costs, the planning tool can come up with a figure for the LCOE (levelized cost of energy). By comparing the plant with a large number of similar configurations, the planners can investigate the sensitivity of the various parameters to find the right solution from a large array of options.

"The software assists the expert with decision-making and helps with the design of the best possible PV power plant for the site involved. Which one is 'best' depends on a number of aspects – from the customer's objectives to the site and environmental conditions, but also on the financing concept and the financial incentives for photovoltaics in the target region. All of these criteria are taken into account," Schüle points out. Dr. Martin Bischoff, project manager at Siemens AG, Energy Sector, is also convinced of this approach: "Aside savings, more than anything else the planning tool provides an overview of the scope for optimization. This provides the best possible support for planning the most cost-efficient systems. There has been no other planning software with this scope or level of detail until now." ■

Huge PV Power Plants like the Solarpark in Les Mées, France, can be planned faster and more efficient in the future. © *Siemens AG*

Sailing with nerves of glass

In the world of racing, tiny details can be the difference between victory and defeat. It is no wonder, then, that manufacturers of racing yachts are always on the lookout for new technologies to optimize boats and sails. An ingenious new sensor technology now helps them to extend the boundaries of what is possible.

Text: Monika Weiner

The constant hunger to break new records has turned boat building into a high-tech business. The racing yachts that compete at the major international regattas today are sporting machines designed to reach top speeds, with hulls and masts made of carbon fiber, thin membranes for sails, and not an ounce of convenience onboard. The process of optimizing the boats has been ongoing for decades. However, just a short while ago it looked as if a limit had been reached. On the fifth leg of the Volvo Ocean Race in spring 2012, from New Zealand to Brazil, only one of the six teams reached its destination without technical problems – all the others were forced to either take a break from the race or give up altogether. The ultra-light yachts were worn down by heavy storms and swells. There were cracked hulls and broken masts and sheets. The regatta became a war of attrition. And yet the yachts that took part in the race are the best in the world. "These boats are very well constructed," affirms Ian Walker, skipper of the Abu Dhabi Ocean Racing team. "I just think we put too much strain on them, and since they are so rigid and so light it's hard not to believe that they ultimately must break."

So how do you build yachts that are faster than the wind and yet stable enough to withstand the harsh conditions on the high seas? Boatbuilders and sailmakers throughout the world are currently searching for solutions.

Back on course with sensor technology

A new sensor system from the Fraunhofer Institute for Telecommunications HHI can help to detect weak points on time and warn yachtsmen when breaking point has been reached. Prof. Wolfgang Schade and his team in the Project Group for Fiber Optical Sensor Systems in the German town of Goslar have developed "nerves of glass" which can measure the forces that act on hulls, masts, and sails. The technology was actually developed for monitoring wind turbines, where rotor blades and cables are exposed to high loads. "With fiber optic sensors, we can detect, say, delaminations and even cracks at an early stage – long before a part breaks or fails," explains Schade. Until now, strain gages have been the most common monitoring instrument. Because they are electric, however, they are prone to interference during storms. In addition, installing them is a costly, time-consuming business, as you have to lay hundreds of cables. As Schade explains, "Fiber optic sensors are better suited to the task. You only need one fiber optic cable – which is comparatively easy to install – in which dozens of sensors can be fitted. Because there is no electric current, lightning cannot upset the system."

The centerpiece of the new technology is "fiber Bragg grating", microscopic structures that are integrated in the glass fiber at defined intervals and which alter the refractive index. Light racing through the glass fiber is reflected by these lattice points. The wavelength of the reflected light depends on the distance between the microscopic structures: every stretching or compression of the glass fiber alters the wavelength. To be able to measure the reflectance spectrum quickly and cheaply, the Fraunhofer researchers developed a mini-spectrometer, which consists of a chip that splits light into various frequencies. By analyzing the frequency spectrum, the scientists can draw conclusions about the forces currently acting on the glass fiber.

The idea to use the measurement technology on sailboats came to Schade, himself a keen sailor, during a voyage in the fall of 2010. "Sailing is all about making best use of the wind and being as fast as possible. At the same time, you also have to avoid pushing the equipment beyond breaking point. Fiber optic sensors can help to determine the forces acting on hulls, masts, and sails during the journey in real time." Theoretically, boatbuilders and sailmakers can use such a measuring system to improve their designs. The sensor technology can also be used to determine the optimal trim for the given tack and wind strength.

Faster than the wind

A few months later, Schade was able to supply practical proof that fiber optic sensors were up to the task of advancing the sport of sailing. At the Düsseldorf boat fair he met Jens Nickel, who runs a sail workshop in Stade in northern Germany. Nickel was keen on the idea of optimizing sail design using the new measuring technology. For many years the sailmaker had been experimenting with new materials and shapes. But he had no way of measuring the material stress at sea. In collaboration with the sailcloth manufacturer Dimension-Polyant, a web of glass fibers containing 45 measuring points was fitted to a mainsail and a genoa in Nickel's workshop. Measurements were then conducted on the sails on a test journey. The results surprised both the sailmaker and the researcher. "It turned out that the tension in the head, right at the top of the sail, was greater than previously assumed," says Nickel. "However, the strain on the clew, the lower aft corner of a sail, and on the entire leech area, the aft edge of a sail, was smaller than had been thought."

Nickel's sail workshop used the data right away to optimize how their sails are made. The sailmaker started reinforcing the areas that were subject to greater stress and using lighter material in the areas that were less stressed.

Schade and his team's next objective is to adapt the measurement technology so it is fit for use

Fiber optic sensor technology for competitive sailing. © *Fraunhofer HHI*

in competitive racing. "We have now fitted sail battens with fiber optic sensors, which will help competitors in future to find the optimal trim, i.e. the sail position at which the boat travels the fastest under specific wind and wave conditions," explains Schade. Fine adjustments in trim can be the difference between victory and defeat in competitive sailing. For the first time, the fiber optic sensors and the connected measuring equipment – which is no bigger than a cigarette packet and contains an LED light source, spectrometer, and electronics – are supplying reproducible values. This data tells the crew in which areas there is too much or too little pressure, or how stresses shift to different areas, for example when the sheets are pulled in tighter. The results provided by the new sensor technology will be accessible everywhere on board at all times – Schade's team has already developed an app that allows crew members to access real time data from their smart phones. The new measuring system will be launched shortly under the name NextSailSystem.

Fraunhofer researchers are also installing fiber optic sensors in the masts of racing yachts. "During manufacture, glass fibers are easily inserted into the carbon fiber laminate, where they are sheltered against wind and weather," explains Schade. When the yachts are in action, the glass fibers supply information on how much the mast is bending at specific points. The values are of interest to sailors for several reasons: on the one hand, because the bending of the mast affects the sail position; on the other hand, because the mast can break when put under too much strain. The sensor system helps sailors to find and reproduce the optimal trim and warns them when the strain on the mast is becoming too great.

The technology is currently undergoing an endurance test aboard the "Shockwave". The American racing yacht was equipped with sensors in the mast along with the corresponding measuring technology. This equipment will collect data during upcoming regattas and help the crew to find the sail position that allows the boat to move the fastest under the given wind and swells – without running the risk of masts and sheets breaking. ■

Preventing gridlock

Overcrowding on buses and subways, traffic jams stretching back for miles - daily traffic chaos has long been the norm in many big cities. Megacities with upwards of ten million inhabitants often teeter on the brink of total gridlock. Researchers in China are currently studying how it can be prevented in the long term.

Text: Monika Weiner

Five million people currently live in Hefei. The population is predicted to double in just a few years. © *Hefei City*

China is booming. The magnetic pull of the country's industrial centers is drawing in millions of people. In many major cities, the population has increased tenfold within a few years, with new housing developments mushrooming on their outskirts. The transportation routes connecting these developments with the city centers are jammed around the clock. In Beijing and Shanghai, it is not uncommon for traffic jams to last for days. As in many megacities, total gridlock threatens.

Hefei is to be different. The capital city of Anhui Province, 200 kilometers west of Shanghai, is preparing itself for a great leap. The current population of "only" five million people is set to double to ten million over the next eight years, which will put Hefei in the megacity bracket. Given the phenomenal scale of this development, the Chinese central government wants to leave nothing to chance. The boom in Hefei, which has been an industrial center since the 1930s, is being planned and executed with military precision. Where a short time ago farmers cultivated their paddy fields, the bulldozers have moved in. They are building three- to four-lane roads, along which high-rises are constantly shooting up. These developments are still ghost towns, but soon thousands of people are expected to move in.

For city planners, designing a megacity from the drawing board is both a huge challenge and a unique opportunity. Here you can learn from the mistakes of the past, develop new concepts, implement them, and within a few years actually see how well they work. Fast bus lanes are being constructed in Hefei, along with radial roads with no traffic lights, where traffic is directed over bridges at intersections. In addition, there are plans for an intelligent urban transportation system that allows rapid transfers between

buses and subways, as well as a traffic management system that minimizes the emission of air pollutants. This is a unique opportunity for scientists and engineers to test and put into practice new technologies on a large scale. With its centrally planned economy, China offers an extraordinary testing ground for research.

Planned economy as an opportunity

Hefei is also an El Dorado for the German experts who are providing support to city planners

on various continents as part of the Megacities project of the Federal Ministry of Education and Research. "Here we can test our developments in another climate, in another culture, and on another scale," says an enthusiastic Matthias Schmidt, Research Manager Distributed Embedded Systems at the Fraunhofer Institute for Computer Architecture and Software Technology FIRST in Berlin. He has already visited the Chinese city several times along with experts from the Wuppertal Institute, Freie Universität Berlin , the Frankfurt-based architects Albert Speer & Partner GmbH, the engineering office LUAX, and the German Aerospace Center DGLR. "The municipal government, environmental protection agency, and the police, who are responsible for traffic issues, are very interested in cooperation. Moreover, the Chinese Ministry of Science and Technology supports the project, which we are carrying out together with various Chinese universities and partners," adds Schmidt.

As part of the project, 600 taxis were recently fitted with sensor systems, which enable them to constantly detect the current traffic situation. They transmit their position and speed around the clock to the traffic management center, where the "floating car data" is correlated and evaluated, creating a complete picture of the current traffic situation. In Hefei there is the opportunity to adapt the system to the needs of a megacity for the first time. "It is thought that 8000 vehicles will be collecting floating car data by the end of 2012," reports Schmidt. "We are very excited about the study, because it allows us to test and improve our model calculations."

The insights the researchers are now gaining in China will also benefit Europeans in future. The FIRST team is involved in developing a new standard for collecting and transmitting traffic information. The old TMC (Traffic Message Channel) standard, which provided navigation devices with traffic congestion information, will shortly be superseded by the TPEG standard of the Transport Protocol Expert Group. This service is to provide drivers with more comprehensive and more precise information than previously available, because the traffic data can be generated at an unlimited number of points and combined with up-to-date information about the weather or local public transport.

Beyond borders

In Hefei, researchers are also investigating how changes in traffic flow affect the air quality. The modeling is based once again on the floating car data, which is correlated with the values from the weather stations. "The input for the computer model consists of the traffic data, i.e. how fast the cars are traveling, the current weather values such as wind or rain, and further parameters from the fleet of vehicles," explains Schmidt. "From this data, we calculate the transport emissions, such as particulate matter, nitrous gases, and CO_2. Combined with industrial emissions, which we also factor into the modeling, we can then predict air pollution levels in individual parts of the city. This is important for the authorities, who want to issue warnings – for example, on days with elevated ozone levels."

However, the simulations can also be used to produce long-term scenarios. Schmidt's team can calculate the percentage by which air pollution would decrease if, for example, all vehicles were fitted with catalytic converters or a certain portion of the population switched to using public transport: an ideal tool for city planners who want to peer ahead into the future.

The new computer models are already helping the authorities in Hefei to see the consequences of the growth of their city into a megacity, and they can investigate how traffic congestion can be prevented and air pollutant emissions minimized through new mobility concepts. "It will not only benefit the Chinese if they reduce their CO_2 emissions, but us too. After all, we all live on the same planet," concludes Schmidt. ■

Laser scan at full speed

For the first time a team of researchers was awarded with a special Fraunhofer prize for research of international impact.

Text: Beate Koch

Laser systems can be used to implement highly precise and ultra-fast measuring processes. Railway measuring technology has a huge worldwide need here. One prerequisite for its use is that nobody is damaged or suffers irritations by the laser. Dr. Heinrich Höfler and Dipl.-Ing. Harald Wölfelschneider from the Fraunhofer Institute for Physical Measurement Techniques IPM in Freiburg have worked with their team to develop a 3D laser scanner. It can be used outdoors without hesitation. Extremely fast and precise, it is able to spatially measure and monitor the position of the contact wire or the track from a train travelling at up to 100 kilometers (62 mph) per hour. If the scanner is stationary, it can capture passing trains and check for loads that might have slipped.

Heinrich Höfler explains how that works: "We send off a laser beam and wait until it returns. We measure the time in between and that tells us how far away an object is." The difficult part is capturing the returning beam. Often, only very little light comes back and what's more, the transmitted light beam is back in an extremely short space of time. The solution: A kind of slow motion. The laser beam is very rapidly switched on and off – modulated, as scientists would put it. The time shift of this modulation wave can be determined more quickly and precisely than is possible with a single laser pulse.

Capturing obstacles and constrictions during movement

The system measures, by default, one million times per second. "For Deutsche Bahn, we equipped a measurement train that scans the surroundings of the test track, using several laser beams and which delivers, taking four million measurements per second, a 3D image of what it scans", explains Harald Wölfelschneider. That allows even small obstacles and constrictions to be detected, or we can plan the route via which a heavy load can best be transported to its destination.

Another field of application is the measuring of passing trains. This requires the scanner to be permanently mounted, which, however, does increase the chance of someone looking into the laser beam for a longer period. To make the scanner safe for the human eye, the researchers had to harness a new wavelength range: infrared, which is harmless for our eyes. The consequence being that the entire system had to be fully reconfigured.

From railway to road – in global use

If we examine railways carefully, it makes sense that we then also examine other traffic routes, such as roads. The team at IPM has developed a 3D scanner, safe for the human eye, which is mounted onto a moving car and which scans the road from a height of about three meters. "We can now detect height differences of even 0.2 millimeters on the road, even at speeds of 80 kilometers per hour (approx. 50 mph)", says Höfler. This is the first scanner approved for this purpose by the Federal Highway Research Institute. It is to detect lane grooves, potholes and water drainage potentials.

The laser system has already been marketed and used successfully all over the world for rail traffic safety. Not only fast and precise, this system is also highly robust. In 2012 Heinrich Höfler and Harald Wölfelschneider received a special Joseph-von-Fraunhofer award for their internationally successful project. ■

Success with Fraunhofer

Roger Munday, technical director at Plasser Far East Ltd. was born in England, lives in Australia and works in Hong Kong for an Austrian company. Plasser Far East Ltd. Hong Kong covers all the technical requirements for the surrounding Far East Asian Region.

What is the scanning technology used for in Asia?

Roger Munday: "Here in Asia we have four systems. The first laser scanner was delivered to South Korea around 1996. It is used on a machine that was purposely built just for measuring the aerial contact line. The entire machine measures the vertical and horizontal position of the aerial contact line of the railroad system in Korea. The second system we have here in South Korea has the same purpose, but it's a machine that has more functions. The third one we use in Singapore is different. It's a laser system that measures the internal profile of the metro's tunnel system. The fourth one measures the aerial contact lines in Malaysia." "We use these systems a lot because they are good."

You witnessed the introduction of the system. What was your impression?

Roger Munday: "The first system we had in Korea was very not much more than a prototype but a lot of research was done before they delivered the system. After that there was an intensive follow up to find out all those things which are particular to our region. So I would say the researchers arrived with an excellent working system that is highly developed."

After all these years, what is your impression of Fraunhofer?

"I can only say that we've enjoyed an excellent working relationship with all the Fraunhofer representatives to have visited us in the Far East Asian region. We are fortunate to use well proven systems - and Fraunhofer's have certainly proved to be some of the most reliable. Dealing with Fraunhofer is always a positive experience."

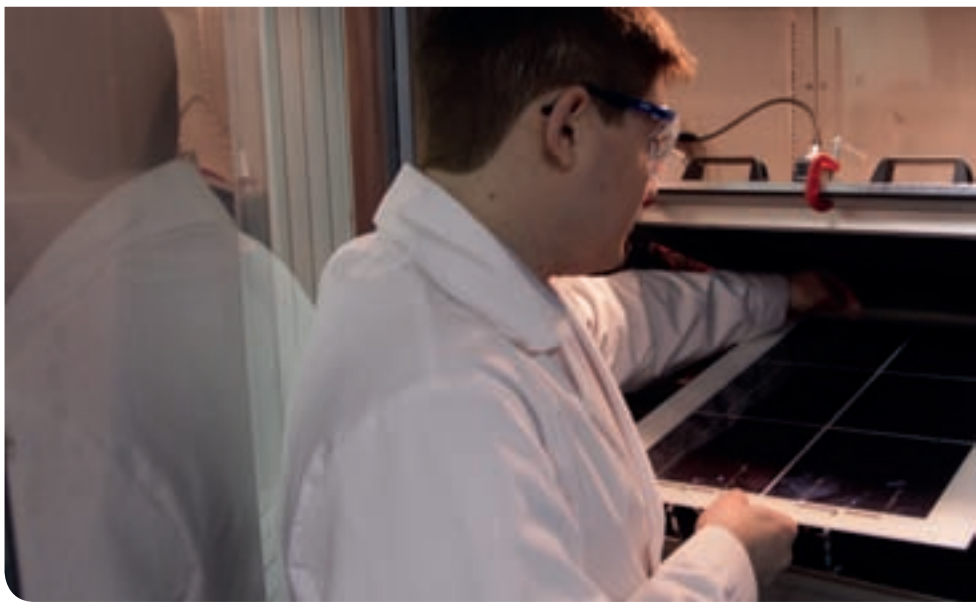
Dr. Heinrich Höfler and Dipl.-Ing. Harald Wölfeschneider (from left to right) with the 3D laser scanner that makes train tracks safer. *© Dirk Mahler / Fraunhofer*

Global application

Measurement of aerial contact lines
Korea
Hong Kong
Italy
Belgium
Baltimore (USA)
Netherlands
Romania
UK
Brazil

Measurement of clearances
Singapore
Serbia
Portugal

The laser system is not only fast and precise but also highly robust. *© Fraunhofer IPM*



In a mechanical test stand the researcher examines the quality of silicone-encased solar modules. © *Fraunhofer CSE*

Anti-aging elixir for solar cells

Photovoltaic modules deliver power without endangering the environment and climate. But solar power is expensive. Therefore, it is imperative that the modules last as long as possible, 25 years or more. Fraunhofer researchers in the USA are now investigating materials to protect solar cells from environmental influences to meet that goal.

Text: Monika Weiner

Sometimes it's just a couple of cents that decide the success or failure of a technology. As long as solar power, for instance, is still more expensive than energy extracted from fossil fuels, photovoltaics will not be competitive on the broad open market. "Power generation from solar energy continues to be reliant on public subsidies – this is no different in the USA than in Germany," explains Christian Hoepfner, scientific director of the Fraunhofer Center for Sustainable Energy Systems CSE in Cambridge, Massachusetts, USA. "If we want renewable energy to penetrate the global market over the long term, then we must ensure it gets cheaper."

Steady, resilient and watertight

There are no silver bullets to reach this target: Efficiency cannot be arbitrarily increased, and it is expensive to produce solar cells and modules. If you want to change something here, you have to solve a puzzle with many variables: Engineering teams around the world are searching for new technologies and production methods to make cells and modules cheaper, more efficient, more durable and reliable. One approach is for example to shift the electric contacts and interconnects to the back of the cell – that way no space is lost on the sunny side. This could drop the price per kilowatt hour by a few cents – which might sound like little, but with terrawatts of solar energy being produced during the next decades the cents add up to a meaningful number. So the search for new technologies to make cells better and cheaper continues. Silicone is one of the promising materials. Silicones are highly unusual substances – neither inorganic crystal nor organic polymer – but related to both. The synthetic combination of silicon, oxygen and organic polymers was discovered at the beginning of the 20th century by English chemist Frederic Stanley Kipping. Pretty soon it became clear that the physical traits of "organosilicon compounds" could be strongly influenced by the selection of the chemical ingredients. It is this flexibility that made silicones so successful. While PV modules have been encapsulated with silicones, until now, however, they were not widely used for laminating solar modules. Lamination is a protective coating that surrounds the fragile silicon wafer. Today most manufacturers of photovoltaic cells use ethylene-vinyl-acetate, or EVA for short.

In order to determine if silicone could replace the ethylene-vinyl acetate a team of experts worked together: researchers from Fraunhofer and from Dow Corning Corporation, the world's largest manufacturer of silicones used in medical technology, cosmetics, the automotive industry, paper processing and electronics. The scientists coated photovoltaic cells with liquid silicone. "When the silicone hardens, it encases the cells; the electronic components thus have optimal protection," says project manager Rafal Mickiewicz. The experts at CSE constructed prototypes from the silicone-laminated cells, and analyzed these photovoltaic modules in a climate chamber at low temperatures and under cyclic loads. Afterwards, the module performance was tested with a light flasher. In addition, the researchers used electro-luminescence-imaging for the detection of micro cracks. A comparison of the results with those of conventional solar modules proved that silicone-encased photovoltaic modules are more resistant to cyclic loading of the type modules experience in strong winds, in particular at a frosty minus 40 degrees Celsius.

"Dow Corning Corporation collaborated with researchers at the Fraunhofer CSE Photovoltaic Modules Group for two years. This collaboration significantly improved our understanding of the materials requirements of our solar modules, particularly in regard to sustainability and output," concludes Andy Goodwin, Global Science & Technology Manager, Dow Corning Solar Solutions.

In the meantime, the tests were published at the 26th European Photovoltaics Solar Energy Conference in 2011. "The study results demonstrate that silicone lamination is well-suited for certain applications, because the silicone protects the fragile components on the inside well, and moreover, withstands severe temperature fluctuations. With this technology we can, for instance, make modules with thin solar cells more robust," concludes Mickiewicz. ■

Detecting defects in ship propellers

Ship propellers are as large as a single-family home - and manufacturing them is quite a challenge. During the casting process, pores and miniscule cracks can form that in the worst case may cause a blade to break. Now these massive components can be inspected for defects in a non-invasive manner, using a new kind of ultrasound process.

Text: Britta Widmann

They can weigh up to 150 tons, and it's not uncommon for them to measure nine meters or more in diameter: the ship propellers on huge tankers, container ships and cruise liners are invisible giants. Damage to these massive propellers could render a ship unmaneuverable – with unpredictable consequences for people and the environment. Many defects do not come from external influences, but instead originate in the production or repair process. For example, when the molded parts are being cast, any turbulence could lead to sand inclusions and pores. Left undetected, critical imperfections could lead to breakage of a blade.

Until now, propellers have been inspected manually for inner defects when necessary. To make them visible, the inspector guides an ultrasound test probe over the component by hand – an error-prone procedure that fails to capture the entire volume of the component. This method cannot detect cracks inside the propeller in certain circumstances. To identify defects in a timely manner, researchers at the Fraunhofer Institute for Industrial Mathematics ITWM developed a mechanized ultrasound process that can be used for the non-destructive testing of complex components. The scientists received support from the Germanischer Lloyd, GL Group, and propeller manufacturer Wärtsilä Propulsion Netherlands.

Mobile scanner can be positioned freely

"With our mobile ultrasound test system, we can inspect copper-nickel-aluminum bronzes up to 450 millimeters thick and detect fissures down to a few millimeters in length. Because we emit the ultrasound at defined angles, we also find defects positioned at an angle to the surface", says Dr. Martin Spies of ITWM in Kaiserslautern. The system is capable of recording large volumes of digitized ultrasound test data, taking into account the many and variously intense curvatures of the propeller surface. The device currently scans test grids of 700 by 400 millimeters, achieving a rate of up to 100 millimeters per second. The mobile scanner can be positioned anywhere on the propeller, and, thanks to its suction feet, it can be attached in a horizontal as well as vertical test position. "We obtained the 3D data about the inside of the component by an imaging procedure known as SAFT. It provides a detailed display of inclusions and welding-seam defects. It basically works like computer tomography in medicine," explains Spies.

With the aid of special computational processes and algorithms, the experts have succeeded in reducing interference signals and intensifying error signals – a complicated task, since the various areas of the blade do not have a homogenously coarse grain. This can weaken the echo substantially. The specialists also use simulations to calculate in advance which ultrasound test probe they have to deploy.

The researchers use the mobile scan system for their on-site testing at foundries, at propeller manufacturers, on deck and in dry dock, and are currently improving scan times and 3D defect imaging. Only recently, they were able to put the efficiency of their procedure to the test at the world's largest shipbuilder in Korea. "The customer wanted to document the quality of its propellers, to gain an edge over the competition," says Spies. "With our procedure, we can test not only propellers but also other complex components made of materials that are difficult to test, like offshore components made of duplex steels," he stressed. ITWM researchers Alexander Dillhöfer, Hans Rieder and Dr. Martin Spies recently received the Innovation Award from the Deutsches Kupferinstitut for their outstanding accomplishments with copper and its alloys. ■

Suction feet are used to attach the mobile scanner to the propeller. Researchers record the ultrasound test data on-site.

Software for the future

Brazil is the sixth-largest economy in the world and one of the fastest growing major markets. The country has a progressive technology sector and is developing everything from submarines to airplanes. It has also been home to a Fraunhofer project center since March 9, 2012. The new center is located in the Technological Park of Bahia, where it has IBM, Portugal Telecom Innovation, and several large Brazilian firms for neighbors. It is a joint initiative of the Federal University of Bahia (UFBA) and the Fraunhofer Institute for Experimental Software Engineering IESE in Kaiserslautern.

The Brazilian and German researchers working in the new project center are developing software and system solutions for critical and large systems, decision support and data analysis, mobile business applications, e-government, ambient assisted living, and others.

Establishment of the project center has opened up the Brazilian market for software and system technologies to the Fraunhofer-Gesellschaft.

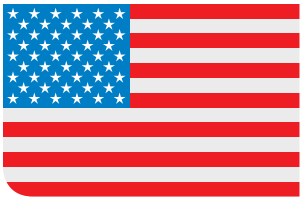
The soft energy path

It will only be possible to meet energy demand in the future with renewable sources. Solar, wind, and hydro power harbor huge potential – it is just a question of knowing how to tap it. Fraunhofer and the University of British Columbia in Vancouver have decided to join forces in the quest for solutions and recently signed a memorandum of understanding.

The two research institutes want to discover how energy can be generated from biomass on a large scale and how electrochemical energy conversion can be improved in electrolytic and fuel cell technologies. They also plan to investigate the conditions under which hydrogen can be used as a universal and renewable energy source.

To carry out these investigations, the Fraunhofer Institute for Solar Energy Systems ISE in Freiburg will be working in close cooperation with the university's Clean Energy Research Centre (CERC). The focus of the CERC's research is on optimizing existing energy technologies such as fuel cells and clean combustion, as well as developing new sustainable energy sources further, including hydrogen and bio fuels.

"We want this research project between Germany and Canada to be a beacon that will be seen within and beyond the borders of the two countries," says Fraunhofer Senior Vice President Prof. Ulrich Buller.



Harnessing wave power

Two thirds of the Earth's surface is covered in water, and this water represents a significant source of energy. Every ocean wave is a mini energy storage device which is charged by the wind. Researchers at the Fraunhofer Center for Manufacturing Innovation CMI in Boston, in collaboration with colleagues from the Fraunhofer Institute for Production Technology in Aachen, have now come up with a new method of converting wave energy into electricity – using mobile harvester ships to collect and store their electrical energy.

The researchers' design features floats, or 'harvesters', placed in the water to port and starboard of the ship and connected to it by hinged arms. These harvesters rise and fall with the motion of each passing wave, creating movement that can be converted into electricity, which can then be stored in on-board batteries. The stored electricity is available for use as soon as the vessel returns to port, and can be fed into the power grid at times of peak consumption.

This type of wave energy harvester has the advantage of being extremely flexible: Ships can travel to wherever the waves are of optimum height and the yield will be greatest, and they also eliminate the need for expensive undersea transmission lines. Andre Sharon, Director of the CMI, estimates that these vessels should be able to produce electricity at a cost of 15 cents per kilowatt-hour – no dearer than that currently generated by offshore wind turbine units.

New cancer diagnostic

In the western world, more and more people are developing aggressive forms of skin cancer that quickly metastasize. The early detection of malignant changes in the skin is a key factor in increasing the chances of recovery.

An international team of researchers working on EU project SKINSPECTION has now developed a new medical imaging technique that is designed to help dermatologists with diagnoses in future. The suspect section of skin is "irradiated" while sensors measure the acoustic waves emitted by the tissue. Using specially developed algorithms, a detailed image of the tissue can be created from the results. This image allows the physician to detect changes not only on the surface but also inside the skin.

The know-how for the new diagnostic system comes in part from Imperial College London and the Fraunhofer Institute for Biomedical Engineering IBMT. Several private sector companies were also involved in developing the system. The new technology's ability to correctly diagnose tumors is currently being tested in a first clinical trial in the United Kingdom and Italy.

Year of science

Fraunhofer researchers already cooperate with scientists and engineers from South Africa on a wide range of joint projects. Current initiatives include cleaning water with the aid of diamonds, developing new alloys, elaborating recycling concepts for reclaiming rare earth metals, and operating a mobile laboratory for diagnosing HIV and tuberculosis.

The experts are hoping to cooperate even more closely in the future. At the inauguration of the German-South African Year of Science in Cape Town, which was attended by key figures including German research minister Annette Schavan and her South African counterpart Naledir Pandor, numerous Fraunhofer Institutes took the opportunity to present their projects.

"More than ten Fraunhofer Institutes are already active in South Africa or have expressed a strong interest in working there," notes Dr. Eckart Bierdümpel from the International Business Development department. "In Sub-Saharan Africa, South Africa is the country that offers by far the best infrastructure and highly qualified researchers. So it is seen as an excellent gateway to the South of the continent."

Profit with saving water

Clean drinking water is essential to life – yet in many areas of the world it is a scarce commodity. Providing adequate water supplies to major conurbations has become an increasingly challenging and expensive task. Fraunhofer researchers are now working on finding new solutions.

Scientists at the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB in Stuttgart have developed a method of drastically reducing the amount of water people consume. In their 'Decentralized Urban Water Infrastructure Systems' project each house has two water supply pipes – one to provide the occupants with valuable drinking water, and the other to supply treated rainwater for washing, showering and watering plants.

The heart of the system is a series of fully-mixed anaerobic bioreactors which treat the wastewater without aeration or oxygen and convert the organic constituents into biogas, which can be used to provide power and heat. The purified wastewater produced by this process is still rich in inorganic nutrients, which makes it suitable for use as a fertilizing solution in irrigation.

The concept is not only intended for remote villages – it is also of interest to megacities, as the researchers are currently demonstrating in China. As part of the project 'Advanced wastewater treatment in Guangzhou', the researchers are developing a strategy for supplying water to the industrial park of the city of Guangzhou in Guangdong Province.

European Platform

Top-tier industrial concerns and research institutes have joined forces to boost Europe's position in the competitive global market. Together they are establishing a European Technology Platform for High-Performance Computing, known in short as ETP 4 HPC.

High Performance Computing (HPC) can be used to model highly complex processes, create optimum designs and perform scientific analyses. Applications for HPC include forecasting the weather and predicting climate change, producing safe and energy-efficient vehicles, and developing new materials. Various systems combining hardware and software are already commercially available, with most of them stemming from the USA and Asia.

Researchers are currently working on the next generation of systems which will be even faster and more powerful. With the aim of keeping Europe one step ahead of its international rivals, more than a dozen prestigious companies and research institutions – including Fraunhofer – have now joined forces and developed an ETP 4 HPC strategy.

They have also appealed to the European HPC community to close ranks and join the initiative. It is expected that funds will be available to develop the new technologies as part of the next European funding program, Horizon 2020.

Cooperation with Carnot

Fraunhofer researchers and experts from the French Carnot Institutes are keen to continue their close cooperation in the future. Binational teams of researchers are already collaborating on nine new projects from the fields of microelectronics, material sciences, life sciences, energy, and information and communication technology.

Examples include the NextGenPack project, in which experts from the Fraunhofer Institute for Process Engineering and Packaging IVV are working together with the Carnot Institute 3BCAR in Montpellier to develop a new generation of packaging for fresh produce: As well as being made from renewable resources, the packaging materials are also biodegradable and have antibacterial properties.

Researchers and engineers from Fraunhofer and Carnot have spent many years working closely together with the goal of developing marketable products. Currently there are 26 joint projects running. "The next step is to create long-term strategic partnerships on the basis of the joint funding program," says Volker Tippmann from the Fraunhofer research planning team.

Pioneering building

Americans have always needed a lot of power to heat and cool buildings. But, as elsewhere, energy is getting more and more expensive in the US. As a result, technologies that help to save energy are in demand. In the building innovation center in Boston's Seaport District, Fraunhofer researchers are showing just what can be achieved with innovative building and insulating materials.

Text: Monika Weiner

The old factory in Boston is now an energy-efficient living lab.
© *Fraunhofer CSE*

The Partners

The reseachers in Boston cooperate with

- Fraunhofer Institute for Solar Energy Systems ISE
- Fraunhofer Institute for Building Physics IBP
- Fraunhofer Institute for Industrial Engineering IAO

Just a few months ago the 5 Channel Center brick building in Boston resembled a ruin: windows broken, banisters rusted, plaster peeling off the walls, seagulls nesting on the roof terrace. The old factory had been empty for ten years. "The property looked completely run-down, but the foundation and interior structure – beams and brick walls – were still in good condition," recalls Nolan Browne, Managing Director of the Fraunhofer Center for Sustainable Energy Systems CSE. He was excited about the property from the first time he visited it. "The location is ideal. Channel Center is near the research areas in Cambridge and is part of the Innovation District, where Boston's Mayor Thomas Menino has encouraged CleanTech companies and others with forward-looking ideas to settle. The new Boston Convention Center behind the new property attracts a lot of visitors and the new hotels and bars on the waterfront are the new hot spot of Boston's entertainment scene. Also very important is the direct subway connection to MIT, which will remain a primary partner in our endeavor here."

In order to transform the old factory into a modern living lab, Fraunhofer researchers had to renovate the building from the ground up. This was no easy task, as the 100-year-old brick building has landmark status. All alterations made to its exterior required approval from three different historic committees and the local neighbors. "There is nothing quite as frustrating as getting the go ahead from the neighborhood and a thumbs up from two historic preservation authorities only to be blocked by the third. But in the end we got the job done and I think all parties are very happy with the outcome."

Living Lab for energy-efficient construction technologies

The renovation was a real challenge for the Building Energy Efficiency team at CSE. For months, Nolan Browne and his team weighed up the advantages and disadvantages of different building materials, drew up construction and project plans, and negotiated with authorities and industrial customers. Meanwhile, the ruin was being transformed into an energy-efficient building with a façade test and solar array next to it, windows that generate electricity, walls that absorb heat and emit it into the interior of the building when required, floors that help to air condition the rooms, and intelligent lighting that only supplies as much light as is actually needed at a given moment, depending on the weather and time of day.

Meanwhile the construction work on the pioneering building is finished – a living laboratory where building technologists will work together with industrial customers to develop new strategies that can dramatically reduce energy consumption in homes. It is the first building innovation center in the United States where new technologies will be developed in full-scale and can be tested under real conditions. To complete this jewel of energy efficiency some 27 million US dollars were spent, including nearly four million dollars of donated systems and labor from industrial partners.

The new technologies – e.g. vacuum insulated panels, floor heating, building management systems – were installed throughout the building. In the multimedia data center on the first floor of the 5 Channel Center, visitors can investigate how it works.

Technologies for a growth market

There has never been a building information and research center like this in the US before. In fact, until recently there has not been much interest in the subject of energy efficiency. Although energy is now expensive by American standards, it is still much cheaper than in Europe. Moreover, there is a lack of legislation making energy efficiency mandatory or even attractive. However, with resources becoming scarcer, the introduction of numerous incentive programs by utilities and expected regulation from both the federal government and the Commonwealth of Massachusetts, technologies that help to save energy will begin to attract interest. Until now there has been little awareness of the possibilities offered by modern, intelligent materials and building technologies and how much money they can save over the long term. "When materials are available that bring down energy costs to a level where the cost of investment is recouped in the medium term, then you will see demand go up," predicts Browne. "Then the markets will trigger a shift to energy efficiency."

Browne wants the living lab to give manufacturers an opportunity to present new products and also to improve them through cooperation with the team of researchers. This offer is not only appealing to American companies but European ones too. "Energy-efficient construction, for example, has long been an important issue in Germany. And there are huge reserves of know-how in this field, which could be used to help Americans with energy solutions, opening up a lucrative market worth billions to German and US joint ventures."

Measurements accelerate the mindset shift

On the sixth floor of the 5 Channel Center building, CSE researchers will be demonstrating that the new technologies – for example, insulating foil and solar windows – are genuinely capable of reducing energy consumption. The test center being set up there enables researchers to test whole sections of exterior wall and window façades. The wall has several large openings in which test materials can be inserted. "We have created a unique testing environment here. We can precisely monitor the behavior of building materials and systems during different times of the day and the year," explains Browne. Fraunhofer researchers also plan to test the temperature resistance, moisture resistance, and long-term durability of new materials and renovation methods in the new test center.

When outdoor tests under more sun are required – for example, if a customer wants to know how their insulating material behaves under the roof of a frame house – the CSE personnel in Albuquerque are on hand to help. On the grounds of the CFV Solar Test Laboratory, they have an open space of seven square kilometers, where model homes have been erected. In these homes, researchers can observe the behavior of insulating and building materials under extreme conditions – there are 300 days of sunshine every year. Those are ideal conditions to test whether the new materials keep their promise. ■

The light of the future

Bigger means more powerful is a rule of thumb that still applies to laser technology today: If your drilling, cutting or welding job needs a lot of power, then you need a big solid state laser. But now smaller lasers are finding their way into the spotlight, too: Researchers in an EU-funded project are busy preparing a new generation of fiber lasers for the markets of the future.

Text: Monika Weiner

Which products will be in demand in a decade's time? What tools will industry rely on to produce them? And which manufacturing techniques will be the most popular? Finding answers to these questions is far from simple. Some people might be tempted to trust their psychic abilities and a crystal ball, but Udo Klotzbach prefers to draw conclusions based on his discussions with customers: "I like to discover first-hand what people need. We can derive product development strategies from listening to what people want," says Klotzbach, who works as a researcher at the Fraunhofer Institute for Material and Beam Technology IWS in Dresden. "In microelectronics, for example, you have an ongoing trend towards miniaturization, so companies are desperately searching for new, faster methods of making the features on wafers smaller and smaller. In contrast, the photovoltaic business is all about achieving higher efficiencies: Photovoltaic manufacturing companies are searching for techniques that can help them improve semiconductor fabrication and minimize shadowing of the cell surface."

These kinds of goals can only be met using novel production techniques. Laser technology can be used to quickly and efficiently pattern features in the semiconductor layers of solar cells during the coating process itself. In microsystems engineering, laser light is already being used to replace time-consuming etching and structuring processes. One solution that is particularly cost-effective is to use flexible materials such as plastics to produce microchips that can be printed in large quantities using a roll to roll process. This technique is already being used to produce RFID chips.

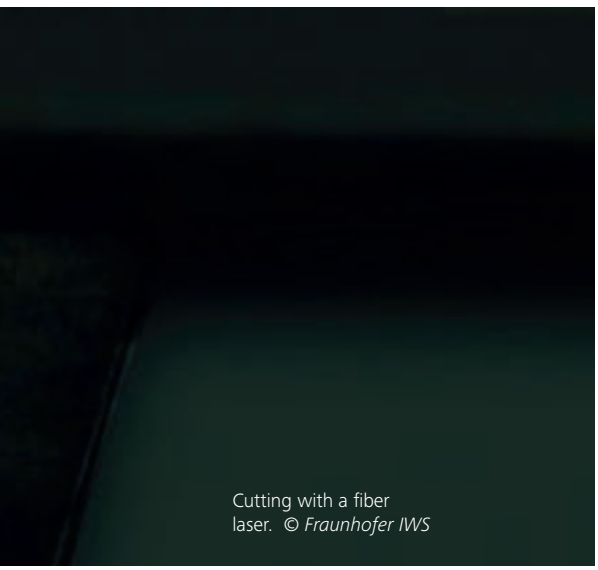
New technologies give rise to new products

"The manufacturing techniques that are putting down roots right now will provide the basis for developing a new generation of products," Klotzbach predicts. "We're already getting inquiries from customers who want to use the roll to roll method to produce larger films with microstructures." It is easy to see how these kinds of displays could pave the way for multiple different applications – for example cost-effective displays on advertising panels in subway trains and buses which could carry advertising, travel information and light entertainment programs; e-books that can be rolled up like a newspaper; or wallpaper printed with organic light-emitting diodes which light up rooms in the evening.

"Lasers will play a key role in manufacturing these kinds of novel products," says Klotzbach with conviction. For the past two years, he has been coordinating the EU project Leadership in Fiber Laser Technology, known for short as 'LIFT'. The goal of the 16 million euro project, which involves 22 research and industry partners, is to get fiber lasers ready to play their part in the markets of the future.

Fiber lasers in the fast lane

Fiber lasers have a number of advantages over solid state lasers. As well as offering better focus-



Cutting with a fiber laser. © *Fraunhofer IWS*

Germany:
Fraunhofer Institute for Material and Beam Technology IWS
Fraunhofer Institute for Applied Optics and Precision Engineering IOF
Rofin Sinar Laser
Dilas – The diode laser company
France:
European Photonics Industry Consortium EPIC Perfos
Eolite Systems
Quantel
3S Photonics
IxFibre
Switzerland:
Oclaro
Time-Bandwidth Products
United Kingdom:
Gooch & Housego
University of Swansea
SPI Laser
Finland:
Tampere University of Technology
Corelase
Italy:
Politecnico di Torino
Denmark:
Crystal Fibre
Sweden:
Optoskand
Israel:
Raicol Crystals

ing properties, they also require fewer components because some of the optical components can be incorporated in the optical fiber – plus they are lighter, smaller, easier to handle and cheaper. Yet their use in the production of cars, tools, microchips, biochips and solar cells is currently minimal, with fiber technology forming the basis of just one in every 10 industrial lasers sold worldwide. There are good reasons for this: Glass fibers melt when they get too hot, so fiber lasers cannot be used to generate the high levels of energy required for processes such as cutting and soldering sheet metal. Equally, fiber lasers cannot deliver the short wavelengths with high pulse peak powers which are required to produce microchips and biochips – or at least not yet.

The researchers working on the LIFT project are hoping to overcome some of these technical hurdles. "We can modify the design and create new optical fiber structures to improve the laser's performance, for example by making the fiber thicker and shorter or incorporating microstructures in the fiber which would enable high pulse peak powers," Klotzbach explains. The LIFT researchers are also hoping to develop fiber lasers that emit different wavelengths, giving users a choice between long-wave infrared, visible red, blue or yellow light and even short-wave UV radiation – all at the touch of a button. Plans are also underway to produce next-generation systems that would be capable of emitting ultrashort pulses.

"The ultrashort pulses produced by picosecond and femtosecond lasers open up a whole series of new opportunities in production engineering because they combine very high peak power with very short pulse duration. That makes them suitable for machining thermally sensitive materials with low heat tolerance which have a tendency to melt," says the project manager. Ultrafast lasers are an excellent tool for cutting or perforating films printed with microelectronic circuits or organic LEDs.

Speed boost from scanners

The LIFT researchers are also working on a novel beam deflection system designed to reduce the time it takes fiber lasers to process large surface areas. "A laser beam can process materials tremendously quickly, but the actual achievable speed is currently limited by the frequent repositioning of the laser," says Klotzbach. These changes of position are necessary because the orientation of the laser light must always be perpendicular to the workpiece. Current commercially available scanners for micro material processing, which use mirrors to steer the laser beam, can only guarantee this level of accuracy within a 10 square centimeter area. Once this area has been processed, the workpiece must be moved or the position of the laser must be changed – all of which takes up valuable time.

"This method simply isn't efficient enough to use in the microelectronics or photovoltaic industry where you need to process large areas," Klotzbach explains. "Those applications need a beam deflection system capable of processing at least one square meter without changing position." The researchers have already come up with one solution that uses a combination of a positioning system and a scanner system to steer the beam across the workpiece at an impressively rapid speed. Known as 'on-the-fly' processing, the solution uses a special lens system to ensure that the angle of incidence of the light always remains perpendicular to the workpiece even when processing large areas. "There is a definite trend towards laser applications for large surface areas – I predict that we will be processing whole rolls of film or wallpaper in the future," says Klotzbach. "The new beam deflection system will enable us to do that."

This new era should start sometime in August 2013 – at least that's when the EU project comes to an end and the researchers hope to present the first prototypes of their new, flexible, compact and powerful system. The idea is that the lasers of the future should be no bigger than a shoebox and should be easy to integrate into existing manufacturing processes. "That is exactly what customers want," Klotzbach emphasizes. He is convinced that these technical innovations will prompt a huge surge in demand for fiber lasers: "According to one study that we carried out at the start of the project, fiber lasers have the potential to take a 30 percent share of the global industrial laser market." That is one reason why Marcel Dierselhuis, a technical assistant on the EU project, sees fiber laser development as an important step forward for Europe: "The EU project is creating the conditions that European industry needs to participate in this global market in the future." ■

Smart lighting

Incandescent light bulbs will soon be relegated to history as museum pieces. The future of lighting technology is the LED. In the EU-funded En-Light project, researchers are investigating ways of using the new light source to save energy and – through integrated control electronics – create different mood-enhancing lighting effects.

Text: Monika Weiner

The Parathom Classic A75 Advanced, the first LED substitute for the 75W incandescent light bulb to be launched on the European market. © *OSRAM*

The incandescent light bulb, patented by Thomas Edison in 1880, is now an endangered species. It is condemned to extinction because it no longer meets the technical requirements of the 21st century. A conventional light bulb converts just five percent of the energy it consumes into light, while the remaining 95 percent is emitted as heat. Such inefficiency cannot be accepted in an age of rising energy prices and declining reserves of fossil fuels. In 2008, the European Commission issued a directive banning the manufacture and sale of frosted and high-energy bulbs in the EU member states. The directive is being implemented in gradual stages.

As a result, the old incandescent light bulbs are rapidly disappearing from the supermarket shelves and being replaced by a new generation of energy-saving lamps. Instead of using a heated filament to produce light, these new lamps work by creating an electrical discharge in a gas-filled tube. This process generates hardly any waste heat, and its energy efficiency is five times higher than that of conventional light bulbs. This alone enables high energy savings. And yet there is another light source that easily beats the performance of these compact fluorescent lamps. Light-emitting diodes, or LEDs for short, have a high efficiency, and are also smaller, more flexible, and offer far more scope for innovative lighting design solutions.

Lighting engineers have been working away for years to develop applications for this new technology. But they have still not found the killer application that would allow LED lighting to make the ultimate commercial breakthrough. If LEDs aren't illuminating our living rooms, offices and store windows yet, the reason lies, as so often, in the technical details. LED-based lighting systems consume less energy, but their manufacturing costs are relatively high and the light they produce fails to meet customer requirements. An interdisciplinary team of experts drawn from 30 European companies and research institutes is therefore participating in the EU's EnLight project, which aims to develop sustainable and energy-efficient lighting systems based on LEDs that emit light at frequencies compatible with human comfort requirements.

There is no patent recipe, because the drawbacks of LED lighting systems are determined by their physical properties. The tiny diodes are fabricated using a semiconductor material that emits light at a specific wavelength, depending on its band gap. To produce light consisting of more than one wavelength, more ingenious methods must be employed. For example, white light is created by combining LEDs emitting at red, blue and green wavelengths. An alternative solution involves the use of optically active films to modify the colors.

The researchers working on the EnLight project are currently developing methods to adapt LEDs' output to end users' lighting requirements. For example, a relatively cold light is required in the waking hours of the early morning, corresponding to natural sunlight, whereas in the evening a warmer lighting effect is preferred that imitates the warm glow of a candle.

Longer-lasting components

"To create truly intelligent lighting systems, there also has to be a means of reliably detecting the presence of people in the room, and their exact position," says Jens Döge of the Dresden branch of the Fraunhofer Institute for Integrated Circuits IIS. He and his team develop circuits with the necessary intelligence. "Existing automatic room lighting systems are controlled by means of movement sensors. But for them a person who is sitting still – for instance reading or watching TV – is effectively invisible." The presence detector that the Fraunhofer researchers are working on is also expected to be able to detect people who are not moving. The detector module consists of an image sensor and a connected electronic device. The completed system will be able to produce the appropriate light in all circumstances – depending on the time of day and the people present in the room. "But as well as functioning reliably in all situations, we also want our presence detection module to consume a minimum of energy, be cheap to manufacture, and be able to process data very quickly and efficiently," sums up Döge.

To ensure that the finished product is small, compact, and easy to use, Rafael Jordan and his colleagues at the Fraunhofer Institute for Reliability and Microintegration IZM are taking care of the component integration work: "We are developing packages that can be connected easily to the control electronics, or even have them built in." Another aspect that presents a challenge for the new technology is the components' heat resistance: "While LEDs convert 50 percent of the energy they consume into light, that still leaves 50 percent that is converted into heat, which needs to be dissipated," says Jordan. This is a real challenge for the engineers, because the amount of heat generated is huge compared with the tiny surface of the LEDs: The heat density of four watts per square millimeter is equivalent to that of the surface of the sun. Under such extreme operating conditions, the life expectancy of light sources and sensors is normally very low, as they melt very quickly. But the manufacturers want to commercialize reliable lighting systems. As part of the EnLight project, the Fraunhofer researchers at the IZM are therefore looking into new ways of dissipating the heat. One promising approach involves etching tiny holes in the substrate and filling them with a heat-conductive material, such as copper.

The engineers at the Fraunhofer Institute for Electronic Nanosystems ENAS in Chemnitz can tell in advance whether the new designs and manufacturing processes will be viable in practice, while they are still being developed. "We use computer simulations to predict their heat resistance and thermal load capacity. In this way, the most promising approaches can be picked out for further development," explains ENAS researcher Jürgen Auersperg. Once an LED sensor system has passed this theoretical test, Rafael Jordan's team at the IZM check whether it can produce the same results in real life. Prototypes of the modules are required to withstand numerous thermal shock cycles without the slightest damage.

Economizing with light

The widespread use of LED technology could help to save a huge amount of energy. In Germany alone, annual electricity consumption could be reduced by 11.5 billion kilowatt-hours using the present generation of LED lamps – that corresponds to the output of one large power plant. With the new, smart LED systems, the saving could be increased by 40 percent, or an additional 4.6 billion kilowatt-hours. According to calculations by the Fraunhofer researchers, the cost of switching to LED technology can be amortized in just a few years through the reduction in power consumption. So now nothing stands in the way of the conquering might of smart lighting technology. ■

Software development made easy

Newly developed digital tools enable you to model and analyze software for safety-critical components in devices or systems.

Text: Evdoxia Tsakiridou

As in other sectors, software development for today's automobiles is becoming more and more complex.
© *Fraunhofer ESK*

Machine control systems, medical devices, sensors, telecommunications systems, elevators, antilock braking systems … All around you there are invisible processors working away in conjunction with software. Our high-tech world could not function without these "embedded systems", which process data and control devices and systems.

Embedded systems are meanwhile taking over more and more safety-critical functions. This raises the bar for the safety and quality requirements they must meet. They are also faced with an additional challenge: the software is steadily becoming more complex while development cycles become shorter and shorter. This is why manufacturers need tools to be able to generate and test the software. Functional behavior such as braking or accelerating is not the only issue here; reliability and timing are also very important: Does the desired function step in at the right time moment? Specialists refer to this as the software's non-functional characteristics. To date, no satisfactory software tools and methods have been available for displaying and testing non-functional characteristics in suitable models. However, this is about to change. In the recently completed EU-funded CHESS project (Composition with Guarantees for High-Integrity Embedded Software Components Assembly), researchers and industrial partners have devised a methodology for the systematic development, modeling, validation, verification, and generation of software.

The Fraunhofer Institute for Communication Systems ESK is also involved in CHESS, with a focus on automotive applications. ESK computer scientists carried out research on the timing behavior of modules and functions and incorporated their results into the jointly developed tool chain for component-based software development. This combination of methods enables functional and non-functional characteristics to be displayed as models, so that the plausibility of input values can be validated before they are used to automatically generate the relevant software code.

Alongside formal test procedures, researchers use the ESK-developed tool DynaSim to evaluate response timing behavior. This makes it possible to both simulate and analyze the runtime model during the development period and to validate the software being developed in several stages. In other words, testing shifts back to an earlier development phase, namely from the coding to the modeling stage. The results from the simulation flow back into – and thus help to optimize – the development model. This allows errors and weaknesses to be identified and corrected at an early stage of development.

Improving quality

"Our goal was to optimize consistency and reduce complexity. The new tool allows users to improve the quality of the software while also reducing development costs for embedded systems," reports ESK scientist Alexander Stante. The new methodology can be used in a range of different sectors, including the telecommunications, railway, and automotive industries. ■

Spotting letter bombs

Bombs in letters or parcels pose a great threat. Post has to be checked not only at the premises of logistics companies, penal institutions and the authorities but also for private individuals at risk in their own homes. But at the same time, the confidentiality of communications has to be preserved. In contrast to the x-ray scanners currently used in certain situations, terahertz post scanners offer a universally applicable solution to the problem.

Terahertz radiation sits between microwaves and the far infrared on the electromagnetic spectrum. One of its great advantages is that it poses no risk to human health. What's more, the new scanners not only reveal the outline of what's in the post, they analyze its chemical makeup too, as this test method is able to identify molecules by their unique chemical fingerprint.

The compact, durable and versatile scanner was developed by metrology experts from the Fraunhofer Institute for Physical Measurement Techniques IPM in Kaiserslautern, in collaboration with Hübner GmbH in Kassel and IANUS Simulation GmbH in Dortmund.

The touchscreen displays the type and location of dangerous substances identified within the item of post. © *Hübner GmbH*

Solar helmet for the pistes

Whether you're looking for a solar-powered headset or stereo headphones for the ski slopes, solar helmets are the answer. An innovative technique now allows efficient and durable solar cells to be fitted to the curved helmet shape.

Smartphones or MP3 players can be connected wirelessly via Bluetooth, allowing skiers to receive calls and operate their MP3 player conveniently with the accompanying Bluetooth glove.

The greatest challenge facing researchers was how to fit solar modules to the curved surface of the helmet. Their answer was to develop a special production and encapsulation process that takes extremely high-grade monocrystalline silicon solar cells and splits them into tiny individual chips which are produced specifically to fit a three-dimensional, curved contour.

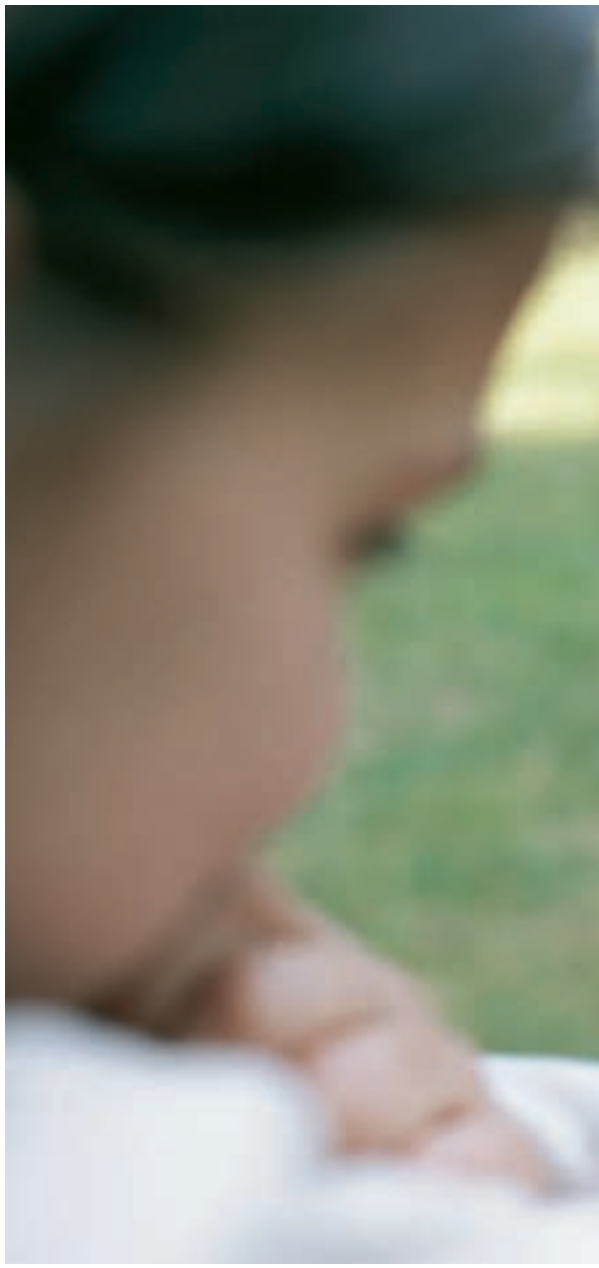
Even rucksacks, car body parts and other similar items can be fitted – or retrofitted – with such modules. When the helmet is not being used for skiing, it can serve as a charging station for mobile devices. The project is a collaboration between experts from the Fraunhofer Institute for Reliability and Microintegration IZM in Berlin, the Fraunhofer Institute for Solar Energy Systems ISE in Freiburg, the Technische Universität Berlin and the company TEXSYS.

When mounted on a ski helmet, the three-dimensional solar module is almost invisible. © *Fraunhofer IZM*

Knowledge of practical utility

Max Planck and Fraunhofer researchers are collaborating on numerous projects in areas such as bone and cartilage substitutes, automatic video analysis, and many more. Their goal is to accelerate the transfer of the latest basic research findings into new applications.

Text: Marion Horn



"The two research organizations have different ways of approaching things," says Prof. Martin Stratmann, Vice President of the Max Planck Society, discussing how the teams work together. "Max Planck primarily focuses on acquiring knowledge and insights, though it is certainly interested in the potential applications. In contrast, Fraunhofer focuses more on the demand for innovative products – yet it still performs excellent application-oriented basic research." Both organizations share an ability to deliver outstanding projects which meet the highest scientific standards while offering significant potential for innovation. These projects also enjoy strong financial backing, with each team receiving up to two million euros for a three-year period. "We already have 19 projects up and running," says Prof. Ulrich Buller, Senior Vice President Research Planning at the Fraunhofer-Gesellschaft. "The results of these projects help lay the foundations for our innovation-based society. The funding for these collaborative projects stems from the Pact for Research and Innovation, an initiative which includes a commitment from the German federal government and Länder to help expand networking and collaboration between research institutes in Germany."

Artificial tissue from autologous cells

One of the research teams is developing customized bone and cartilage substitutes. "We anticipate rising demand for implants in the future as populations age and people's bodies show more signs of wear and tear. We also see a trend towards more personalized medicine – in other words drugs and implants tailored to each individual patient," says Prof. Thomas Hirth, director of the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB in Stuttgart. He explains how this could work in practice: "If a patient needs a new hip joint, we begin by extracting adult stem cells from the patient. We then use a lab culture medium to develop these into cells which we can place on the surface of the implant. The key advantage of this method is that the body does not treat the material as a foreign object because it is coated with the body's own cells – so you eliminate the problem of rejection." Specialists are developing the new biomaterials for bone and cartilage in collaboration with colleagues from the Max Planck Institutes for Intelligent Systems and for Polymer Research and from two institutes at the University of Stuttgart.

"Where do cells feel comfortable? That's the key issue for us," says Hirth. "To answer that question, we look at how materials and cells interact. We imitate what nature teaches us to create optimum living conditions for cells outside the body. But lots of basic research still needs to be done in this area." The team of experts begins by analyzing how the cells' immediate environment affects them, looking at factors such as the chemical composition of the environment and whether it is hard or soft. Adult stem cells take numerous factors such as these into account when deciding what to become – for example choosing to be a cartilage cell. To recreate these processes, the Max Planck researchers have developed a biochip which is capable of reproducing different environments. Different materials are mounted on the chip – for example three-dimensional matrices of polylactic acid, a biodegradable and biocompatible polymer – and the cells grow on these structures to form the tissue. "This mini laboratory enables us to determine experimentally how the patient's cells behave. And the biochips also provide the basis for creating larger quantities of the tissue," says Prof. Joachim Spatz, director of the Max Planck Institute for Intelligent Systems. However, he expects it will take 10 more years of research before scientists can actually create these kinds of replacement parts.

Analyzing spoken language, facial expressions and gestures

Another of the projects – a collaborative venture known as AVATech – is at a more advanced stage, and many of its results are already being applied. Linguists are researching the fundamentals of communication by recording people's spoken language, facial expressions and gestures and then analyzing the resulting audio and video materials. "One of our primary goals is to docu-

A new software program makes it easier for linguists to analyze video recordings. © *MEV*

ment languages and knowledge for future generations. Every week one of the world's 6,500 languages becomes extinct, and we lose the cultural information enshrined in that language. But it is no simple task to keep hold of this knowledge as it slips away: We already have 200 terabytes of data to work through at our institute, the equivalent of 200,000 hours of video recordings," says Dr. Peter Wittenburg, technical director of the language archive at the Max Planck Institute for Psycholinguistics in Nijmegen. It is impossible for the experts to process this quantity of data using existing language recognition systems, which are generally designed for one specific language.

"That's where the Fraunhofer specialists' expertise really comes in useful," says Wittenburg. "Our Fraunhofer colleagues have spent years researching systems that enable people to use information more intelligently." Prof. Stefan Wrobel, director of the Fraunhofer Institute for Intelligent Analysis and Information Systems IAIS in Sankt Augustin explains their approach: "We are working with video experts from the Fraunhofer Institute for Telecommunications, Heinrich-Hertz-Institut, HHI in Berlin to develop the basic functionality you need to deal with several thousand languages. Our analysis process is based on very small word fragments which are used to compose words in multiple different languages." The Fraunhofer researchers' software uses these sounds to detect patterns in sound recordings. The HHI's contribution is a method for analyzing facial expressions and gestures – the scientists have adapted the required algorithms to enable the software to handle videos of differing levels of quality. Video annotation is a laborious process, but this multi-pronged solution reduces the time the linguists spend on this task by up to 70 percent.

The Fraunhofer software has already proved its credentials in the ARD media center (ARD Mediathek), a website that enables viewers to quickly research things they have heard on the news and other programs. Wittenburg is delighted with the positive spirit of collaboration among the researchers: "Our team offers the perfect combination of skills in basic research and applied science." ■

Easily digestible foodchain data

How many days was this yoghurt on the road? How fresh are these tomatoes? What is the provenance of this steak? Food chain management can provide immediate, reliable answers to these questions.

Text: Monika Weiner

Aiming to bring transparency to the life history of fresh and processed foods. © *istockphoto*

As the old saying goes, the customer is king, and food stores compete for his favor by offering a huge range of fresh produce each day, including apples from South Tyrol and New Zealand, tomatoes grown in Spain, Holland and Italy, milk, butter and yoghurt from cows grazing in the Bavarian Alps, Ireland, Bulgaria and Schleswig-Holstein, organically farmed meat, and fair-trade bananas.

The customer might be king, but the only information he has when choosing which product to buy is that printed on the packaging label. This information is limited, and doesn't necessarily state the country of origin, or how the fruit and vegetables, meat, and dairy products have been treated, processed and transported – at least not yet: but this situation could soon change.

The concept of food chain management brings transparency to the life history of fresh and processed foods. All the information needed to evaluate a product can be stored and retrieved whenever required. In this era of mobile communication, all the customer in the supermarket has to do is pull out a smartphone and scan the square QR code on the packaging. On the phone's display they can then immediately read the name of the farm where the animal that provided the veal chop was raised, the date on which the calf was slaughtered, the address of the meat-packing company, the maximum and minimum temperatures during transportation, and the date of delivery to the retail store. The place of production and cold-chain data of milk, yoghurts and cheese can be displayed in the same way. Smartphone users can even click to read other customers' opinions or compare prices.

A recent pilot project enabled Fraunhofer researchers to demonstrate that all these functions actually work. A group of chemists, physicists, packaging engineers, logistics specialists and computer scientists from six Fraunhofer Institutes had spent three years working on their food chain management concept. "In principle we can record the entire manufacturing and logistics chain for a food product. The data can be shipped at the same time as the product, enabling companies

to optimize their workflows and providing the end user with useful additional information," explains Dr. Mark Bücking, a researcher at the Fraunhofer Institute for Molecular Biology and Applied Ecology IME and spokesman for the Fraunhofer Food Chain Management Alliance. "The result is a win-win situation: Retailers and logistics companies save money, because fewer goods are spoiled on their way to the customer, and the latter benefits from greater transparency."

Tomatoes as guinea pigs

With cleverly designed sensors to capture measurements, RFID tags to store the data, and smart labels for displaying the information, the researchers are able to record and reproduce every single step in the manufacturing, processing and logistics chain for fruit and vegetables and meat. "We created an Internet platform to map all the interfaces," relates Dr. Volker Lange of the Fraunhofer Institute for Material Flow and Logistics IML. In the case of tomatoes, which served as the guinea pigs in the scientists' tests, there are about a dozen such interfaces: The fruit is harvested, loaded onto trucks and driven away, unloaded again, and packed. A robot places the packaged produce in cardboard crates, and stacks the crates on pallets. A transportation company collects the pallets and delivers them to the wholesaler, who then distributes the crates to the retail stores. The route taken by meat is no simpler: The farmer sends livestock to the abattoir, and then the carcasses are delivered to the meat processing plant, where the meat is cut and packed. The packaged meat is transported to the wholesaler in refrigerated trucks, and then on to the retailers. "The Internet platform shows us the precise points in the food chain where the quality of the end product is most at risk, and indicates which technologies can be used to counteract these risks," sums up Lange.

The necessary information is provided by sensors, some of which the researchers developed specifically for their pilot project. One of these is a new micro-optical ethylene sensor from the Fraunhofer Institute for Physical Measurement Techniques IPM, which measures the concentration of the ripening hormone in the air surrounding the produce during transportation. These measurements reveal a lot about the condition of the fruit or vegetables being transported: The higher the ethylene concentration, the riper the bananas, apples or tomatoes. "Until now it wasn't possible to obtain such measurements inside a truck or shipping container," says Prof. Jürgen Wöllenstein of the IPM. To check the ethylene concentration, he and his team use a light source that sends out pulses of infrared light and a detector that measures the reflected light. Because ethylene absorbs infrared light of a specific wavelength, the quantity of ripening hormone in the air inside the container can be deduced from the amount of light absorbed. The monitoring system based on the new sensor permits logistics companies to control the ripening process: A cleverly designed circuit forwards the information from the sensor directly to a smartphone. If the truck driver or the captain of the container ship receives a warning message in this way, they can take appropriate measures such as increasing the flow of fresh air into the refrigerated container. To verify the freshness of meat products, researchers at the Fraunhofer Institute for Reliability and Microintegration IZM have developed a scanner capable of measuring the concentration of bacteria on the surface of chops and steaks – without removing the packaging film. In the past, this kind of test took several days in a well-equipped laboratory. The new analysis device can do the job in a matter of minutes. It works by measuring the fluorescence caused by bacterial metabolic products.

Data invades the supermarket shelves

The data captured by these sensors – indicating the degree of ripeness or the presence of bacteria – are stored in a database and also in tiny devices known as RFID (radio frequency identification) tags attached to the crates in which the produce is transported. The smart labels, which contain additional sensors to measure the temperature and humidity, are another IZM development. "The RFID tags accompany the product throughout all stages of processing and shipment, allowing the data to be visualized at any time using an RFID reader," says Dr. Lange of the IML. "Wholesalers and retailers can then enable end consumers to access this information by placing a QR code sticker on the product and linking the QR code to the stored data."

The Fraunhofer researchers were able to demonstrate the viability of this solution in their food chain management pilot project. An iPhone app developed by Jörg Weidner and his team of researchers at the Fraunhofer Institute for Integrated Circuits IIS in Erlangen is used to read the QR code: the provenance of the veal chops then appears on the smartphone's display. "Our app is theoretically capable of displaying all of the information collected at all points along the production and distribution chain," says Weidner, but he suspects that this would only confuse the end consumer. Does this mean that our supermarket shelves will soon be drowned in data?

"All we have done is to create the technological framework. Experience will show which items of data retailers make available, and how often consumers make use of this information," says Bücking. "The new technology is of particular interest to food manufacturers who wish to be better informed of the value-added components of their products, enabling them to guarantee that they were procured from certified organic farms or are free of allergenic ingredients." Consequently, consumers will still be faced with a gargantuan choice of grocery products, but at least they will be able to base their purchasing decision on solid facts. ■

Leviathans of the seas

In years to come, enormous container ships will carry ever-increasing volumes of goods by sea. And German ports are well equipped to deal with this development. These are just two of the conclusions drawn by the study entitled 'Maritime Transport 2020'.

Text: Frank Grotelüschen

Giant container ships, tankers, cruise liners, fishing trawlers – there are up to 100,000 merchant ships constantly plying the world's oceans. Globalization has led to more and more goods being moved around by sea, and experts estimate that maritime transport currently accounts for roughly two thirds of the global trade volume, with this share only set to rise further. The maritime sector has grown disproportionately in recent years – faster, indeed, than the global economy. And the trend shows no sign of abating.

But what's important for the next decade? Will the ships of 2020 be bigger and more powerful than those of today? Will they be more environmentally friendly? Will shipping companies start to cooperate more? Are Germany's ports equipped for the future? In order to answer all these questions, the Hamburg-based Fraunhofer Center for Maritime Logistics and Services CML conducted a study in which it asked 60 industry players to complete an online questionnaire, among them ship owners, port operators and maritime associations.

Professor Carlos Jahn is head of the CML. He says: "The volume of goods transported by sea will continue to rise. Even if periods of economic crisis cause temporary blips and troughs, all the indicators point to growth." Container shipping, in particular, is likely to benefit – over the last few decades, increasing numbers and types of goods have been packed in containers, which specialist cranes can stack on ships and unload again in record time.

Since more and more goods are being packed specifically for container transport, the trend looks set to continue. As a result, we'll see rising numbers of container ships – and they'll get bigger and bigger. In the 1990s, the biggest container vessels could take a maximum of 8000 standard intermodal containers, or twenty-foot equivalent units (TEU). By comparison, today's leviathans boast capacities of up to 15,000 TEU.

"Soon we'll see the first ships capable of carrying 18,000 TEU," says CML staff member

More goods, more containers, bigger container ships – the trend continues. © *plainpicture*

Claudia Bosse, who headed up the 'Maritime Transport 2020' study. These giants are almost 400 meters long and will begin to appear in ports around the world in the next few years. But even that won't be the end of the story: "People have already floated the idea of building container ships with a capacity of 22,000 TEU."

Ports, too, are responding to these developments, for example by using larger and larger cranes to load and unload the ships. And operations in container terminals are becoming increasingly automated, which speeds up the loading and unloading process. The results are plain to see: more efficient transshipment, shorter berthing times and lower costs.

"Germany's sea ports are extremely well equipped for the future," states Professor Jahn. "In Hamburg, the Burchardkai container terminal is currently undergoing extensive modernization, which will double its capacity." Similarly ambitious projects are also under way in Bremen. And the Jade-Weser-Port in Wilhelmshaven, scheduled to commence operations in August this year, will provide the country with another transshipment center.

The study also found that ship owners are now taking more of an interest in the day-to-day business of container terminals. "This gives them greater influence over shipping operations and allows them to configure their transport routes more efficiently," explains Bosse. It would likewise be prudent for shipping companies to follow the example set by the airlines, and establish more alliances to ensure their carrying capacities can be utilized even more effectively in the future. Where such cooperation agreements already exist, one ship owner generally transports a given number of containers belonging to a competitor on a particular route, while the competitor carries his freight on another.

One of the main challenges currently facing the maritime industry is how to improve in terms of the environment and the climate. After all, ships and port facilities emit large quantities of CO_2, nitrogen oxides and sulfurous gases. "Our study revealed that all the players are taking the matter of the environment very seriously," says Bosse. "They are planning considerable investments in environment and climate-friendly technologies."

Environmentally friendly technology

As a result, ships that are launched in 2020 will have significantly more environmentally friendly technology on board than today's freighters. More efficient engines and more streamlined hulls will reduce fuel consumption. Wherever possible, special filters and catalytic converters will clean the exhaust gases. And certain ships will even travel more slowly than they do at present, in order to burn significantly less oil. "In 2020," ventures Professor Jahn, "vessels will move with a greater range of speeds than they do now. There will be faster ships, but also slower ones, depending on the customer's wishes."

Sulfur emissions – traditionally one of the biggest environmental problems in shipping – are expected to fall dramatically. Merchant ships on the high seas are currently permitted to burn fuels with a sulfur content of 3.5 percent. In the North Sea and the Baltic Sea, as well as the English Channel, this limit was cut to one percent in July 2010. And with effect from January 2015, the maximum permissible level will be reduced to 0.1 percent –the limit already in force along the coast of North America. "In order to comply with these limits, ship owners will be obliged either to use low-sulfur fuels or to fit their vessels with exhaust gas after-treatment systems," maintains Jahn. "Both solutions will significantly increase their operating costs."

Ballast water to be treated in future

The same can be said of another emerging technology – the treatment of ballast water. So that they remain stable when not carrying cargo, every ship has ballast tanks, which can be filled with sea or port water as required. However, there's a potentially major drawback: All sorts of organisms are scooped up in this water, and in the worst-case scenario, when the ballast tanks are emptied in other ports, these imported organisms can multiply aggressively and crowd out native species.

Indeed, this was how the Chinese mitten crab arrived in Germany. A pernicious invader, it destroys the edges and beds of rivers and has caused as much as 85 million euros worth of damage to date. Professor Jahn hopes "nothing like that will be able to happen again in the future. In a few years, the International Convention for the Control and Management of Ships' Ballast Water and Sediments will come into force, and then all large vessels will have to be fitted with systems to chemically or physically clean the water."

Ports, too, are expected to become more environment and climate-friendly. Cranes and transport vehicles operating in container terminals could be fitted with low-emission or even emission-free engines – for example using fuel cell technology. Furthermore, ships that currently produce their own electricity on board using diesel generators could in future be supplied from shore, ideally with renewable electricity. Jahn sums up the situation as follows: "It's true that there are many good initiatives promoting environmentally friendly marine technology, but the industry could undoubtedly be doing more to drive these forward." ■

Bolts of lightning in the lab

Mountains of construction rubble weighing millions of metric tons accumulate every year, yet there is still no efficient way to recycle concrete. Researchers are currently working on new methods.

Text: Katja Lüers

Whether showcased by the Pantheon in Rome or by the German concrete canoe regatta, whether ultra-lightweight or fair-faced, concrete is incredibly versatile and the world's most ubiquitous building material. Each year, 8000 million metric tons of concrete are used in construction, including around 250 million in Germany and 3000 million in China. The grey material is made from cement, water and aggregate – a mixture of sand/gravel and crushed stones of varying sizes. When cement and water are combined, they produce hardened cement paste, a binding agent that holds the gravel and stones together. The resultant concrete lasts for millennia, as evidenced so impressively by the Pantheon, with its coffered concrete dome.

Concrete is widely regarded as a 20th and 21st-century building material. However, it is associated with significant CO_2 emissions, which occur primarily during the cement manufacturing process. Producing one metric ton of cement clinkers from clay and limestone releases 650 to 700 kilograms of carbon dioxide into the atmosphere. Indeed, eight to 15 percent of the world's annual CO_2 emissions can be attributed to the manufacture of cement. And unfortunately, no ideal solution has yet been found as regards recycling scrap concrete and closing the material cycle. Every year, the United States, Europe and Japan produce around 900 million metric tons of construction waste between them. In 2010, Germany alone accounted for almost 130 million metric tons of rubble.

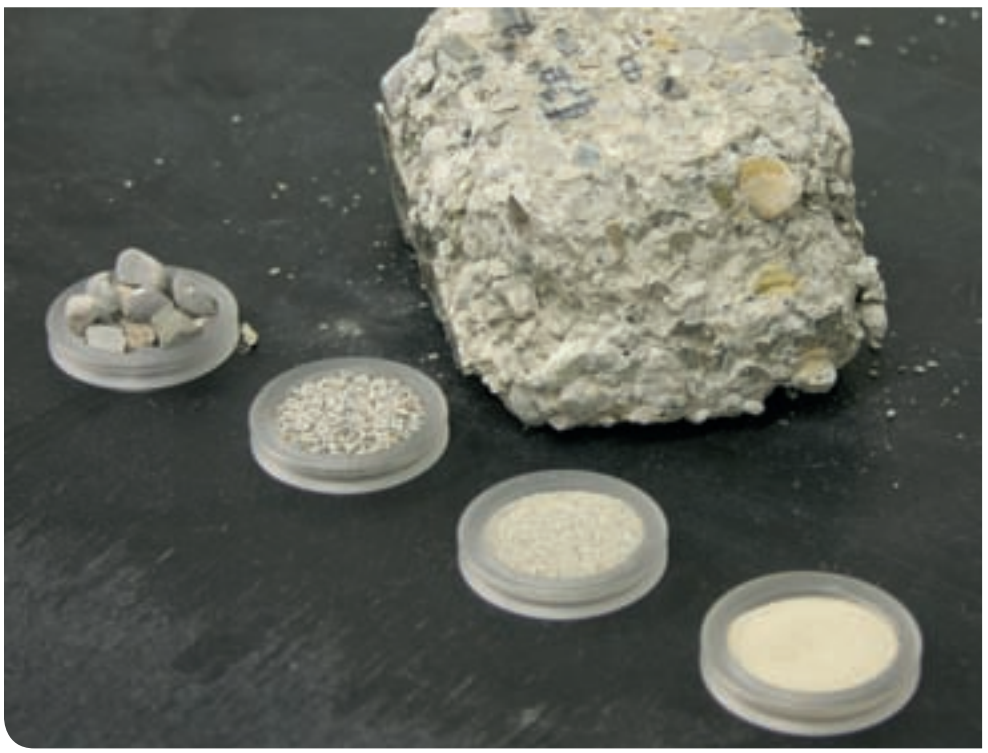
"That's a tremendous flow of material, yet at present there's no effective way to recycle scrap concrete," says Volker Thome of the Fraunhofer Institute for Building Physics IBP and the Concrete Technology Group in Holzkirchen. At present, waste concrete is crushed – a process that produces enormous clouds of dust – and at best, the residual chunks are used as road metal. "We call that downcycling," explains Thome – the repeated re-use of raw materials in which their quality deteriorates with each successive cycle. By contrast, if it were possible to reseparate the aggregate from the hardened cement paste, the gravel could quite easily be re-used in fresh concrete – a crucial initial step towards the recycling of concrete waste. "Being able to recover high-grade aggregate from scrap concrete would increase the recycling quota roughly ten-fold, pushing it to around 80 percent," states Thome. It would also conserve gravel pit resources and reduce the amount of rubble being poured into landfill sites. And if it were somehow also possible to obtain an alternative cementitious material from concrete waste, the cement industry's CO_2 emissions could likewise be reduced significantly. With this goal in mind, Thome has been revisiting a process originally developed by Russian scientists back in the 1940s, which has remained on the back burner for many years: electrodynamic fragmentation. This technology can be used to break down concrete into its constituent components – namely aggregate and hardened cement paste.

Recycling of high-grade components

The researchers in Holzkirchen are using a machine that produces 'bolts of lightning', or high-power pulses, to help them achieve their aim. "Lightning will always choose to run through air or water in preference to a solid material," says Thome. "It follows the path of least resistance." In order to ensure that the high-power pulses actually travel into the concrete and break it down, Thome is employing knowledge gleaned by those Russian scientists over 70 years ago: Dielectric strength – i.e. the inherent resistance to breakdown by an electrical pulse that every

To date, concrete has hardly ever been recycled. © *Caro / Sven Hoffmann*

Researchers have developed a method of breaking the material down into its constituent components. © *Fraunhofer IBP*



liquid and solid possesses – is not a constant value, but changes with the duration of an electrical strike. "In the case of extremely short pulses of less than 500 nanoseconds, water actually has a higher dielectric strength than most solids," he observes. It therefore follows that if a piece of concrete is submerged in water and the scientists generate a high-power pulse lasting 150 nanoseconds, the bolt will no longer choose to run through the water, but through the solid material instead.

"That's the key to the whole process," declares Thome. The electrical pulse will follow the path of least resistance through the concrete; in other words, it permeates the borders between the different components, i.e. the aggregate and the hardened cement paste. A series of preliminary pulses, or pre-discharges, are used to mechanically weaken the material first – rather like a chip that flies into an automobile windshield but doesn't cause it to shatter completely. "In our fragmentation system," says Thome, "the pre-discharge travels to the counter electrode, thereby initiating electrical breakdown." At that precise moment, a plasma channel forms in the concrete, and within a thousandth of a second, it spreads through the material like a shock wave. Both the temperature and the pressure inside the plasma channel are exceptionally high.

Separating concrete into constituentparts

"The force of the shock wave is comparable to a small explosive blast," continues Thome. The concrete is forcibly ripped apart into its various components. Using the fragmentation equipment in their laboratory, the Fraunhofer researchers are currently able to process one metric ton of concrete waste an hour. "We're looking to increase this to at least 20 metric tons an hour to make the process economically viable," Thome says. Suitable machinery could be market-ready in as little as two years. Of course, electrodynamic fragmentation can serve other purposes too, not just the recycling of scrap concrete. High-power pulses can similarly be used to separate municipal solid waste incineration (MSWI) bottom ash and carbon fiber reinforced plastics into their respective individual components.

The Fraunhofer researchers have already notched up some very promising results, particularly as regards the treatment of MSWI bottom ash, which has a terrible reputation because of the materials it contains. "No-one wants to deal with MSWI bottom ash," states Thome bluntly. "But in 20 years, Germany will run out of places to dump it, and we have to find a solution by then. For now, our primary aim is to separate out all the metal, glass and ceramic components, in order to reduce the overall volume." At a later stage, the researchers also hope to use the leftover material to develop a cement substitute or cement aggregate – after all, when combined with water, MSWI bottom ash reacts in a remarkably similar way to cement.

The recycling of MSWI bottom ash falls under the Beyond Tomorrow project 'Molecular Sorting for Resource Efficiency', an in-house collaboration that pools the resources of seven Fraunhofer institutes. For materials such as used glass and wood, the researchers are seeking to drive forward the concept of systematic recycling and production in a closed-cycle flow. Their aim is to devise a production process that requires no new input of raw materials, and to this end, they are developing innovative separation and sorting technologies right down to molecular level. ■

Cars and cellphones: a dangerous relationship

Are interactive applications compatible with road safety? A group of researchers has been delving into this question.

Text: Klaus Jacob

© Jens Bonnke

"What's the problem: I know what I'm doing." Thousands of drivers trot out this excuse – until the day they cause an accident because they were distracted by a phone call. Since the introduction of car phones, drivers have built up a complex and intimate relationship with these communication tools, which has intensified since the arrival of the iPhone and other smartphones. A new term, "iPhonization", has even been coined to describe the phenomenon that psychologist Frederik Diederichs of the Fraunhofer Institute for Industrial Engineering IAO in Stuttgart knows all too well. The institute recently organized a conference devoted to this topic, which was attended by representatives of major auto companies and suppliers such as BMW, VW, Daimler, Ford, Bosch, and Harman. On the agenda: communication, comfort, driver-vehicle interfaces, and driver alertness.

Many accidents happen because drivers aren't paying attention – and using a phone at the wheel is a common source of distraction. Since 2001, drivers in Germany caught in the act have been required to pay an on-the-spot fine, but that still hasn't dissuaded hardened smartphone users. It was therefore increased in 2004 and, in addition to the 40-euro fine, offenders now incur one penalty point charged to their driver's license. Even more draconian measures are imposed in other European countries. In Italy, for instance, the minimum fine for this kind of offense is 200 euros. But this has still not had the hoped-for dissuasive effect – it seems that the temptation to communicate effortlessly and spontaneously is stronger. In 2009, Germany's Federal Motor Transport Authority (KBA) registered 418,000 offences against the ban on

cellphone use while driving, but the real figure is probably much higher. Around 30 percent of German drivers admit to driving with a cellphone in their hand – the same percentage as in Sweden, the only European country that allows cellphone use while driving. This comparison demonstrates that the ban is totally ineffective.

It is hardly surprising that drivers are unwilling to comply, given that they are allowed to take their hands off the wheel to fiddle with the controls of their car radio, or unwrap a sandwich, or extract a cigarette from the packet on the dashboard with impunity. But as soon as they reach for their cellphone, another set of rules applies. Strangely, with a hands-free device, they can phone as much as they like. And yet scientific studies have long since proven that the use of such devices does not significantly reduce the risk of accidents, because cognitive distraction effectively reduces attentiveness to a far higher degree than tasks involving coordinated physical movement. But the lawmakers can only punish behavior for which they have undeniable proof, and that is the only reason why the use of hands-free mobile phones remains free of sanctions – because there is no means of obtaining photographic evidence.

Nowadays the smartphone is a cult object that large swathes of the population are unwilling to do without, especially for the apps that are indispensable to social networking. This is a trend that started in the USA, as Diederichs explains: "People live their lives through Facebook, and they don't want to be excluded from this community when they get into their cars." The auto industry reinforces this trend by focusing its marketing efforts on the demands of the younger generation of car buyers, which they aim to satisfy by modernizing the onboard infrastructures of their vehicles and establishing new business models. This strategy involves integrating the smartphone as a component of the car, and using its intelligent functions to enhance the dashboard functions – customized apps make everything possible. It is a land of unlimited possibilities: Daimler has announced the "applification" of its vehicles and is now a regular exhibitor at the Consumer Electronics Show in Las Vegas and other similar exhibitions, along with most other car manufacturers.

But safety remains the prime consideration, and this is where the IAO has much to offer. Its researchers have spent many years investigating the question of driver alertness and distraction. Their laboratory is equipped with a sophisticated simulator that imitates the movements of a car in different driving scenarios. Images are projected onto six large screens to create a realistic optical illusion. These facilities help the researchers to find ways of measuring the impact of external factors and designing telephony applications that do not impair the driver's ability to concentrate on essential tasks. Their approach is based on one simple theoretical rule: drivers will always intuitively strive for an optimum workload that is neither too demanding nor too boring. Understimulated drivers will look for something to keep them occupied. An over-tired car driver will step on the accelerator; and truck drivers have been known to cut their toenails, watch TV or take a look at their Facebook status while driving in order to relieve the boredom. On the other hand, someone who is stressed or distracted will tend to drive more slowly. It would be good if there was a sensor capable of measuring the driver's level of attentiveness, but that's not easy to achieve.

In the driving simulator at the IAO in Stuttgart, there is a small suspended camera pointed toward the driver's face. Experiments have shown that drivers who take their eyes off the road for more than two seconds, or briefly look away at least four times in succession, almost certainly lack concentration. Physiological signs such as changes in respiration, heart rate and skin resistance can also help to assess the driver's alertness. Other technical solutions include monitoring for lane-keeping errors. But none of these methods are infallible, as the IAO researchers know all too well. They are therefore developing reference standards to support the automotive industry in its efforts to improve its algorithms by providing a reliable means of evaluating the driver's distraction level. Mercedes has already developed an Attention Assist system that registers dozens of parameters and triggers a warning when it detects signs of drowsiness, signaled by a coffee cup icon in the instrument cluster. Admittedly, this system addresses the problem of driver fatigue rather than loss of concentration, but this is another area in which Fraunhofer researchers see a potential use for their expertise – because the percentage of drivers who actually heed the "Time for a Rest?" message is minimal. This is where the human-machine interface could play a major role.

Diederichs and his group want to take the idea a step further and help drivers to keep up the right level of alertness. If drivers are understimulated, an app could set tasks that make additional demands on their mental faculties – without competing for attention with the resources needed for actual driving. If a driver is stressed or overstimulated, on the other hand, the amount of information to be processed could be reduced, for instance by limiting the number of options shown on the display and increasing the font size. Another measure that has proved useful is to issue collision warnings one second earlier than usual, for a distracted driver is willing to accept the occasional false alarm, which he would otherwise find unforgivable.

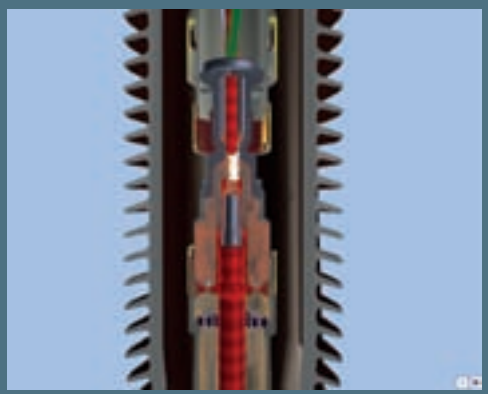
This research is all the more important given that the range of factors that drivers need to take into account has been growing steadily in recent years. As well as having to deal with a dense forest of road signs, increasingly complex traffic situations, and the rising number of onboard functions, the smartphone is now also vying for their attention. Carmakers are forging ahead in their efforts to integrate the device. The new A-Class Mercedes, due to be launched in September, will offer the "Drive-Kit-Plus" as an option. Other manufacturers such as Ford are following close behind with similar products, making them available also in middle class cars. The basic communication functions generally include voice recognition, a steering wheel control interface, and an extra-large display. For the old rule that exhorts drivers to "keep your eyes on the road and your hands on the wheel" still applies today and will remain so until automatic driving is actually introduced.

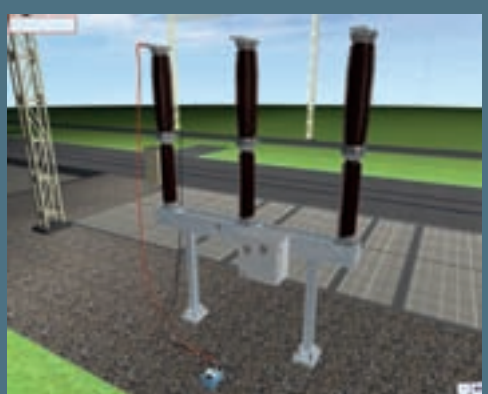
The "applification" of the automobile is striding ahead. Reading emails and sending text messages on the road are just the beginning: soon the cars themselves will be able to communicate with one another and warn their drivers of upcoming danger spots. At present, the available Internet speeds are too slow to allow the full spectrum of possible communication services to be exploited. But the new LTE mobile communication standard, the successor to UMTS, will soon be available, making it possible to transfer data reliably even when traveling at high speed. Despite all these enticing offers, there is one thing that drivers must never forget: The ultimate responsibility for safety lies in their hands. ■

Electrifying learning

Purely and simply, learning by doing expedites learning. When training equipment is live however, one false move can be extremely dangerous. Virtual learning environments provide a solution.

Text: Bernd Müller





Virtual learning environments.
© *Fraunhofer IFF*

Imagine a dark cellar with children playing in the stairwell. A bicycle is leaning on the wall next to the electricity meters. An error when disconnecting the power would be dangerous. The electrician sends the children out, makes sure there is enough light, moves the bicycle to the side and then dons protective gear and lays out special tools with insulated grips.

Unfortunately, utility company employees also get sent out to disconnect power to customers in arrears. Rather than in some dark cellar, this scene is playing out at RWE Deutschland AG's training center in Plaidt near Koblenz where the utility company trains its service staff for "live-line working". The German Association for Electrical, Electronic and Information Technologies (VDE) defines this as all work performed on or in electrical installations that cannot be disconnected from the supply completely or with absolute certainty. In other words, electricians can receive an electric shock if they are not careful. Service technicians practice such work at the training center – not only on real systems but also in virtual reality – so that exactly this does not happen. The software that displays the scene in the cellar so realistically was developed by the Fraunhofer Institute for Factory Operation and Automation IFF in Magdeburg.

The experts in Magdeburg have been working with virtual reality for nearly twenty years and with the visualization and interactive learning of procedures on electrical installations since 2006. Their goal is to make learning by working realistically on a computer more efficient than classroom instruction. "Procedures learned by doing are retained much better," says Tina Haase, project manager for virtual learning environments at the Fraunhofer IFF.

Obstacles blocking meters furnish one example: What does one do when the lighting in the cellar is inadequate? What does one do when there is a pool of water on the floor in front of the meters? RWE staff now deal with such situations on computers, where they gain a true appreciation of the consequences of errors. In another instance, staff equip a dummy with the required protective gear, including a flame retardant jacket, in the correct order.

In a pilot project with RWE Rhein-Ruhr Netzservice GmbH's Technik Center Primärtechnik in Wesel, Fraunhofer IFF developed a learning environment for the disassembly of transformers that have to be loaded onto freight cars. This first joint project in 2006 was complex because there was no CAD data available for the old transformers and the experts from Fraunhofer IFF had to create a new three-dimensional model for virtual training on the basis of old engineering drawings.

Virtual line circuit breaker maintenance

It quickly became clear that equipment manufacturer Alstom Grid GmbH in Kassel also needed to be brought on board for the next project – line circuit breaker maintenance. Alstom supplied the important CAD data, Fraunhofer IFF developed the virtual reality technology, while RWE and Alstom contributed the expertise for assignments. Even though line circuit breakers are disconnected from the grid during maintenance, the work is still dangerous because the circuit breakers are connected with large energy storage mechanisms with a spring bias of up to two tons and thus a considerable risk of injury. Here too, everything must be done exactly right. The virtual model additionally improves communication. Since all of the employees learn on the same model, they employ the same terms for the same components. In the past, staff in the field and colleagues at headquarters taking down failure diagnoses over the phone occasionally miscommunicated. Now, they view the same virtual model, thus eliminating any misunderstandings.

This saves time and money. "Virtual reality pays because it can be duplicated at will and exceeds the capabilities of real training," boasts Tina Haase, who has roughly calculated the costs. A functional, virtual cutaway model of a pole column costs around 25,000 euros, a real model around 10,000 euros. The virtual model can however be used on an unlimited number of laptops without further expense.

The procurement of several real models, for use in seminars and at different locations for instance, incurs far greater costs. Virtual cutaway models provide significantly more functions than physical models. In addition to mechanical movements, they also make invisible processes such as current flow visible. A comparative test revealed that higher learning efficiency is obtained with the virtual model. In the test, two groups received conventional classroom instruction and one of the groups was additionally allowed to practice on the virtual model. After four weeks of training, the group that had completed the virtual training was able to complete tasks on the real circuit breaker in the workshop faster and made fewer mistakes. A welcome side effect was that learning in a virtual environment additionally motivated younger trainees experienced with computer games. Even experienced employees found training to be lots of fun. They explored the virtual model in detail and even reconstructed malfunctions they had dealt with in the past.

The circuit breaker training simulation is part of the project ViERforES (Virtual and Augmented Reality for Maximum Embedded System Safety, Security and Reliability). In addition to Fraunhofer IFF, the Fraunhofer Institute for Experimental Software Engineering IESE in Kaiserslautern and the Universities of Magdeburg and Kaiserslautern are involved in this project, funded by the German Ministry of Education and Research (BMBF). ViERforES is the basis for other applications.

Other virtual training applications

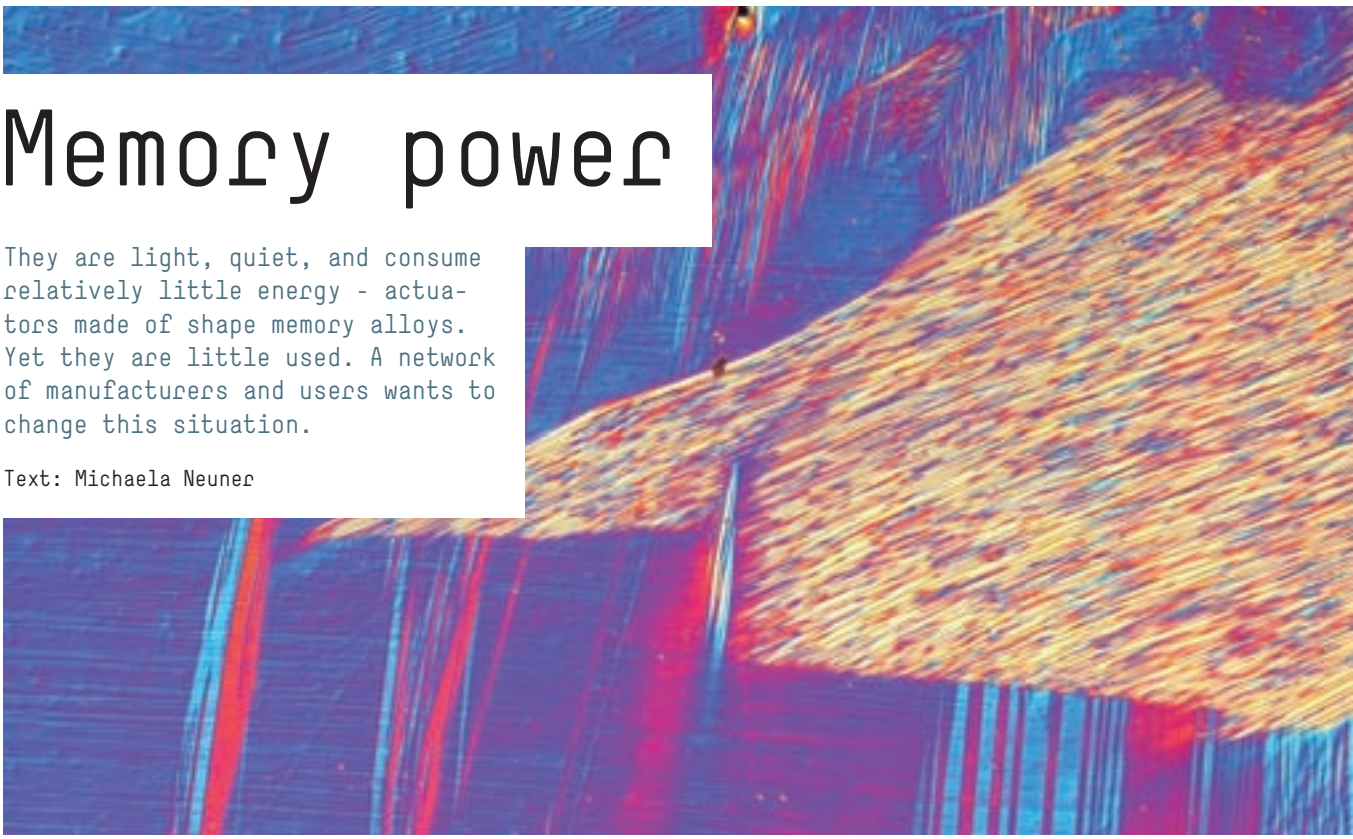
The collaboration with RWE and Alstom is continuing. RWE plans to use virtual training applications in the future for job safety training. Precautions such as isolating and grounding electrical installation before starting work ought to become second nature to technicians. RWE project manager Thorsten Tabke is thrilled with virtual reality: "In addition to its outstanding capabilities in advanced training, this system provides us with a simple, self-explanatory tool for saving know-how."

Alstom, too, would like to expand the collaboration. It is planning an interactive knowledge base from which service technicians will be able retrieve any information needed before a tricky job. Virtual reality is also an ideal marketing tool. Alstom would like to make the Fraunhofer IFF's software available to its sales staff so that they can explain switchgears' distinctive properties and features to customers clearly and understandably on a virtual model. ■

Memory power

They are light, quiet, and consume relatively little energy - actuators made of shape memory alloys. Yet they are little used. A network of manufacturers and users wants to change this situation.

Text: Michaela Neuner



The pictures show magnetic Ni-Mn-Ga SMAs with twins (bands), which make the shape memory effect possible. The optical microscope images were taken using a special contrast procedure. © *Fraunhofer IWU*

As soon as the key turns in the ignition and the engine starts running, an electric motor will be whirring almost constantly somewhere in the car. Whether button-actuated or automatic, our electric helpers are busy setting seat height and side mirrors, repositioning headlights, moving windows and windshield wipers, and adjusting heater valves. Current car models contain more than 50 electric actuators and counting.

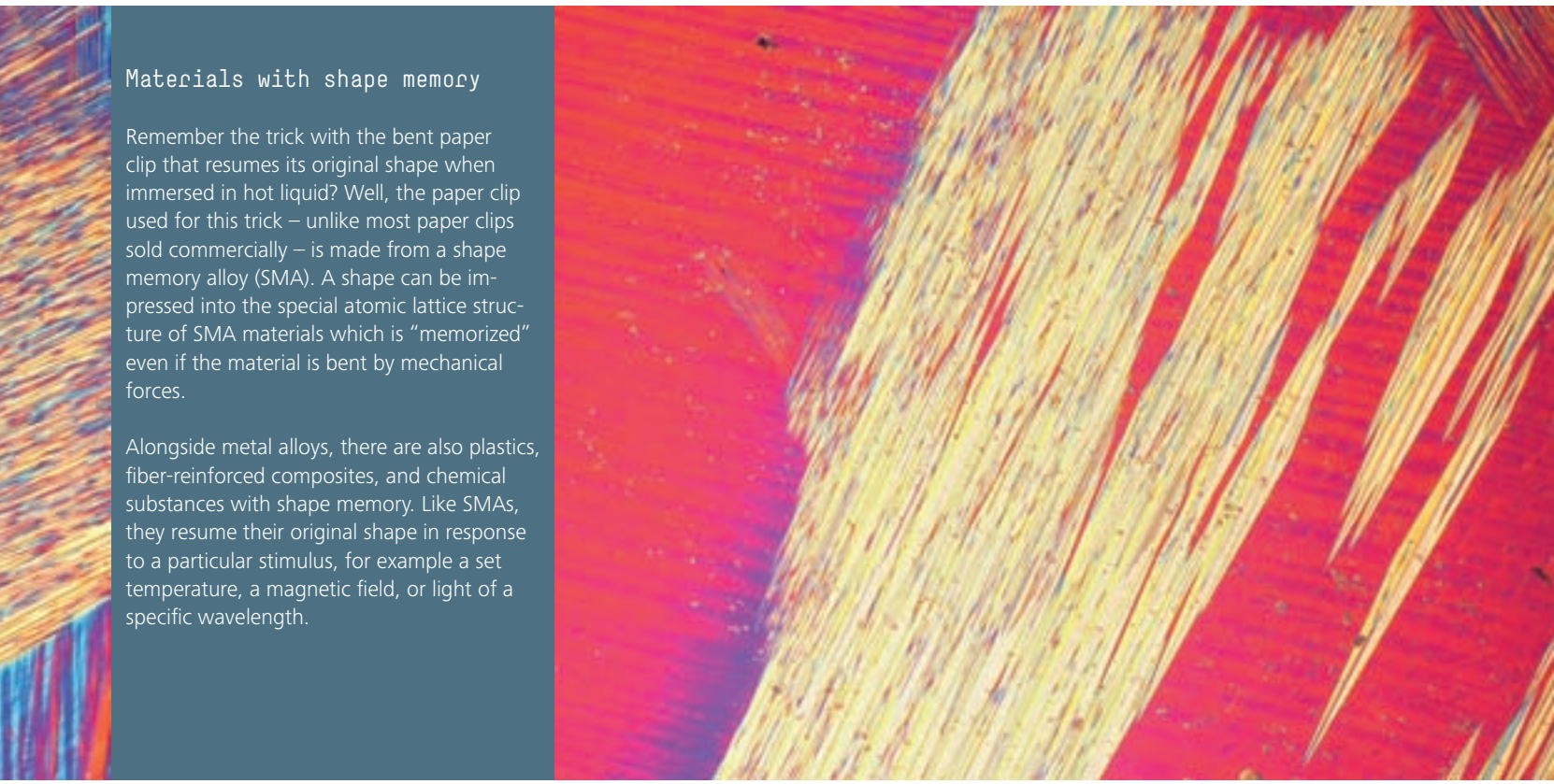
"Sooner rather than later this trend will come up against technical, physical, and economic limits," notes Holger Kunze from the Fraunhofer Institute for Machine Tools and Forming Technology IWU in Dresden. Conventional actuators consume electricity and take up space; and their weights all add up too – by virtue of the magnetic coils alone, which all electric motors need. Not to forget the stricter requirements for energy efficiency and climate protection – after all, the lighter a vehicle, the less energy you need to move it. Weight and power consumption are especially critical for electric vehicles. "Mechatronic components offer interesting alternatives to small electric motors here," asserts adaptronics engineer Kunze, who is looking particularly at the far from exhausted potential of actuators based on shape memory alloys (SMAs). They are best suited as replacements for small actuators, e.g. for opening and closing valves, moving ventilation flaps, or adjusting mirrors.

SMA systems have a whole host of advantages over electric motors: They are lighter and take up less space, for instance. They work silently. They are more compact and consume less power. They also contain a smaller number of individual parts, which makes them less prone to failures. Shape memory alloys can stretch by eight to ten percent, making them significantly more elastic than conventional alloys. Nevertheless, they can move objects several times their own weight: a two-millimeter-thick shape memory wire can hoist a load of more than 100 kilograms.

Scientists at Fraunhofer IWU have compared shape memory alloy actuators with conventional systems for various applications in vehicles, with interesting results. For example, headlight range control can be powered by an electric motor weighing about 50 grams or by an SMA actuator weighing 35 grams that reacts three times faster. Or take the locking and release mechanism for a remote-controlled flap protecting access to the fuel tank: it can be powered either by an electric motor with gearbox weighing 104 grams, comprising a total of ten individual parts, or by a three-part shape memory actuator weighing only ten grams –which then requires no more installation space than would be needed to lay a cable.

Medical applications for shape memory alloys

Whereas the use of shape memory alloys in car manufacturing is still in its infancy, the same cannot be said for medical technology. Shape memory alloys have long been used to make surgical tools, braces for supporting broken bones, and stents. The latter are tube-shaped mesh supports fitted inside constricted arteries in order to restore the flow of blood. Shape memory stents are made from a nickel-titanium



Materials with shape memory

Remember the trick with the bent paper clip that resumes its original shape when immersed in hot liquid? Well, the paper clip used for this trick – unlike most paper clips sold commercially – is made from a shape memory alloy (SMA). A shape can be impressed into the special atomic lattice structure of SMA materials which is "memorized" even if the material is bent by mechanical forces.

Alongside metal alloys, there are also plastics, fiber-reinforced composites, and chemical substances with shape memory. Like SMAs, they resume their original shape in response to a particular stimulus, for example a set temperature, a magnetic field, or light of a specific wavelength.

alloy whose shape memory effect (see box) is triggered by a specific temperature. This enables the wide-meshed grid of the stent to contract into a compact but extremely pliable tube for the operation. Only when in place does it expand back to its original size and shape.

"One reason why shape memory alloys have already become established materials in medical technology is that function and quality carry a good deal more weight than costs in this field," explains Dr. Andrea Böhm from Fraunhofer IWU. "Elsewhere people are more concerned with price, and materials that are somewhat more expensive are at a disadvantage." Also, the materials and their possibilities are not well enough known. Finally, many applications still lack material data, design and simulation tools, and standardized processes and procedures.

To remedy this situation, Fraunhofer IWU founded the "SMA Network" in summer 2010. The network's goal is to make shape memory alloys useful for technical applications on an industrial scale. "We want to help close existing gaps in the value chain," says network manager Böhm. The network is open to all companies who work with, or are interested in, shape memory alloys, and its main purpose is to bring together users and manufacturers. "The problem is that the material manufacturer needs a specific request to be able to manufacture a special material with the required characteristics, while the user wants a readymade solution," reports Böhm.

www.fgl-netzwerk.de

To date, 13 companies and three research institutes are involved in the network. The focus is on applications that use the already established thermal shape memory effect. On the agenda of one of the companies in the network, however, is the latest generation of SMAs, which are activated by magnetic fields. This magnetic shape memory effect was discovered in 1996 for the first time in a Ni-Mn-Ga alloy which is the common material class in this field to date. "The main advantage of magnetic SMAs is that they can be operated over a higher frequency range. They are faster than thermal SMAs, as a magnetic field can be switched on or off from one moment to the next, whereas bringing back down the temperature of a solid nickel-titanium material is a relatively slow process," explains Böhm.

The basic principles involved in the full-scale production of magnetic SMAs already exist. Among other things, scientists at IWU are currently working on machining processes and looking for alternative alloys. "The temperature ranges within which magnetic shape memory alloys work are still limited. For nickel-manganese-gallium alloys, there is the additional drawback that prices for the raw material gallium are relatively high. Therefore, we want to develop alloys without gallium and with higher transformation temperatures," reveals Böhm.

Meanwhile, thermal SMA actuators based on a nickel-titanium alloy are currently conquering new territory: autofocus and image stabilization systems for smart phones. The new generation of models is scheduled to go into production later this year. ■

The laboratory of the future

Robots that automatically freeze biological samples, or software that saves time by automating the task of documenting each step of the testing process, enable biomedical laboratories to work faster and more efficiently, and obtain more reliable results.

Text: Tim Schröder

Biomedical laboratories are a hive of activity, carrying out numerous different tasks each day. Lab technicians pour liquids drop by drop into test tubes, freeze living cells in liquid nitrogen, and mix chemicals with blood samples to help diagnose diseases. They use centrifuges to separate blood into its components, and grow bacterial cultures in petri dishes in incubators. Many of these analytical stages – such as transferring test tubes – are carried out by hand. Even in the most modern, automated laboratory, up to 80 percent of the work still requires manual intervention. Patients usually have to wait several days for the results of a blood test. This means a long period of uncertainty and anxiety, especially when the outcome could be critical, such as confirmation of an HIV infection.

http://labor-der-zukunft.com

The time it takes to conduct a laboratory analysis would be much shorter if it wasn't for the amount of paperwork involved. Meticulous records have to be compiled for every sample and each stage of the process. This is a time-consuming task and a common source of errors. To simplify the work of the lab technicians, reduce errors, and speed up analysis, researchers at the Fraunhofer Institute for Biomedical Engineering IBMT are working on a project to develop the "laboratory of the future" with the aid of Saarland government funding. They have already come up with numerous technical solutions to automate many aspects of laboratory testing, especially the documentation of samples.

This by no means requires that laboratories should replace all their equipment or radically change their working practices. "Our solutions allow them to continue using their existing procedures and instruments," says IBMT project manager Daniel Schmitt. "The laboratories can install the technologies as needed, one by one." The same applies to future new solutions. The next product in the pipeline is a wireless power socket for laboratory equipment. An inductive energy transfer device is retrofitted to the equipment. Power is transmitted by means of a traveling electromagnetic field, without the use of cables. This solves an age-old problem: Conventional plug-and-socket connections are difficult to insulate and clean and thus do not meet the strict hygiene requirements for biomedical laboratories.

Test tubes with built-in microchips

In collaboration with local universities and small businesses in the Saarland region, the IBMT experts have developed other novel concepts, such as a system for automatically tracking samples. Tiny microchips are incorporated in the plastic test tubes. These chips can then be used to store a wealth of data including the date and origin of the sample, the name of the patient, and other relevant information concerning the processing of the sample and any other specific details. In the past this information was recorded on handwritten labels, or more recently in scannable barcodes. But even barcodes are not sufficiently flexible for use in fully automated laboratory systems, because the stored data cannot be modified.

This is the advantage of the microchip: When the test tube is inserted into the analyzer, the chip automatically records each operation, along with the time and the person responsible. The entire history of the sample is thus recorded in the test tube itself, relieving the lab technician of the need to keep detailed written notes. "Biological samples are usually accompanied by a report slip containing all relevant information for subsequent processing steps," says Schmitt. This information can also be transmitted in an email. "By contrast, with the chip, the sample and the information are inseparably linked, and that way nothing can get lost."

Preserving samples at minus 140 degrees Celsius

A major focus of the IBMT researchers' development work is cryogenic storage, an established technique used by biotech laboratories for the conservation of living biological samples. The Fraunhofer-Bioarchive conserves samples at a temperature of less than -140 degrees Celsius. Nowadays, biobanks use cryotechnology to freeze stem cells, cell tissue, and even entire skin grafts for treating burns.

But they all face the same problem: Every time the storage container is opened to deposit or remove a sample, moisture from the air is admitted and immediately turns to ice. The ice accumulates on the walls of the container, which eventually has to be emptied to allow the ice to be removed. To avoid having to perform this complicated operation, the IBMT researchers have developed a handling robot that deposits and removes the vials containing the biological samples through a cooled airlock, which prevents moist air and other contaminants from entering the container.

In modern laboratories, samples are analyzed in a combination of manual and automated processing steps. Here, a reagent rack is checked before being placed in an automated cell culture system.
© Bernd Müller/ Fraunhofer IBMT

Large cryogenic tanks can store several thousand samples. This makes it difficult for lab technicians to keep track of what is stored where, and it can often take a while to locate the desired sample. Robots can do the job faster if the vials have electronically readable labels that allow their position in a specific rack to be identified. This inventory system enables the robots to immediately access the correct vial, without any risk of error. "We took great care to ensure that our vials would be compatible with standard rack configurations," says Schmitt. The researchers also conducted numerous tests to ensure that the microchips would be capable of operating reliably at the necessary low temperatures and withstanding frequent changes in temperature between ambient and cryogenic.

As an option, the chips can be additionally equipped with a radio communication function in the form of an RFID antenna, allowing information to be read from and written to the chip over the air. At present, this function is mainly used to encrypt the data on the chips – an important security consideration when information about patients or other confidential data are stored there.

Cryotechnology is just one facet of the laboratory of the future. The IBMT researchers had set their sights on understanding the laboratory as a holistic entity and optimizing and standardizing workflows accordingly. To do this, they got together with the software engineering company Soventec to develop a powerful software solution to control operating procedures: the Lab OS® lab management platform. When a vial containing a sample is placed in the chip reader, the Lab OS® Station instantly displays the data, the sample's history, and the next steps to be performed. And not a single sheet of paper in sight!

The lab technicians still have to control the laboratory equipment themselves, but one day even that task will be automated too. To make this possible, IBMT has developed a network system that links all of the devices with a central controller, in a collaborative project with the Technische Universität Braunschweig. This "smallCAN" bus system works in a similar way to the networks linking electronic components in cars. It even allows individual items of laboratory equipment to be accessed via the Internet. To enable different types of apparatus to be connected to the smart network, the researchers have developed a plug-in adapter that permits them to communicate with the control electronics.

"Using smallCAN and Lab OS®, the laboratory can be run with very little outside intervention and the test procedures can be controlled and documented automatically," says Schmitt. This cuts down significantly on paperwork. Instead of spending precious time filling out report forms, the lab technicians can concentrate on their actual work of preparing and testing samples. ■

Building innovations from South Tyrol

The researchers will conduct projects in international and interdisciplinary teams together with scientists from the University of Bolzano and partners from industry.
© *Fraunhofer*

Demographic change, sustainability, mobility, urbanization, and digitization are megatrends, which call for new solutions in the building and construction industry. In the collaborative research project build4future, Fraunhofer scientists from Bolzano are teaming up with industrial partners from South Tyrol to show how companies can begin preparing for the future today.

Undertaking a construction project these days requires strong nerves. Delivery problems, missed deadlines, and rejected materials are the order of the day. "Usually, there are significant delays, with actual costs ending up well above those agreed in the contract," explains Prof. Dominik Matt, head of the Fraunhofer Innovation Engineering Center IEC in Bolzano, the capital of the Italian province of South Tyrol. Matt has become an expert on the everyday chaos of the construction sector. Together with his team, he has scientifically analyzed problems faced by building contractors and developed new approaches in order to solve them.

In the first stage of the project build4future, the specialists of the project team interviewed 400 building and construction companies as well as suppliers from Germany, Austria, Switzerland, and Italy. The results showed that one third of all respondents are dissatisfied with the scheduling and coordination of their construction projects. "There is a lack of communication between architects, construction companies, plumbers, window fitters, glaziers, electricians, roofers, and the many other groups that are required for a construction project," says Matt. He estimates that the lack of coordination drives costs up by as much as a third.

With the aim of minimizing losses arising from friction between the various parties and to reduce costs, Fraunhofer researchers in Bolzano have developed a new organizational concept. This allows optimal scheduling and coordination for all the various activities of the companies involved in construction projects – in the case of large projects, there may even be as many as 50. "The challenge was to develop a concept that works independently of the particular companies involved," explains Matt. Having this kind of flexibility is important in the construction sector, as the parties involved change quickly. Each project sees a new call for tenders, which means that new players are getting involved. A "process map" developed by Fraunhofer researchers in Bolzano now gives all parties involved in a project access to the scheduling and logistics of the other parties. Standards are laid down, and data for quality management is provided.

Building for the future

The cradle of the new planning strategy is South Tyrol, a region where – thanks to tourism – the construction industry is booming and which is home to an especially large number of small and medium-sized companies. The researchers want to help these companies to prepare for the challenges of the future. "Megatrends, such as demographic change, sustainability, mobility, urbanization, and digitization present new challenges for the construction industry," says project manager and deputy director of the IEC, Daniel Krause. "Long-term innovation planning is of particular importance: after all, people are building for the future."

16 project partners – alongside Fraunhofer, the project benefits from the participation of the Free University of Bozen/Bolzano, the KlimaHouse Agency, the TIS innovation park, and 12 South Tyrolean companies – now collaborate in order to develop new construction concepts: houses that save energy, are amenable to modular renovation, and adapt to the needs of their occupants, who need varying amounts of living space at different stages of their lives. "Only when these requirements are known, defined, and taken into account at the planning stage, do you end up with buildings fit for the future," explains Matt. Sometimes, simple measures are enough: for example, façade elements that generate solar power and can be quickly replaced if they are damaged; wiring that is laid so that wires can be replaced easily without having to break open walls; or partition walls that can be taken out and moved around. "It is also crucial that planners and suppliers work together in the best possible way," adds Matt. "Only if all partners communicate, is it possible to avoid planning errors, delivery problems, missed deadlines, and rejected materials." Matt and his project partners presented the new concept at the Innovation Festival in Bolzano.

Venturing over to British shores

Now the work can begin. Fraunhofer UK Research Limited, the latest foreign subsidiary of the Fraunhofer-Gesellschaft, was founded only a few short weeks ago. Yet as early as on September 1, work will get underway in the first research center – the Fraunhofer Centre for Applied Photonics in Glasgow.

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

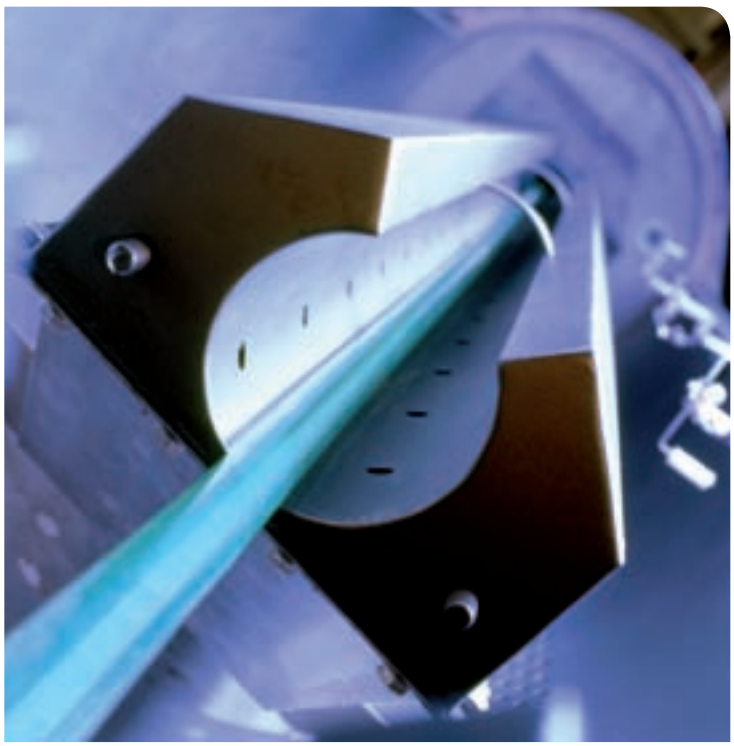
Photonics has long been a major topic in the United Kingdom. The British photonics industry is the second-largest in Europe after Germany. Over 80 manufacturers of laser-based products are headquartered in Scotland alone, and the researchers at the University of Strathclyde are internationally recognized experts in the field of photonics. The excellence found locally and the closeness of the research to industrial practice make for an attractive environment for Fraunhofer; indeed, Fraunhofer institutes have been cooperating with experts in Scotland for many years. "We are delighted at the opportunity to work even more closely with the University of Strathclyde in future," explains Fraunhofer Senior Vice President Prof. Ulrich Buller. "The university and more specifically the Institute of Photonics and other research groups have an excellent reputation as regards contacts with industry in general and photonics research in particular."
Professor Jim McDonald, Principal of the University of Strathclyde, adds: "It is fitting that the UK's first Fraunhofer Centre is dedicated to lasers, a thriving industry Scotland has excelled in for decades."

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's mission is to cooperate with the best British research groups and develop solutions for industrial clients. Initially, the main focus will be on developing innovative infrared laser sources for optical sensors, which will help to solve pressing, important problems in fields such as environmental technology, process metrology, and medicine. The new Fraunhofer Centre will also be a contact point for other institutes of the Fraunhofer-Gesellschaft that are thinking about venturing over to British shores.

This means further growth in the Fraunhofer-Gesellschaft's international network, which currently comprises 60 institutes in Germany along with subsidiaries in the United States, Italy, Portugal, Austria and Chile. In the coming years, further centers will be able spring up under the umbrella of the new Fraunhofer UK Research Ltd.

Technology and Innovation Centre (TIC) in Glasgow city center. This is where the Fraunhofer Centre will be based from 2014 on.
© University of Strathclyde

Cellulose is not only a renewable resource but also infusible. © *Armin Okulla*



Award for brilliant research

This year's Anselme Payen Award of the American Chemical Society, Cellulose and Renewable Materials Division, was bestowed on Prof. Hans-Peter Fink, Head of the Fraunhofer Institute for Applied Polymer Research IAP in Potsdam. The award is given annually to honor and encourage outstanding professional contributions to the science and chemical technology of cellulose and its allied products.

Cellulose is the most common renewable energy source on earth. Because of its structure the material does not melt and is under normal conditions unsolvable. The use of cellulose for the production of synthetic materials is therefore difficult. In close cooperation with industry Fink however developed novel processing routes for cellulose and has shown a novel way to manufacture high modulus technical cellulose fibers via liquid crystalline solutions.

In April 2013 he will be honored with the Anselme Payen Award, the most prestigious and internationally recognized award in the field of cellulose research.

Solving challenges in the developing world

Chief Executives of nine of the world's leading applied research agencies met in Sydney recently to improve access in the developing world to science and innovation. "It has become increasingly clear, to even the most scientifically and technologically advanced nations, that no nation can go it alone and no single country can lead in all fields," stated chief scientist Professor Ian Chubb, advisor of the Australian government. "

Only collectively can problems be solved. In order to pool knowledge, skills and technological resources, the Global Research Alliance was launched in 2003. Today it connects 60,000 scientists who want to help solve the world's most serious problems like access to clean water, energy, digital information and a healthcare system. The members are Battelle (United States), CSIR (India), CSIR (South Africa), CSIRO (Australia), Danish Technological Institute (Denmark), Fraunhofer (Germany), SIRIM (Malaysia), TNO (the Netherlands) and VTT (Finland).

"Fraunhofer is proud of being able to contribute to reaching the United Nations' millennium goals. It is our corporate social responsibility to offer knowledge and technology to those who are in need. And it is an honor to pursue this goal together with the world's leading research organizations", explains Fraunhofer's Senior Vice President Professor Alfred Gossner.

Fraunhofer, CSIRO, CSIR, and VTT are currently undertaking a project in Sub-Saharan Africa. Together with MachaWorks in Zambia, the researchers combine the expertise of the institutes in wireless communication, robust infrastructures, renewable energy, antenna systems, network management, usability and local culture to design and implement a wide-area low-cost and robust wireless infrastructure providing internet access to people living in rural Africa.

Solar cooling for India

It's nearly 40 degrees Celsius outside, but pleasantly cool in the office. More and more, buildings are now air-conditioned; according to the International Energy Agency (IEA), energy demand for air-conditioning is increasing at almost twice the rate of the overall energy demand in buildings. Demand is particularly high in countries that receive higher levels of solar radiation, with cities like Bangalore, Chennai or New Delhi reaching record levels of around 2000 kilowatt hours per square meter each year. And yet it is precisely in places such as these, where power grids are unstable and energy shortages are common – especially around midday and during the afternoons – that conventional technology is unable to operate reliably. "Indian companies often use emergency generators to accommodate peaks in demand," reports Dr. Clemens Pollerberg of the Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT in Oberhausen.

Alongside thermally powered steam jet cooling, Pollerberg and Peter Schwerdt are also developing absorption cooling systems to cool buildings using solar energy. They are working with their colleague Andreas Weber to bring the technology to market in India.

In 2011 UMSICHT entered into a joint venture agreement with VSM Energy Private Limited in Bangalore to found VSM Solar Private Limited. "Our aim is to take what we already know about solar thermal cooling and translate it into a marketable product that we hope will become widespread," resumes Pollerberg.

Research agreement with Dow AgroSciences

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

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

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

Editorial notes

Fraunhofer magazine
Research, technology and innovation.
This bi-annual publication can be ordered free of charge by customers, partners, employees, media representatives and friends of the Fraunhofer-Gesellschaft.
ISSN 1615-7028 (Print)
ISSN 1617-1438 (Internet)

A publication of:
Fraunhofer-Gesellschaft
Hansastrasse 27c
80868 München, Germany
Editorial address as above
Press & Public Relations
Phone + 49 89 1205 1301
Fax + 49 89 1205 77 1301
presse@zv.fraunhofer.de
www.fraunhofer.de/magazine

Subscription:
Phone + 49 89 1205 1366
publikationen@fraunhofer.de

Editors:
Franz Miller (Editor-in-chief),
Monika Weiner (Senior Editor),
Beate Koch, Birgit Niesing, Britta Widmann
Christa Schraivogel (Photography and production)

Editorial assistants:
Frank Grotelüschen, Daniel Hautmann, Katja Lürs, Klaus Jacob, Bernd Müller, Michaela Neuner, Tim Schröder, Lisa Spannknebel, Evdoxia Tsakiridou

Illustrations: Vierthaler & Braun
Cover picture: ddpimages
Lithography and Printing:
J. Gotteswinter GmbH, Munich
Translation: Burton, Van Iersel & Whitney, Munich; Allround-Service, Munich
Advertisement:
Next closing date: 08.05.2013
Price included in the membership subscription.

Fraunhofer

Are you curious about tomorrow? Then why not start a career in applied research and join us in developing technologies and products for the future?

Apply now at **www.fraunhofer.de/jobs.**

Fraunhofer